Fastvideo Image & Video Processing SDK

TECHNICAL MANUAL

v.0.17.3

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1 Introduction

1.1 *About this manual*

We sincerely hope that this manual can answer your questions, but should you have any further questions or if you wish to claim, please contact your local dealer or refer to the FASTVIDEO support on our website.

The purpose of this document is to provide a description of the **FASTVIDEO Image & Video Processing SDK** and to describe the correct way to install related software and drivers and run it successfully. Please read this manual thoroughly before getting started the software for the first time. Please follow all instructions and observe the warnings.

This document is subject to change without notice.

1.2 *About FASTVIDEO*

FASTVIDEO is one of worldwide leaders in the field of high performance GPU image and video processing solutions. Based in Russia, FASTVIDEO offers their GPU software solutions worldwide. In close collaboration with customers FASTVIDEO has developed a broad spectrum of technologies and cutting-edge, highly competitive products.

FASTVIDEO software solutions find use in machine vision cameras, scanners, high speed imaging applications, robotix, broadcasting and streaming, heavy-loaded internet services, 3D and VR, other applications for image and video processing. The broad spectrum of solutions also includes medical applications and digital cinema.

1.3 *Contact FASTVIDEO*

FASTVIDEO is a worldwide operating company.

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1.4 *Conformity*

FASTVIDEO Image & Video Processing SDK has been tested at the following:

- Windows-7/8/10 (64-bit)
- Linux Ubuntu, OpenSUSE 12, SLC-7.5, CentOS, etc.
- NVIDIA GPUs with Compute Capability ≥ 3.0
- CUDA-10 for server, desktop, laptop and mobile GPUs
- NVIDIA drivers 457.30 or later
- All sample applications are prepared for MSVS 2019 and gcc

1.5 *Useful Links*

- FASTVIDEO Homepage
  https://www.fastcompression.com
- NVIDIA CUDA and GPU drivers download:
  http://www.nvidia.com/Download/index.aspx
- JPEG Standard:
  http://www.w3.org/Graphics/JPEG/itu-t81.pdf
- Full Image Processing Pipeline on the GPU:
  http://on-demand.gputechconf.com/gtc/2014/presentations/S4151-full-gpu-image-processing-pipeline-camera-apps.pdf
- gpu-camera-sample application with source codes:
  https://github.com/fastvideo/gpu-camera-sample

2 FASTVIDEO Image & Video Processing SDK

2.1 *Input Data Formats*

Output formats for cameras could differ significantly. That's why we have created input module which handles various image formats acquired from cameras.

2.2 *RAW Data Unpacking and Transforms*

RAW data from cameras could have 8/10/12/14/16 bits per pixel. Quite often input data are packed and we need to do unpacking. For example, 12-bit data are usually transferred as 2 pixels in 3 Bytes. Unpacking module can extract RAW data from bytestream and convert it to standard 8-bit or 16-bit format.

2.3 *Dark Frame Subtraction*

For many image sensors this is important operation mode. One can either subtract one value from each pixel of the image or subtract the whole image (dark frame). For CMOS image sensors that mode could be called FPN (Fixed Pattern Noise) subtraction.

2.4 *Flat Field Correction (Shading Correction)*

It's well known that image intensity is decreasing near the edges of image sensor. It happens due to differences in amount of light falling on each pixel. To take that into account one have to multiply pixel values to correction coefficients.

2.5 *RGB coefficients for RAW data*

Four coefficients cR, cG1, cG2 and cB are necessary to balance different RAW color channels before demosaicing. Usually bayer RAW image looks greenish, which is not good for further demosaicing. That simple image color balancing is widely used for color cameras.

2.6 *Raw Curve as 1D LUT transform*

Standard or custom 1D look-up tables (LUT) could be applied to each channel of RAW data before debayering. Master curve has the same form all three channels. There are also individual curves for each channel of Bayer pattern.

2.7 *Temporal Raw Denoiser (under development)*

There is an opportunity to suppress temporal noise for image series (not applicable to single image). That algorithm is based on correlation of adjacent frames to check motion detection and to remove temporal noise.

2.8 *Spatial Raw Denoiser together with Splitter and Merger*

It is possible to suppress spatial noise for each channel of Raw Bayer image before applying demosaicing. One can split Raw Bayer image into 4 planes according to Bayer pattern and then remove spatial noise for each plane separately. Finally we need to merge these planes to get an image with Bayer pattern. Parameters: Bayer pattern, wavelet name, threshold function, number of DWT resolution levels, array of denoising thresholds for each wavelet band.

2.9 *Median Filter*

Median filter can suppress impulse noise on images. GPU-based implementation of Median filter with window 3×3 is working very fast and efficient.

2.10 *HDR Builder*

HDR is.

2.11 *Demosaic (Debayer)*

Demosaicing is a transformation of a 8/16-bit Raw Bayer image into the conventional 24/48-bit RGB format. Demosaicing is required because digital cameras normally don't produce ready-to-go RGB images, instead they store visual information as a set of separate

R, B, and G values derived from the image sensor of the camera and the actual color of a pixel in that array is determined by interpolating nearby pixel colors. Demosaicing software does the following:

- Algorithms: Binning, HQLI, L7, DFPD, MG
- Converts 8/16-bit Raw Bayer images to 24/48-bit BMP/PPM
- Can do that really fast on NVIDIA GPU, much faster than on any CPU
- All Bayer mosaic patterns for input data are supported (RGGB, BGGR, GBRG, GRBG)
- High quality image demosaicing
- Significant moire suppression
- Immediate and precise time and performance measurements

2.12 *Color Surface Converter*

Color Surface Converter is intended to transform RGB data to separate planes of R, G and B. It also performs bit depth transform for the whole image.

2.13 *Spatial Denoiser for luma and chroma*

There is an opportunity to suppress luma and chroma spatial noise for each color image. One have to set algorithm type, threshold function, number of DWT resolution levels, and array of denoising thresholds for luma and chroma channels for each wavelet band.

2.14 *Color Correction*

That functionality is a must for color correction procedure. To get good color reproduction, we need to specify or calculate color correction matrix and apply it to the image.

2.15 *1D LUTs*

Standard or custom 1D look-up tables (LUT) could be utilized in the software. Gamma transform is also implemented via 1D LUT.

2.16 *3D LUTs for RGB and HSV*

Standard or custom 3D look-up tables (LUT) in .cube format could be utilized for color grading.

2.17 *Crop*

To cut an image with specified dimensions we utilize Crop function. We offer high performance implementation of Crop algorithm on GPU.

2.18 *Rotate*

To rotate or flip/flop an image with specified dimensions we utilize Rotate function. We offer high performance algorithm for real-time image rotation (90/180/270 degrees) and flip/flop on GPU. We've also implemented rotation to an arbitrary angle.

2.19 *Resize*

Quite often one has to show pictures with resolutions which are different from monitor or window resolution. Here comes a task of image resize. We offer high quality algorithm for real-time image resize on GPU (both downsampling and upsampling).

2.20 *Remap*

We offer remapping algorithm to perform the following actions: rotation to an arbitrary angle, undistortion, affine and perspective transforms, various projections, arbitrary image mapping on GPU.

2.21 *Sharp*

To enhance image quality we have implemented Sharp function. We offer very fast and high quality algorithm for real-time image sharpening on GPU.

2.22 *Histogram*

Various histograms could be calculated for 8/16-bit grayscale images and for 24-bit color images to evaluate distribution of grayscale/color component values of particular image. There is an option to get a histogram for each color channel of RAW or DNG data as well.

2.23 *Parade (Waveform monitor)*

Parade is a set of histograms for vertical rows of each RGB component of color image. This is useful representation of color image data to evaluate image quality, white balance and color distribution.

2.24 *OpenGL Output*

After GPU image processing one has to show a picture on the screen. As soon as all computations on GPU are done, then OpenGL is the fastest way to show the image on monitor because all data are already in GPU memory.

2.25 *CUDA Streams support*

CUDA Streams technology offers an opportunity to perform computations on GPU at the same time with data copy to or from GPU. This is the way to improve total performance due to overlap between copy and computations.

2.26 *JPEG Compression and Decompression*

This is CUDA implementation of JPEG Baseline algorithm for compression and decompression on NVIDIA GPUs according to JPEG Standard.

Key Features

- Implementation is 100% compliant with JPEG Baseline standard
- Baseline JPEG compression and decompression for grayscale (8-bit) and color (24-bit) images with arbitrary width and height
- Extremely fast lossy image encoding and decoding with variable compression ratio
- Chroma subsampling modes: $4:4:4$, $4:2:2$, $4:2:0$

- Minimum input image size: 1×1 for all chroma subsampling modes
- Maximum input image size is $16,000 \times 16,000$ or more (optional)
- JPEG image quality in the range from 1 to 100%
- Option to read/write any EXIF section
- Standard data input: 8/24-bit images from RAM/HDD/RAID/SSD/GPU
- Optional data input/output: 12/36-bit images from RAM/HDD/RAID/SSD/GPU
- Optional parameters: quantization tables
- Data output: final compressed/uncompressed image in RAM/HDD/RAID/SSD/GPU
- Continuous data mode (input one image after another)
- Standard set of computations for parallel implementation of Baseline JPEG compression and decompression
  - JPEG Encoding: Input data parsing, Color Transform, Level shift, 2D DCT, Quantization, Zig-zag, AC/DC, DPCM, RLE, Huffman, Byte stuffing, JFIF formatting
  - JPEG Decoding: JFIF parsing, Restart Marker search, Inverse Huffman, Inverse RLE, Inverse DPCM, AC/DC, Inverse Zig-zag, Inverse Quantization, IDCT, Inverse Level shift, Inverse Color Transform, Output formatting
- Optimized for the latest NVIDIA GPUs
- Compatible with Windows-7/8/10, Linux Ubuntu, OpenSUSE, CentOS, L4T

We have succeeded to make all stages of JPEG algorithm parallel including entropy encoding and decoding. There was a widespread opinion that Huffman algorithm could be only serial and that's why this is a bottleneck of JPEG performance. In our solution Huffman coding is not a bottleneck anymore because it's fully parallel and is performed on GPU. We don't off-load anything from GPU to CPU to make JPEG codec faster. CUDA JPEG codec is extremely fast and is functioning completely on GPU.

2.27 *JPEG2000 Encoder and Decoder*

This is CUDA-based implementation of JPEG2000 algorithm for image encoding and decoding according to JPEG2000 Standard.

Key Features

- Implementation is compliant with JPEG2000 standard

- JPEG2000 encoding and decoding for grayscale and color images with arbitrary width and height
- Lossy (CDF 9/7) and lossless (CDF 5/3) image compression and decompression
- Bit depth: 8–16 bits per channel (optionally up to 24 bits per channel)
- Color spaces: RGB, YCbCr, XYZ
- Number of DWT resolution levels: 1–12
- Code-block size 16×16, 32×32 or 64×64
- Subsampling $4:4:4$, $4:2:2$, $4:2:0$
- Image quality in the range of 1–100 (float value)
- Rate control option to set image compression ratio
- Support of tiling both for encoder and decoder
- Window mode for JPEG2000 decoder
- Data input: images from HDD/RAID/SSD/CPU/GPU
- Data output: final compressed or uncompressed image in HDD/RAID/SSD/CPU/GPU
- Modes of operation
  - Single image mode (minimum latency)
  - Batch mode (streaming processing with max throughput)
  - Multiple tile mode for big images
  - Other fast modes: massive parallelism with high performance and slightly less compression (option)
- CUDA Streams support to offer maximum performance
- Standard set of computations for JPEG2000 encoding and decoding on CUDA
  - **CUDA JPEG2000 Encoder**
    - Input data parsing
    - Color Transform (ICT/RCT)
    - 2D DWT with CDF 9/7 or 5/3
    - Quantization
    - EBCOT Tier-1 (Context modeler and Bit-plane MQ-Coder)
    - PCRD (Post Compression Rate Distortion)
    - Tier-2 (Tag Tree Coding)
    - Output formatting
  - **CUDA JPEG2000 Decoder**
    - Input parsing

    - Tag Tree Decoding
    - Binary Decoder
    - Inverse Quantization
    - EIDWT
    - Inverse Color Transform
    - Output formatting
- Performance is much better than CPU-based JPEG2000 codecs JasPer, JJ2000, OpenJPEG, Kakadu, etc.
- Performance is significantly higher than CUDA-based JPEG2000 encoders CUJ2K and GPU JPEG2K

Please note that last stages of JPEG2000 encoding (Tier-2 and output formatting) and decoding algorithms are carried out on CPU, that's why powerful GPU and CPU are necessary to get maximum performance for J2K encoding and decoding.

2.28 *RAW Bayer Codec*

Performance of image processing in camera applications could be much higher is we apply image compression for raw data without using Debayer. That approach is usually called Raw Bayer Compression. Right after image acquisition, we can create four planes according to colors of Bayer pattern (RGGB). Then we can do JPEG/JPEG2000 data compression for each plane with high quality. It could be done very fast and without introducing significant image artifacts. In this way, we can temporary exclude debayer from image processing pipeline and increase performance for realtime applications.

2.28.1 *Pipeline description for image acquisition stage*

- Image acquisition and unpacking of raw data
- Image preprocessing: dark frame (black offset) and FFC
- Decomposition and alignment of real bayer pattern to 4 separate color planes (Split)
- JPEG compression (quality > 90%), optionally JPEG2000 (CDF 5/3 or 9/7)
- Data storage to SSD/HDD/RAID

2.28.2 *Image processing and visualizing for compressed RAW*

- Bayer image decompression (JPEG decoding)
- Image composition with real bayer pattern from 4 color planes

- White balance
- Debayer
- Denoiser
- Color correction
- Crop/Rotate/Resize/Sharp
- LUT (gamma)
- OpenGL output
- Optional output MJPEG compression to AVI

3 Operation

3.1 *Software Requirements*

FASTVIDEO Image & Video Processing SDK is compatible with the following OS (64-bit):

- Windows 7 SP1
- Windows 8
- Windows 10
- Linux Ubuntu
- Linux OpenSUSE 12.3
- Linux SLC-7.5
- Linux CentOS
- Linux4Tegra

3.2 *Hardware Requirements*

FASTVIDEO Image & Video Processing SDK is compatible with NVIDIA GPUs with Compute Capability 3.0 and more. The most ol supported architecture is Kepler for GeForce family and Quadro/Tesla. We also support the following mobile Jetson GPUs: Nano, TK1, TX1, TX2, iTX2, NX and AGX Xavier (Linux4Tegra).

To work on laptop, one have to download CUDA, which is designed for laptop GPUs. While working, laptop should be connected to mains to offer maximum performance. If you try to work from internal battery of laptop, the performance will degrade.

3.3 *System Configuration*

3.3.1 *Minimum system configuration*

For a basic operation of FASTVIDEO SDK the following minimum system configuration is required. Please note that bandwidth and processing performance are tied to the hardware configuration and the minimum hardware configuration could lead to reduced bandwidth and limited performance.

- CPU: Intel Core-i3 or better
- RAM: 4 GB RAM or more

- HDD/SSD: 200 MB of free disc space
- Video: NVIDIA GPU with Compute Capability $\geq$ 3.0, GPU memory 2 GB or more
- Ports: Motherboard with PCIe $\times$16 Gen2 or Gen3 slot for GPU

One can also use **FASTVIDEO Image & Video Processing SDK** with a laptop which has NVIDIA GeForce GT series GPU with Compute Capability $\geq$ 3.0.

3.3.2 *Recommended standard system configuration*

For good processing performance and bandwidth we recommend to use the following system configuration.

- CPU: Intel Core-i7, 4770K or better
- RAM: 8 GB RAM or more
- HDD/SSD: 1000 MB of free disc space
- Video: NVIDIA GeForce 1080TI / 2080TI or Quadro 6000M / 6000, GPU memory 8-12 GB
- Ports: Motherboard with PCI-Express $\times$16 Gen3 slot for GPU

For maximum throughput in addition to top-level GPUs we recommend to use motherboards with PCI-Express $\times$16 Gen3 support and Intel IvyBridge CPUs to benefit from PCIe-3.0 technology.

To work with PCIE/Thunderbolt cameras or PCI-Express frame grabbers (which are custom for CameraLink, CoaxExpress and 10GigE high speed and high resolution cameras) we recommend to use motherboards with $>$ 40 PCIe lanes (chipset 2011 or better).

3.3.3 *Recommended professional system configuration*

- 1U / 2 $\times$ 2609v4 / 32 GB DDR4 ECC REG / 960 GB SSD Intel S4600 2.5”
- NVIDIA Tesla T4, GPU memory 16 GB

3.4 *Supported Image and Video Formats*

Standard image formats: BMP, PGM, PPM, YUV, YCbCr, JPG, J2K, JP2
Optional image formats: DNG, CinemaDNG, OpenGL texture or PBO, RAW
Video format for MJPEG codec: AVI
Video format for MJPEG2000 codec: MXF

3.5 *IP protection*

Demo version of SDK is protected with time limitation usage and with watermarks. We could also supply hardware dongles which allow to work without the above mentioned restrictions. Demo version has almost the same performance and one can utilize demo SDK to build your own demo application or integrate SDK into your software and test it in corresponding environment.

Apart from hardware dongles we also have other licensing options

3.6 *Technical Overview*

- C language API provides total control over image processing functions in SDK
- API in C/C++
- Thread-safety allows multi-threaded client applications
- Image data input/output provided by buffers offers maximum flexibility
- Both static and dynamic libraries are available
- Designed for CUDA-10 (64-bit)
- Compatible with the latest NVIDIA GPUs
- Available on multiple platforms including Win-7/8/10, Linux, L4T

3.7 *GPU Test for Windows*

To check available GPUs on PC, one could download freeware software TechPowerUp GPU-Z from the following link: https://www.techpowerup.com/gpuz/

GPU-Z is a lightweight utility designed to provide you with all information about your graphics card and GPU. You can also find out the info about PCI-Express connection to PC.

3.8 *Quick Start*

Download SDK, create a directory and unzip the Software Development Kit (SDK) into the directory.

Run sample applications without any parameters. This will display all parameters.

In sdkReadme.txt file you can find general info about the software.

In release_log.txt file you can see all changes that we've done.

3.9 *Installation*

1. Read the Standard License Agreement (SLA).
2. Download the latest drivers for your NVIDIA GPU from the following link: http://www.nvidia.com/Download/index.aspx
3. Download the latest Senselock dongle drivers here: http://senselock.ru/files/senselock_windows_2.52.1.0.rar
4. Start the installer. Be sure that you have administrator privileges or start the Installer with administrator rights (right click and select "Run as Administrator").
5. Unzip **FASTVIDEO Image & Video Processing SDK**

4 Programming components

This is brief list of components from **FASTVIDEO Image & Video Processing SDK** :

- ImportAdapter and ExportAdapter
- Raw data unpacking
- Serial Digital Interface (SDI) importer/exporter
- Image Preprocessing (dark frame subtraction, vignetting removal, etc.)
- Raw per-channel coefficients for RGGB
- Raw Tone Curve (master and per-channel)
- Raw Bayer Splitter and Merger
- Raw Bayer Codec
- Median filter
- Binning filter
- Flat-field correction
- Spatial Raw Denoiser
- Debayer (Binning, HQLI, L7, DFPD and MG algorithms)
- Spatial Denoiser for luma and chroma
- Color Surface Converter (RGB to R, G, B; bit depth converter)
- RGB to Gray
- Color Transforms (RGB, HSV, YCbCr)
- Color Correction with matrix profile
- 1D LUT and Gamma
- 3D LUT for HSV and RGB
- Affine Transforms (Rotate, Flip, Flop)
- Crop
- Resize
- HDR Builder
- Remap (rotation to arbitrary angle, perspective transforms, undistortion, etc.)
- Sharp
- Histogram
- Parade (Waveform monitor)
- OpenGL output
- JPEG Encoder/Decoder, MJPEG Reader/Writer
- JPEG2000 Encoder/Decoder, MXF Reader/Writer

- H.264/H.265 Encoder/Decoder
- CUDA Streams support
- Trace
- Time, performance and quality measurements
- Multiplexor
- Sample applications with source codes

All functions and types are declared in fastvideo_sdk.h

4.1 *Library of components*

There are multiple libraries in that SDK. FASTVIDEO SDK is a primary library of SDK. Other libraries of components are the secondary libraries. Each secondary library contains optional, experimental or wrapper components. Wrapper component wraps some external library to use it together with FASTVIDEO components.

Primary library has to be initialized first. After that any secondary library can be initialized. Primary library contains global options that affects some functionality of all components. Global options have to be passed to the secondary library to allow primary library control and to manage secondary library.

Primary library of SDK is initialized by `fastInit` function call. It takes affinity mask of GPU devices and attach CUDA context to defined GPU. If SDK will be used with OpenGL, integration `openGlMode` flag in `fastInit` has to be `true`. In this case SDK calls `cudaGLSetGLDevice` to initialize device instead of `cudaSetDevice`. In all other cases `openGlMode` flag has to be `false`.

For the current version of SDK `openGlMode` flag is depricated and will be deleted soon. In general `fastInit` call can be replaced by `cudaSetDevice` without any consequences. Or alternatively `fastInit` should be called first and then call `cudaSetDevice` to assign new GPU.

After primary library initialization, function `fastGetSdkParametersHandle` has to be called to get handle of global options. Any secondary library has to be initialized by this handle. Initialization function of any secondary library has format `fastlibrary_nameLibraryInit`, where `library_name` is the name of the library. Initialization function takes handles for global options as parameters.

In case if user application does not use secondary library, it is not necessary to call `fastGetSdkParametersHandle` function.

4.2 *Pipeline*

In computing, a pipeline is a set of data processing elements connected sequentially, where an output of one element is the input for the next one. FASTVIDEO SDK uses pipeline paradigm for data processing. Actually, SDK is a set of data processing components. Each component in general has one input and one output. Input of one component has to be connected to output of another component.

Every pipeline has the first component, several central components and the last component. Each central component has input and output. The first component has only output. The last component has only input.

Link between the components is aggregated by `fastDeviceSurfaceBufferHandle_t` structure or Link Buffer. In general, `fastDeviceSurfaceBufferHandle_t` is a buffer together with some additional service information. Its details are hidden from user. The buffer is always allocated by the previous component and is used by the next component.

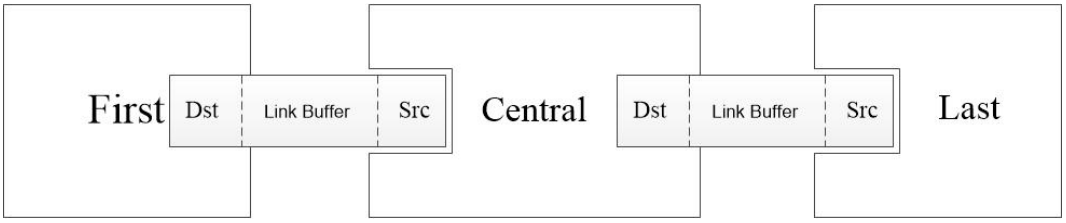

Fig. 1. Pipeline diagram

There are three stages of life cycle of every component: creation, processing, destroying. Every component has three general methods for corresponding live cycle stages. Method with suffix "Create" corresponds to creation stage. Method with suffix "Destroy" corresponds to destroying stage. Method with suffix "Transform" corresponds to processing stage for most components, but for some components processing methods have another names that more accurately define the essence of component's operation (e.g. Encode, Decode, Copy, etc.).

On creation stage all necessary components are instantiated and linked to each other. Every central component has two parameters in `Create` method:
`fastDeviceSurfaceBufferHandle_t srcBuffer`,
`fastDeviceSurfaceBufferHandle_t *dstBuffer`.

`dstBuffer` is a pointer to output buffer for the current component. `srcBuffer` is an output buffer of the previous component. So the First component has only `dstBuffer`

and Last component has only `srcBuffer`. Components of the pipeline are instantiated in the order from the First to the Last. For component creation it's necessary that source buffer already has been instantiated. So when none of components exists, only the First component can be created.

Main functionality of the First component is to prepare data from an external source and to import it to the pipeline. Main functionality of the Last component is to export data from the pipeline to external destination. In general, external source and destination could be both GPU and CPU buffers. Components that import from CPU (Host) and GPU (Device) buffer data to pipeline are `ImportFromHost` and `ImportFromDevice`, respectively. Components that export data from pipeline to Host and Device buffer are `ExportToHost` and `ExportToDevice`, respectively. External source and destination buffers can have quite complicated format (e.g. JPEG). So `JpegDecoder` is the First component of the pipeline and `JpegEncoder` is the Last component of the pipeline.

As soon as the pipeline is created, it is ready to process the data. Any pipeline is intended to process not just one, but many images. Array of images should be organized by user application and they could be processed in a loop. Processing method of every stage of the pipeline has to be called sequentially to process every image. Processing method takes data from the input buffer, processes it and copies to the output buffer, so processing method of the next component can be called.

During creation, every component of a pipeline takes maximum size of processing image. Accordingly, all internal buffers are allocated according to max size of the image. Setting up maximum image size is the task for user application. Any pipeline can process images with sizes less than maximum at each dimension. Processing method returns `FAST_INVALID_SIZE` if image size is greater than maximum value.

As soon as data processing is finished, the pipeline should be destroyed. Each component is destroyed by calling `Destroy` method. It doesn't matter in which order you are going to destroy the components.

Some central components of the pipeline are containers for multiple subcomponents or methods. For example, Image Filter component is a container for a set of image filters. Container provides common interface for subcomponents with individual parameters.

4.3 *Programming interface*

Fastvideo SDK has C-like API. It consists of POD (Plain Old Data) structures and functions. It has simple interface to support multiple platform and compilers.

Let us discuss important question how to initialize API structure. Structure contains multiple fields. Default value in Fastvideo SDK API for field is zero. Zero value means to disable optional feature or to use default component options. Fastvideo SDK is a dynamically developing product. Sometimes new fields are added to an existing structure. New field has to be initialized by zero automatically without additional code changes. Therefore, we suggest using the following code for structure initialization in C++ compiler:

```
struct C {
  int x;
  int y;
};

C c = {0}; // zero initialize POD
C c = C; // use the default constructor.
C* c = new C; // use the default constructor.
```

Use memset for C file or compilers :

```
C c;
memset(&c, 0, sizeof (C));
```

The next important question is how to assign a value to a certain field of a structure. We insist that value to the field has to be assigned explicitly. Do not use implicit initialization like

```
C c = {2, 3};
```

Please use

```
c.x = 2;
c.y = 3;
```

Sometimes we change field semantics or field order in a structure. In the case of explicit assignment by field name, this could result in error during compilation. Developer has to take care to investigate and to apply necessary changes.

4.4 *Import and Export Adapters*

There is no way to offer direct feed for central component of pipeline by user data. In order to import user data to the pipeline, we need to run Import Adapter. To export data from the pipeline to user application, we need Export Adapter. That's why the shortest pipeline contains at least three components: Import Adapter, Central Component (e.g. Debayer), and Export Adapter.

`ImportFromHost`, `ExportToHost` adapters allow to communicate with any pipeline through CPU (Host) buffer. It is a common case for most of applications. Host buffer should be allocated by `fastMalloc`. If the buffer is allocated by original `malloc`, then it also can be used, but in that case the performance of copy will degrade.

Function `fastMalloc` calls `cudaMallocHost` to allocate page-locked memory in CUDA context.

Some info concerning `cudaMallocHost` from CUDA documentation: the driver tracks the virtual memory ranges allocated with this function and automatically accelerates calls to functions such as `cudaMemcpy*()`. Since the memory can be accessed directly by the device, it can be read or written with much higher bandwidth than pageable memory obtained with functions such as `malloc()`.

To lock in CUDA context already allocated host buffer user application should call `cudaHostRegister`. Function `cudaHostRegister` page-locks the memory range specified by ptr and size and maps it for the device(s) as specified by flags. This memory range also is added to the same tracking mechanism as `cudaHostAlloc()`. The pointer ptr and size must be aligned to the host page size (4 KB).

OS specific page lock functions (like `VirtualLock` in Windows) don't work the same as `cudaHostRegister`. OS specific page lock functions lock memory for system, but CUDA context knows nothing about this memory. So that memory cannot be accessed directly by the device because device knows nothing about it.

`ImportFromDevice`, `ExportToDevice` adapters are used in the case when user application has its own GPU kernels. And it is necessary to communicate between user kernels and SDK components. Device Adapters also allow to insert user-specific kernels in a pipeline. Device buffer has to be allocated by `cudaMalloc`.

Import and Export Adapters make some image transforms. Pipeline supports only RGB format of color pixel. To process color image with BGR pixel format, Import Adapter transforms it to RGB. Export Adapter allows to transform internal RGB format to BGR.

Format of external buffer is shown on Fig.2.

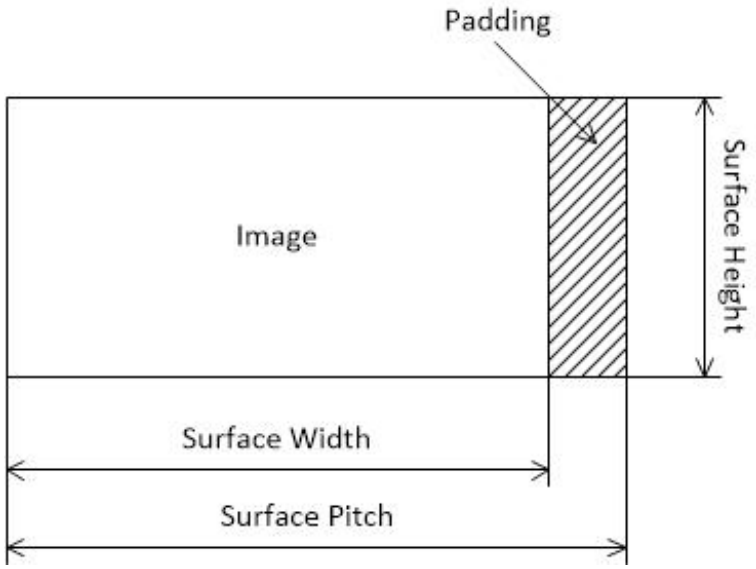

Fig. 2. Surface buffer

Pitch means the size of image row in Bytes. It is possible to have padding after row pixels. To get good performance, it is necessary that every image row has to be aligned on 4-bytes boundary. This is important for both Host and Device buffers. If user application uses bigger alignments (e.g. 8, 16, 32 or more) it will not influence on performance.

4.5 *Pipeline Surface Format*

There are several surface types supported in FASTVIDEO SDK: FAST_I8, FAST_RGB8, FAST_I10, FAST_I12, FAST_RGB12, FAST_I14, FAST_I16, FAST_RGB16, FAST_BGR8, FAST_BGRX8. Surface FAST_I is a grayscale or Bayer filtered image, surface FAST_RGB is a color image with components order as $R_0G_0B_0$ $R_1G_1B_1$ $R_2G_2B_2$ etc. The number in a surface format name means bits per channel.

The following table describes all supported formats in terms of number of channels, bits per channel, max channel values, Bytes per channel.

Surface Type	**Number of Channels**	**Bits per channel**	**Max Channel Value**	**Bytes per channel**
FAST_I8	1	8	255	1
FAST_RGB8	3	8	255	1
FAST_I10	1	10	4095	2
FAST_I12	1	12	4095	2
FAST_RGB12	3	12	4095	2
FAST_I14	1	14	65535	2
FAST_I16	1	16	65535	2
FAST_RGB16	3	16	65535	2

Bytes per pixels = {Bytes per channel} × {Number of Channels}

Surface format FAST_BGR8 is supported by SDK but it is converted by importer or exporter (ImportFrom or ExportTo) to FAST_RGB8.

Surface format FAST_BGRX8 is supported by SDK but it is converted by importer or exporter (ImportFrom or ExportTo) to FAST_RGB8. Alpha channel of FAST_BGRX8 is lost during import and populated by zero during export.

Surface formats FAST_CrCbY8, FAST_YCbCr8 are defined but have not supported yet.

Surface FAST_I10, FAST_I14 are aliases for FAST_I12, FAST_I16 respectively. Only few components support these formats. Main role of these surfaces is to import raw 10- and 14 bits-per-channel images to pipeline and to perfrom conversion automatically.

Pipeline surface format is initiated by the First component (ImportFrom* or JpegDecoder) which has surface format as input parameter. Every Central component gets surface format from the previous component through Link Buffer. Some components remain surface format unchanged and other components have different output surface formats. So output surface format of the pipeline may differ from initial one. Last components ExportTo* have output surface format as output parameter in Create method. It allows

to know the type of the surface and to allocate appropriate buffer.

8-bit surfaces are supported by all components in the current version of SDK. 12/16-bit surfaces are supported by a few components. So general approach for 12/16-bit surfaces is the following:

1. At the beginning of the pipeline, 12/16-bit components could be used.
2. If the next component supports only 8-bit surfaces, then LUT component should be used to transform 12/16-bit data to 8-bit format.
3. At the end of the pipeline 8-bit components should be used.

If the component doesn't support input surface, then its Create method returns `FAST_UNSUPPORTED_FORMAT`.

Table below lists all components and subcomponents with supported types

Component/subcomponent	**Input surface formats**	
	Grayscale	**Color**
Affine	8, 12, 16	8, 12, 16
Bayer Splitter	8, 12, 16	
Bayer Merger	8, 12, 16	
Crop	8, 10, 12, 14, 16	8, 12, 16
Debayer HQLI	8, 12, 16	
Debayer L7	8, 12, 16	
Debayer Binning	8, 16	
Debayer DFPD	8, 12, 16	
Debayer MG	12, 16	
Image Filter: Base Color Correction	8, 12, 16	8, 12, 16

Continued from previous page

Component/subcomponent	**Input surface formats**	
	Grayscale	**Color**
Image Filter: Bayer black shift	12, 16	
Image Filter: Binning filter	12, 16	
Image Filter: Flat-field correction	12, 16	
Image Filter: Color Saturation {HSL, HSV}		8, 12, 16
Image Filter: Gaussian sharpen	8	8
Image Filter: LUT_8_{8,12,16}	8	8
Image Filter: LUT_8_{8,12,16}_C		8
Image Filter: LUT_12_{8,12,16}	12	12
Image Filter: LUT_12_{8,12,16}_C		12
Image Filter: LUT_16_{8,16}	16	16
Image Filter: LUT_16_16_FR	16	16
Image Filter: LUT_16_{8,16}_C		16
Image Filter: LUT_16_16_FR_C		16
Image Filter: LUT_8_16_BAYER	8	
Image Filter: LUT_10_16_BAYER	10	
Image Filter: LUT_12_16_BAYER	12	

Continued from previous page

Component/subcomponent	**Input surface formats**	
	Grayscale	**Color**
Image Filter: LUT_14_16_BAYER	14	
Image Filter: LUT_16_16_BAYER	16	
Image Filter: LUT_16_16_FR_BAYER	16	
Image Filter: LUT RGB 3D		12, 16
Image Filter: LUT HSV 3D		12, 16
Image Filter: MAD	8, 10, 12, 14, 16	
Image Filter: MAD16	10, 12, 14, 16	
Image Filter: Median Filter	12, 16	12, 16
Image Filter: White Balance	8, 12, 16	
Image Filter: Tone Curve		16
JPEG Encoder	8, 12	8, 12
JPEG Decoder	8	8
Resizer	8, 12, 16	8, 12, 16
Surface Converter: BIT_DEPTH	8, 10, 12, 14, 16	8, 12, 16
Surface Converter: SELECT_CHANNEL		8, 12, 16
Surface Converter: RGB_TO_GRAYSCALE		8, 12, 16

Continued from previous page

Component/subcomponent	**Input surface formats**	
	Grayscale	**Color**
Surface Converter: GRAYSCALE_TO_GRAYSCALERGB	8, 12, 16	
Surface Converter: GRAYSCALE_TO_RGB	12, 16	
Surface Converter: BAYER_TO_RGB	8	

That table lists all components and subcomponents that transform pipeline surface types

Component/subcomponent	**Transformation**	
	Color	**Bits**
Debayer	I → RGB	
Image Filter: {LUT_8_12, LUT_8_12_C}		8 → 12
Image Filter: {LUT_8_16, LUT_8_16_C}		8 → 16
Image Filter: {LUT_12_8, LUT_12_8_C}		12 → 8
Image Filter: {LUT_12_16, LUT_12_16_C}		12 → 16
Image Filter: {LUT_16_8, LUT_16_8_C}		16 → 8
Image Filter: LUT_{8,10,12,14}_16		8, 10, 12, 14 → 16
SurfaceConverter: BIT_DEPTH		8, 10, 12, 14, 16 → 8, 12, 16

Continued from previous page

Component/subcomponent	Transformation	
	Color	**Bits**
Surface Converter: SELECT_CHANNEL	RGB → I	
Surface Converter: RGB_TO_GRAYSCALE	RGB → I	
Surface Converter: GRAYSCALE_TO_GRAYSCALERGB	I → RGB	
Surface Converter: GRAYSCALE_TO_RGB	I → RGB	
Surface Converter: BAYER_TO_RGB	I → RGB	

4.6 *Pipeline Split and Merge*

In terms of SDK pipeline, split is a case when two or more components use the same buffer as an input. That operation allows to split data processing for multiple path. For example split can be used for debug purposes. Export to Host component could be attached to output buffer of debugging component together with the next central component.

Central component at any pipeline does not modify input buffer. But there are some output components which change input buffer: JPEG Encoder and Debayer. If after splitting one of components is changing its input buffer, then this transform method should be called last.

Sometimes it is necessary to bypass a certain component in the pipeline. In this case, multiplexer (Mux) component should be used. Mux selects one of its inputs and passes data to output. Transform method of Mux takes number of inputs that will be passed to output.

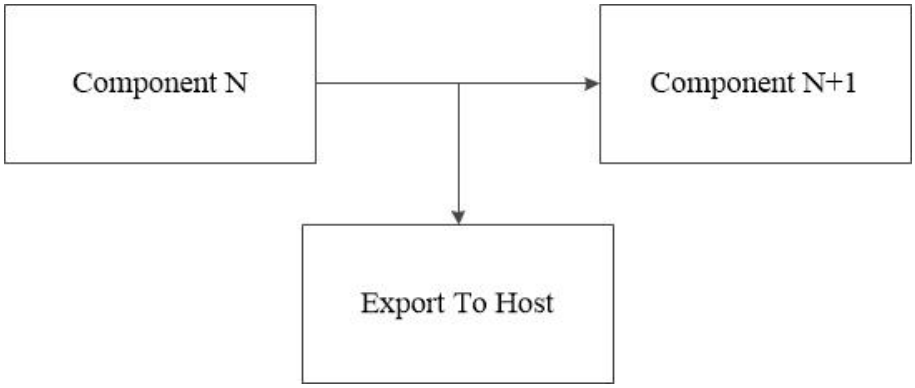

Fig. 3. Debug Pipeline

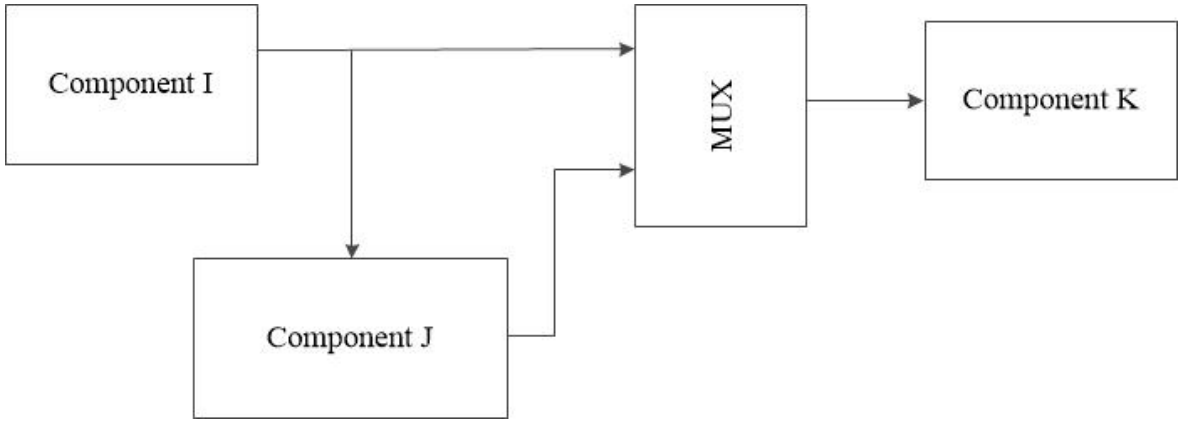

Fig. 4. Bypass Pipeline

4.7 *Component recreation*

Sometimes we need to recreate a component in the existing pipeline. Functions ChangeSrcBuffer allows to avoid whole pipeline recreation in this case. ChangeSrcBuffer function sets new source buffer for the component. So to insert a new component instead of existing component in a pipeline, destination buffer of created component has to be set as a source for the next component through ChangeSrcBuffer function.

4.8 *Threads, Streams and Performance*

SDK is compiled with CUDA option "–default-stream per-thread". It means that every CPU thread has its own CUDA stream. SDK does not use CUDA default stream. So SDK pipeline has no influence on CUDA kernel in either default or custom stream. If user kernel has started without stream specification in the same thread, it will share the stream with SDK kernels.

Individual stream for each thread gives an ability to run multiple pipelines concurrently. In general, each pipeline has import, computation, and export components. Concurrent execution of pipelines allows to overlap computations from one pipeline with data transfer from another pipeline.

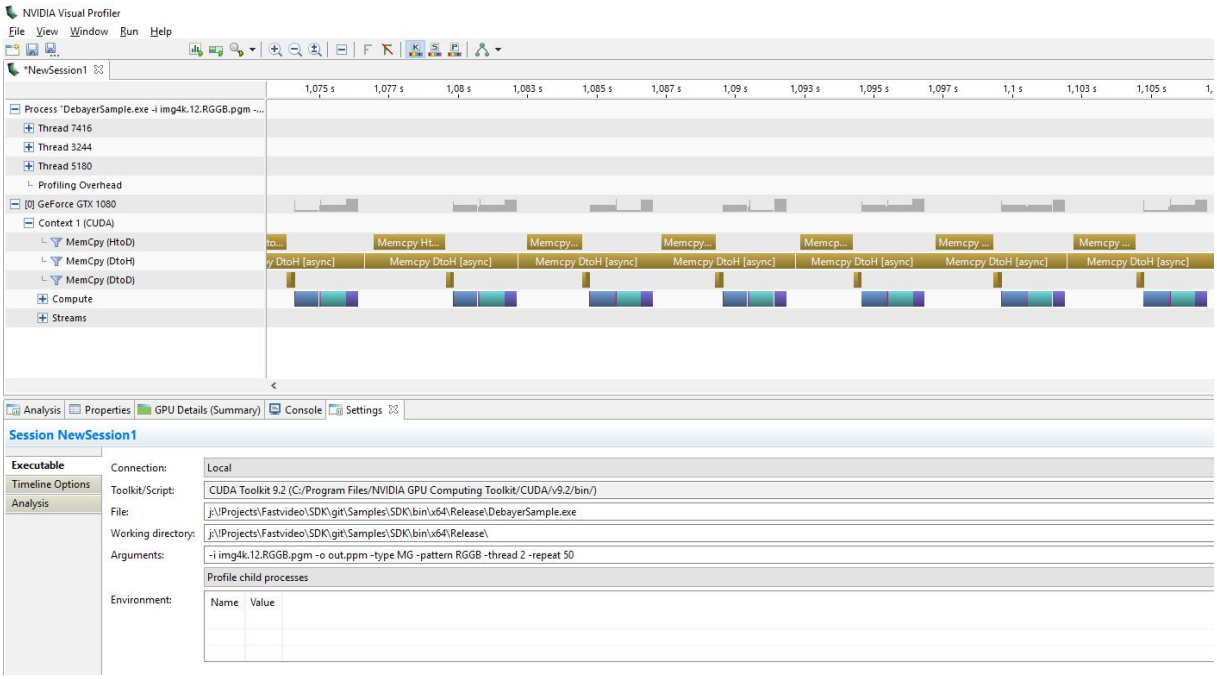

Fig. 5. Overlapping device-to-host, host-to-device transfers and computation

Concurrent pipelines also increase GPU utilization by decreasing a time when GPU is idle. GPU that has two copy engines (some high range GeForce, Titan, Tesla and Quadro) can overlap host-to-device transfer and device-to-host transfer from concurrent pipelines. Kernels with small amount of workloads can be overlapped also. Figure 5 is a screenshot from NVIDIA Visual Profiler which shows overlap for device-to-host, host-to-device transfers and computation. That GPU has two copy engines.

Concurrent pipelines increase overall system performance but also increase latency. If you need to get pipeline result as quickly as possible, then concurrent pipelines and multi threading are not suitable.

Also concurrent pipelines are increasing device memory usage. Each pipeline has its own data set. So four pipelines use almost four times more memory than just one. But some service information is shared between pipelines. So four separate processes with one pipeline consume even more device memory.

In most cases the best choice is two concurrent pipelines. This is the way to overlap

device-to-host and host-to-device transfers together with computations, and get significant performance boost. More concurrent pipelines (3 or greater) on the same GPU can be even better in the case when we need to process small images (Full HD resolution or less).

4.9 *Multi GPU*

SDK can be used in a multi GPU system. That case intended for hardware setups with multiple GPUs and user has to manually adjust workload between GPUs.

SLI interconnection does not offer any benefits.

Default scenario for Multi GPU system is to create a separate pipeline for each GPU. User need to create CPU thread for each GPU and then call cudaSetDevice to assign GPU for each CPU thread. After that, user can create pipelines individually for each GPU.

4.10 *Debayer*

Debayer module restores image colors from Bayer filtered source image according to the pattern. There are 4 supported patterns – RGGB, BGGR, GRBG and GBRG; where R stands for red, G – green, B – blue. Enum `fastBayerPattern_t` contains all supported patterns.

At the moment there are five implemented Debayer algorithms (types): Binning, HQLI, L7, DFPD and MG. These algorithms are enumerated in `fastDebayerType_t`. List of debayer ordered by quality (first is the best): MG, DFPD, L7, HQLI. This is the list of debayers ordered by performance (the first is the best): HQLI, L7, DFPD, MG.

HQLI debayer algorithm is working with window 5×5, L7 – 7×7, DFPD – 11×11, MG – 23×23.

Debayer supports 8/12/16-bit formats (MG supports 12/16 only). All debayers support only image with even width. User has to crop odd width by 1 pixel.

Binning debayer restores color by calculating average value of Bayer pattern. Therefore it reduces the size of image by binning factor. There are three supported binning factors: 2, 4, 8. If binning factor is equal to 2, then red and blue colors of pixel are taken from red and blue colors of Bayer pattern respectively and green color of the pixel is an average of two green values of Bayer pattern. If binning factor equals 4, then four neighboring Bayer patterns are taken for averaging and so on.

Debayer module changes pipeline surface format. Initial surface format is `FAST_I{8,12,16}` before Debayer, and after Debayer format becomes `FAST_RGB{8,12,16}` respectively. Debayer changes format from gray to color, and after debayering we finally

get three color components (RGB) per pixel instead of one (Gray). At the same time, number of bits per each color component is not changed. For example, if input format has 16 bits per color component, then output format will have 16 bits per each color component of the pixel as well.

The function `fastDebayerCreate` creates Debayer component. Input parameters for this function are the following: maximum image size and name (type) of Debayer algorithm. Instance of Debayer component is associated with a handle which returns `fastDebayerCreate` function. Function `fastDebayerCreate` also allocates all necessary buffers in GPU memory. In case GPU does not have enough free memory, `fastDebayerCreate` returns `FAST_INSUFFICIENT_DEVICE_MEMORY` status. Customer application has to detect and to process that status correctly. Enum `fastStatus_t` contains all statuses.

Function `fastDebayerTransform` performs debayering according to initial parameters. That function takes image size and bayer pattern as parameters.

4.11 *Spatial Denoiser*

Spatial Denoiser module is based on Discrete Wavelet Transform (DWT) and removes spatial noise from images according to specified parameters: wavelet name, thresholding function, number of DWT resolution levels, array of threshold values, etc. Denoise supports grayscale and color images. Also it supports separated planes of Bayer filtered image.

For color images, Spatial Denoiser converts data to YCbCr and performs denoising for these components separately. We recommend to apply the same parameters both to Cb and Cr components to avoid false colors after denoising.

At the moment there are two implemented wavelets for Spatial Denoiser: `CDF53` and `CDF97`. These wavelets are enumerated in `fastWaveletType_t`. They have comparable quality, but `CDF53` shows better performance.

Thresholding function could be `Hard`, `Soft` or `Garrote`. These functions correspond to different algorithms of threshold approximation.

Spatial Denoiser supports the following surfaces: `FAST_RGB8`, `FAST_I8`, `FAST_RGB12`, `FAST_I12`, `FAST_RGB16`, `FAST_I16`.

Function `fastDenoiserCreate` creates Spatial Denoiser component. Input parameters for this function are the following: maximum image size and static parameters. Instance of Spatial Denoiser component is associated with a handle which returns

`fastDenoiserCreate` function.

Static parameters for denoiser are incapsulated by `denoise_static_parameters_t` struct. It contains wavelet name and type of threshold function. Types of threshold function are enumerated in `fastDenoiseThresholdFunctionType_t`.

Function `fastDenoiserTransform` performs spatial denoising according to initial static and current dynamic parameters. Dynamic parameters for denoiser are the following:

- dwt_levels – number of DWT transforms (maximum is 11)
- enhance[3] – gain coefficients for each channel of YCbCr. Applied after threshold function to wavelet coefficient.
- threshold[3] – basic threshold for Y, Cb and Cr channels respectively.
- threshold_per_level[33] – individual relative thresholds for each wavelet band. The first three values in the array correspond to values of Y, Cb and Cr of the first band. Resulting threshold for each wavelet band of channel is multiplication of threshold by respective threshold_per_level.

Resulting threshold is applied to wavelet coefficient through threshold function multipliers for threshold_per_level for Y, Cb and Cr. Total threshold is equal to the result of

$$\text{threshold\_per\_level} \times \text{threshold}$$

for each band and each color channel.

The `fastDenoiserTransformBayerPlanes` processes distinct color planes of Bayer filtered image prepared by Bayer Splitter component. It filters each planes separately. Resulted planes have to be merged to one color image by Bayer Merger component. Calling the function for normal grayscale image will cause image destruction. So the only way of using denoise component with the function is as part of pipeline, where preceding component is Bayer Splitter and the following component is Bayer Merger component.

4.12 *JPEG Load and Store functions*

SDK includes set of functions to load and store JPEG files. These are six functions for load and two functions for store:

- `fastJfifLoadFromFile`,
- `fastJfifHeaderLoadFromFile`,
- `fastJfifBytestreamLoadFromFile`,

- `fastJfifLoadFromMemory`,
- `fastJfifHeaderLoadFromMemory`,
- `fastJfifBytestreamLoadFromMemory`,
- `fastJfifStoreToFile`,
- `fastJfifStoreToMemory`.

These functions are not a pipeline components because they work on CPU only. You can find them in \common\helper_jpeg\folder.

Load functions parse JPEG file and save data to `fastJfifInfo_t` struct the following JPEG entities:

- image width and height
- restart interval
- quantization tables
- Huffman tables
- EXIF sections
- Huffman bytestream

Functions `fastJpegHeaderLoad*` allow decode only header to populate `fastJfifInfo_t`. For example, to get JPEG file width and hight. `Functions fastJpegBytestreamLoad*` extract Huffman bytestream to `fastJfifInfo_t`.

Load functions can parse only JPEG files supported by SDK JPEG Decoder. If format of JPEG file is not supported (for example, 12-bit JPEG, JPEG with arithmetic coding or progressive JPEG), then function returns `FAST_UNSUPPORTED_FORMAT`. If any error occurs during file parsing, then function returns `FAST_INVALID_FORMAT` and puts error description to stderr.

There are two storages for Load/Store functions: file or memory buffer. Memory buffer as a storage is useful for applications that send/receive JPEG images via network.

Memory buffers for `fastJfifLoadFromMemory` and `fastJfifStoreToMemory` are allocated by original C `malloc`.

Please note that buffer for Huffman bytestream in `fastJfifInfo_t` has to be allocated by user application with `fastMalloc`. Size of allocated buffer is set to `bytestreamSize` in `fastJfifInfo_t`. If size of `h_Bytestream` is smaller than size of bytestream of loaded image, then the function returns `FAST_INVALID_SIZE`.

Store functions serialize `fastJfifInfo_t struct` to file or memory buffer.

There are two JPEG file formats: JFIF and EXIF. EXIF format allows to store camera meta data, copyright, author information and other.

Load and Store functions can read and write EXIF sections. In general, JPEG file can include multiple EXIF sections, so in `fastJfifInfo_t` there is a pointer to EXIF section array `exifSections`. Count element in array is stored in `exifSectionsCount`. Struct `fastJpegExifSection_t` contains EXIF section code, buffer for EXIF data that starts with EXIF section code and size of EXIF data.

Load functions allocate all buffers for EXIF sections. So after EXIF sections no longer need, then user application has to free all EXIF section buffers by `free`. In other case memory will leak.

Load/store functions work with entire section. To extract tag we propose to use an existing library, for example libexif. Example of using libexif with SDK load/store functions you can find in JpegSample and BayerCompressionSample.

Allocated `fastJfifInfo_t` for JPEG encoder has to be initialized by `exifSectionsCount = 0` and `exifSections = NULL`.

4.13 *JPEG Encoder/Decoder*

JPEG Encoder compresses grayscale and color images into JPG format with different options. Current GPU JPEG Encoder supports images with 8 and 12 bits-per-channel. GPU JPEG Decoder supports only 8 bits-per-channel images. JPEG CPU Decoder component is a temporary solution for decoding of images with 12 bits-per-channel. This component is a wrapper around open source libjpeg-turbo library.

It is important to note that there are no additional parameters to enable 12-bit encoder. The same encoder component and interface functions are used for both 8-bit and 12-bit encoders. Encoder type is selected automatically by bit depth of input surface.

JPEG Encoder supports three color subsampling formats: JPEG_444, JPEG_422, and JPEG_420. The ratios at which the chroma subsampling are usually done for JPEG images are 4 : 4 : 4 (no chroma downsampling), 4 : 2 : 2 (reduction by a factor of 2 in the horizontal direction for components Cb and Cr), or (most commonly) 4 : 2 : 0 (chroma reduction by a factor of 2 in both horizontal and vertical directions). Enum `fastJpegSubsamplingFormat_t` contains all supported subsampling formats.

To compress grayscale image, subsampling format has to be `JPEG_Y`. Also there is an option to compress grayscale image as color. In this case JPEG encoder duplicates gray channel to all color channels. To enable this feature, input image should be gray and subsampling format should be `JPEG_420`.

Quality parameter adjusts output JPEG file size and image quality. Quality is an

integer value from 1 to 100, where 100 means the best quality and maximum image size. Recommended value for JPEG Quality is 90 (this is so called "visually lossless compression").

Restart Interval is an integer number of MCUs (Minimum Coded Unit) processed as an independent sequence within a scan. Current JPEG Encoder has fixed restart interval for each subsampling mode. For subsampling $4:2:0$ restart interval is 5, subsampling $4:2:2$ has restart interval 8, subsampling $4:4:4$ has restart interval 10, for grayscale images this is 32. Please note that Restart Interval = 5 means one restart marker after each five MCUs. These restart intervals are optimal to achieve best JPEG Encoder performance.

If any error occurs during procedure calls, it returns status not equal to `JPEG_OK` and which will appear in `stderr` description of error.

JPEG Encoder is the Last component in terms of SDK pipeline. Its output is structure `fastJfifInfo_t` that resides in CPU memory.

Function `fastJpegEncoderCreate` creates JPEG Encoder. It takes maximum image size. Instance of created JPEG encoder is associated with a handle which returns `fastJpegEncoderCreate` function. Function `fastJpegEncoderCreate` also allocates all necessary buffers in GPU memory. So in case when GPU does not have enough free memory, `fastJpegEncoderCreate` returns status `FAST_INSUFFICIENT_DEVICE_MEMORY`.

Function `fastJpegEncode` compresses images taken from previous component of the pipeline with defined quality and populates `fastJfifInfo_t` with JPEG bytestream and JPEG tables. Buffer for JPEG bytestream in `fastJfifInfo_t` has to be allocated before call. Its recommended size is *surfaceHeight*surfacePitch4*. Real JPEG bytestream size is calculated during compression and put to `bytestreamSize` in `fastJfifInfo_t`. If size of `h_Bytestream` is not enough, procedure returns status `FAST_INTERNAL_ERROR`.

Function `fastJpegEncodeAsync` acts the same as `fastJpegEncode` but stores compressed bytestream to device memory. It takes `fastJfifInfoAsync_t` instead of `fastJfifInfo_t` as a parameter. Structure `fastJfifInfoAsync_t` is the same as `fastJfifInfo_t` except `d_Bytestream` that points to device memory. Important that `d_Bytestream` is not allocated by user. It points to internal buffer in JPEG Encoder. So data from `d_Bytestream` should be coped from before next `fastJpegEncodeAsync` call. To store bytestream to file user should copy all `fastJfifInfoAsync_t` fields to `fastJfifInfo_t`. Also it has to copy data from device to host by standard CUDA copy functions (see JpegAsyncSample).

JPEG Decoder is the First component in terms of SDK pipeline. Its input is struct

`fastJfifInfo_t` that resides in CPU memory.

Function `fastJpegDecoderCreate` creates JPEG Decoder. It takes maximum image size and output surface format as parameters (`FAST_I8` or `FAST_RGB8`). Instance of created JPEG Decoder is associated with a handle which returns `fastJpegDecoderCreate` function. Function `fastJpegDecoderCreate` also allocates all necessary buffers in GPU memory. So in case when GPU does not have enough free memory `fastJpegDecoderCreate` returns status `FAST_INSUFFICIENT_DEVICE_MEMORY`.

Function `fastJpegDecode` uncompresses image from `fastJfifInfo_t` taken from previous JPEG Load function.

Restart Interval has great impact on decoding performance. Optimal restart interval for decoder is 1 (one restart marker after each MCU). So even jpg images from FASTVIDEO JPEG Encoder don't have enough markers to get maximum performance. If jpg image does not contain any markers or if restart interval is greater than 255, then CPU version of Huffman decoder will be used.

Utility jpegtran can change a number of restart markers in existing jpg image. Jpegtran is a part of libjpeg library.

The first step: we need to clear up the image from existing restart markers

```
jpegtran.exe -copy none image\_src.jpg image\_dest.jpg
```

At the end we get the image without restart markers.

The second step: we need to insert necessary amount of restart markers

```
jpegtran.exe -restart 1B image.jpg image\_new.jpg
```

At the end we get the new image with 1 restart marker after each block (MCU).

4.14 *JPEG CPU Decoder*

JPEG CPU Decoder component is a temporary solution for decoding of 12 bits-per-channel images. This component is a wrapper around open source libjpeg-turbo library that is compiled with `BITS_IN_JSAMPLE = 12`. That's why that CPU Decoder does not support 8-bit JPEG images.

JPEG CPU Decoder is not included in primary SDK library. It is delivered in separate dll – fastvideo_jpegCpuDecoder.dll. Please note that libjpeg interface of CPU Decoder is different from GPU Decoder.

Function `fastJpegCpuDecoderCreate` creates JPEG CPU Decoder. It takes maximum image size and outputs surface format as parameters (`FAST_I12` or `FAST_RGB12`).

Function returns `FAST_UNSUPPORTED_SURFACE` if surface parameter was set `FAST_I8` or `FAST_RGB8`.

Function `fastJpegCpuDecode` decompresses JPEG images. It takes buffer for entire file with header. Function puts uncompressed surface to its device surface buffer and puts other JPEG parameters to `fastJfifInfo_t` struct. Decoder returns `FAST_IO_ERROR` if 8-bit JPEG image is supplied as an input.

4.15 *JPEG2000 Encoder/Decoder*

JPEG2000 Encoder compresses grayscale and color images into JP2 format using lossy or lossless algorithm with different options. Current encoder and decoder support images with 8–16 bits per channel.

JPEG2000 Decoder supports three popular color subsampling formats: $4:4:4$ (no chroma downsampling), $4:2:2$ (reduction by a factor of 2 in the horizontal direction for components Cb and Cr), or (most commonly) $4:2:0$ (chroma reduction by a factor of 2 in both horizontal and vertical directions).

Quality parameter adjusts output JP2 file size and image quality. Quality is a floating-point value from 0 to 100 (which is nonlinearly related to the quantization coefficient), where 100 means no quantization and maximum image size. Recommended value for Quality parameter is 85 (visually lossless compression in most cases).

If any error occurs during procedure call, it returns status not equal to `FAST_OK` and description of the error will appear in `stderr`.

JPEG2000 Encoder is the last component in terms of SDK pipeline. Its input must reside in GPU memory, while output resides in CPU memory.

Function `fastEncoderJ2kLibraryInit` should be called before any other call to encoder function in a program.

Function `fastEncoderJ2kCreate` creates JPEG2000 Encoder. It takes maximum image size. Instance of created JPEG2000 encoder is associated with a handle which is returned by `fastEncoderJ2kCreate` function. Function `fastEncoderJ2kCreate` also allocates all necessary buffers in GPU memory. So, in case when GPU does not have enough free memory, `fastEncoderJ2kCreate` returns status `FAST_INSUFFICIENT_DEVICE_MEMORY`.

Function `fastEncoderJ2kTransform` compresses image taken from the previous component of the pipeline with user-defined quality, returns `fastEncoderJ2kOutput_t` structure with JPEG2000 bytestream and `fastEncoderJ2kReport_t` structure with report. Buffer for JPEG2000 bytestream in `fastEncoderJ2kOutput_t` has to be allocated be-

fore the call. Actual JPEG2000 bytestream size is calculated during compression and put to the field `streamSize` in `fastEncoderJ2kOutput_t`. If `bufferSize` is too small, bytestream is truncated.

Functions `fastEncoderJ2kAddImageToBatch`, `fastEncoderJ2kTransformBatch` and `fastEncoderJ2kGetNextEncodedImage` are used to compress multiple images simultaneously in the batch mode. First, images are added one by one to a batch using `fastEncoderJ2kAddImageToBatch` function until maxBatchSize is reached. After that, `fastEncoderJ2kTransformBatch` is used to process the batch and to get the first compressed image. The rest of the images are returned sequentially by `fastEncoderJ2kGetNextEncodedImage`. When all compressed images are returned, images for the next batch can be passed for processing. Function `fastEncoderJ2kFreeSlotsInBatch` can be used to determine how many more images can be added to the batch. Function `fastEncoderJ2kUnprocessedImagesCount` can be used to determine how many images in the batch are ready to be compressed.

Function `fastEncoderJ2kDestroy` frees all resources allocated by the encoder when you no longer need to encode images.

JPEG2000 Decoder is the first component in terms of SDK pipeline. Its input must reside in CPU memory, while output resides in GPU memory.

Function `fastDecoderJ2kLibraryInit` should be called before any other call to decoder function in a program.

Function `fastDecoderJ2kPredecode` allows getting basic parameters of the image, such as image size, number of components, maximum bit depth etc., from the JPEG2000 main header without decoding the image. These parameters can then be passed to `fastDecoderJ2kCreate` in order to pre-allocate an appropriate amount of memory.

Function `fastDecoderJ2kCreate` creates JPEG2000 Decoder. It takes maximum image size and output surface format as parameters. Instance of created JPEG2000 decoder is associated with a handle, which is returned by `fastDecoderJ2kCreate` function. Function `fastDecoderJ2kCreate` also allocates all necessary buffers in GPU memory. So, in case when GPU does not have enough free memory `fastDecoderJ2kCreate` returns status `FAST_INSUFFICIENT_DEVICE_MEMORY`. Function `fastDecoderJ2kGetAllocatedGpuMemorySize` can be used to get the amount of GPU memory allocated by this instance of decoder.

Function `fastDecoderJ2kTransform` decompresses image from CPU memory and returns `fastDecoderJ2kReport_t` structure with report.

Functions `fastDecoderJ2kAddImageToBatch`, `fastDecoderJ2kTransformBatch` and `fastDecoderJ2kGetNextEncodedImage` are used to decompress multiple images simul-

taneously in batch mode. First, images are added one by one to the batch using `fastDecoderJ2kAddImageToBatch` function until `maxBatchSize` is reached. After that,`fastDecoderJ2kTransformBatch` is used to process the batch and to get the first decompressed image. The rest of the images are returned sequentially by `fastDecoderJ2kGetNextEncodedImage`. When all decompressed images are returned, the next batch can be passed for processing. Function `fastDecoderJ2kFreeSlotsInBatch` can be used to determine how many images can be added to the batch. Function `fastDecoderJ2kUnprocessedImagesCount` can be used to determine how many images are ready to be decompressed.

Function `fastDecoderJ2kDestroy` frees all resources allocated by the encoder when you no longer need to decode images.

4.16 *Timer*

Timer component allows to measure time intervals for GPU kernels. For components that executed only on GPU and don't copy anything to CPU, the timer component is the only way to measure time. CPU timer does not get adequate results in this case because GPU kernel calls are asynchronous.

Timer component is a wrapper for CUDA event. Function `fastGpuTimerCreate` creates two CUDA events (start and stop). Function `fastGpuTimerStart` calls `cudaEventRecord` for start event. Function `fastGpuTimerStop` calls `cudaEventRecord` for stop event. Function `fastGpuTimerGetTime` calls `cudaEventSyncronize` for stop event and then calls `cudaEventElapsedTime` for start and stop events.

For time economy reasons `fastGpuTimerGetTime` should be called after all calculations are completed. Otherwise CPU in `fastGpuTimerGetTime` will have to wait until all GPU calculations are done instead of running next kernels that affects total execution time.

GPU Timer has not to be used in case of concurrent pipelines because of great performance degradation.

4.17 *MJPEG Reader/Writer*

MJPEG Reader/Writer is a simple wrapper of FFmpeg to read/write MJPEG file in AVI container. This component is not a part of FASTVIDEO SDK library. It is deployed as separate hpp/cpp files that placed in ffmpeg_wrapper folder.

The Reader is designed to read MJPEG files frame by frame. On initialization, that

component gets MJPEG file path and tries to open it. If the file is opened successfully, then user can get info about frame resolution and total number of frames in the file. Frames from file are read sequentially by function `GetNextFrame`. When the function reaches the end of the file, it returns status not equal to `FAST_OK`.

Frame read by `GetNextFrame` is a standard JPEG file stream. It has a header and can be decoded by any JPEG Decoder. In our sample applications FASTVIDEO JPEG Decoder is used.

The Writer is designed to serialize JPEG file to MJPEG container. On initialization, the component gets MJPEG file path, frame size, frame rate and sampling format. MJPEG supports only 4:2:0 subsampling format. It is possible to store other subsampling modes, but in the header only 4:2:0 is stored. All written frames have to be of the same size. Frame written by `WriteFrame` function has to be normal JPEG file stream with a header. JPEG stream is stored to a file without any transformation, so this is fast process which is limited only by I/O capabilities of the system.

The `FfmpegSample` demonstrates how to work with MJPEG Reader/Writer.

FASTVIDEO SDK is working with FFmpeg which is under the LGPL v2.1.

FFmpeg is compiled without "–enable-gpl" and without "–enable-nonfree".

4.18 *Affine Transforms*

FASTVIDEO SDK supports the following Affine transforms: flip, flop, rotation 180, rotation left 90, rotation right 90. Enum `fastAffineType_t` contains all supported affine transforms. Flip transform reverses order of image columns. Flop transform reverses order of image rows. Rotation 180 degrees reverses order of columns and rows. Rotation 90 left and 90 right changes image dimension: width becomes equal to height, height becomes equal to width. So `maxWidth` and `maxHeight` of the next component in a pipeline have to be properly adjusted.

That component supports `FAST_RGB8` and `FAST_I8` surfaces.

4.19 *Crop component*

The component crops image. Region of interest is defined by coordinates of the left top corner of rectangle and its width and height.

That component supports `FAST_RGB8`, `FAST_I8`, `FAST_RGB12`, `FAST_I12`, `FAST_RGB16`, `FAST_I16` surfaces.

4.20 *Image Filter component*

Image Filter is a component which includes multiple filters. Image filter in terms of SDK means any operation that transforms every pixel of image, but does not change image geometry, size, and bits-per-pixel value. There are five filter groups: LUT, Sharpen filter, Vector operation, Color correction, Median filter. All filters are listed in `fastImageFilterType_t` enum. Every filter can have two sets of parameters: static and dynamic. Static parameters are assigned on creation and can not be changed while filter is working. Dynamic parameters could be set individually for every processed image.

Some filters have the same static and dynamic parameters. In this case static parameters are initial parameters for the filter. Dynamic parameters overload initial parameters and are locked up in the filter until new dynamic parameters will not be passed. Null pointer for dynamic parameters means to use previously set parameters.

Filter that has the same static and dynamic parameters can be initialized both in filter creation and in the first transform. If filter is not initialized neither in creation nor in the first transform then the first transform returns `FAST_INVALID_VALUE` exception.

4.20.1 *Base Color Correction*

Base Color Correction filter supports `FAST_I8`, `FAST_I12`, `FAST_I16`, `FAST_RGB8`, `FAST_RGB12`, `FAST_RGB16` surfaces. Structure `fastBaseColorCorrection_t` defines static and dynamic parameters for the filter. It contains Color Correction matrix. Color Correction matrix has 3 rows and 4 columns. In general, for RGB pixel, that operation is defined in a matrix form as the following:

$$\begin{pmatrix} R_R & R_G & R_B & R_0 \\ G_R & G_G & G_B & G_0 \\ B_R & B_G & B_B & B_0 \end{pmatrix} \times \begin{pmatrix} R \\ G \\ B \\ -1 \end{pmatrix}$$

for grayscale image:

$$\begin{pmatrix} I & 0 & 0 & I_0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \times \begin{pmatrix} I \\ 0 \\ 0 \\ -1 \end{pmatrix}$$

4.20.2 *Bayer Black Shift*

This filter is applied to Bayer filtered image. It simply subtracts constant value from each pixel. There are three constants for each RGB channel.

4.20.3 *Binning Filter*

This filter creates a new pixel based on square group of pixels. There are two modes of binning: averaging and summing. In the first case, a new pixel is the average of pixels in a group. In the second case, a new pixel is the sum of pixels in a group. Filter supports the following square group sizes: 2x2, 3x3, 4x4. Binning factors are aliases for group sizes. The filter decreases image size by binning factor. For example, if `factorX = factorY = 2` then filtered image width and height are half of original image.

Structure `fastBinning_t` is a set of static and dynamic parameters for the filter. It contains binning operation and binning factors. Filter supports `FAST_I12`, `FAST_I16` surfaces.

4.20.4 *Flat-field correction*

This filter used to cancel the effects of image artifacts caused by variations in the pixel-to-pixel sensitivity of the detector and by distortions in the optical path.

Structure `fastFFC_t` is a set of static and dynamic parameters for the filter. It contains divider and pointer to sparsed correction matrix. Filter supports `FAST_I12`, `FAST_I16` surfaces.

4.20.5 *Color Saturation*

Color Saturation filter includes three steps: RGB to {HSL, HSV} transformation, LUT-based {HSL, HSV} transformation, HSL, HSV to RGB transformation. User defines three separate LUTs for each {HSL, HSV} channel. Each LUT has 1024 float values. Interval for H LUT is $[0, 360]$, intervals for S and L LUTs are $[0, 1]$.

LUT-based {HSL, HSV} transformation depends on individual operation for each channel. There are three types of operation: replace, addition and multiplication. In the case of replace, operation value from input is replaced by a new value from LUT. In the case of addition operation, new value is the sum of input value and value from LUT. In the case of multiplication operation, new value is the product of input value and value from LUT.

Structure `fastColorSaturation_t` contains static and dynamic parameters for the filter. It contains three LUTs and three operations. That component supports `FAST_RGB8`, `FAST_RGB12`, `FAST_RGB16` surfaces.

4.20.6 *Gaussian sharpen filter*

Sharpen filter group contains one Gaussian filter with window 3×3. There is one dynamic parameter – sigma (it's so called "Gaussian kernel radius"). The subcomponent supports `FAST_RGB8` and `FAST_I8` surfaces.

4.20.7 *LUT*

LUT group contains multiple Lookup Table filters. Lookup Table filter uses input value as an index in table of new (output) values. Two main parameters for Lookup table are bit-depth of input and output values. Lookup filter contains one table, that is common for all color channels, or separate Lookup tables for each color channel. Total number of Bytes for Lookup table is the following:

$$2^{\{\text{bit}-\text{depth of input value}\}} \times \{\text{size in bytes of output value}\}$$

There are following types of Lookup filters: LUT_8_{8,12,16}, LUT_8_{8,12,16}_C, LUT_12_{8,12,16}, LUT_12_{8,12,16}_C, LUT_16_{8,16}, LUT_16_16_FR, LUT_16_{8,16}_C, LUT_16_16_FR_C, LUT_{8,10,12,14,16}_16_BAYER, LUT_16_16_FR_BAYER. The first number defines bit depth of input value, the second number defines bit depth of output value. Suffix _C means that filter has three Lookup

tables to apply to RGB channels. Suffix _BAYER means that LUT is applied to Bayer filtered image. Bayer LUTs also have three tables to apply to RGB channels. Bayer LUTs take additional parameter to identify bayer type {RGGB, GRBG and etc}. Suffix _FR (full range) means that LUT does not use interpolation. The suffix is only applied to 16_16 LUTs. All LUTs have static and dynamic parameters.

Parameters and structures for all LUTs are listed in the table below. Column "tables" defines a number of tables in a structure. Column "elements" defines a number of elements in LUT table. Column "type of element" means type of LUT table elements.

Table 3. Description of LUT parameters

LUT	**Static and dynamic parameters**	**Tables**	**Elements**	**Type of element**
LUT_8_8	`fastLut_8_t`	1	256	uchar
LUT_8_8_C	`fastLut_8_C_t`	3	256	uchar
LUT_8_{12,16}	`fastLut_8_16_t`	1	256	ushort
LUT_8_{12,16}_C	`fastLut_8_16_C_t`	3	256	ushort
LUT_8_16_BAYER	`fastLut_8_16_Bayer_t`	3	256	ushort
LUT_10_16_BAYER	`fastLut_10_16_Bayer_t`	3	1024	ushort
LUT_12_8	`fastLut_12_8_t`	1	4096	uchar
LUT_12_8_C	`fastLut_12_8_C_t`	3	4096	uchar
LUT_12_{12,16}	`fastLut_12_t`	1	4096	ushort
LUT_12_{12,16}_C	`fastLut_12_C_t`	3	4096	ushort
LUT_12_16_BAYER	`fastLut_12_16_Bayer_t`	3	4096	ushort
LUT_14_16_BAYER	`fastLut_14_16_Bayer_t`	3	16384	ushort

Continued from previous page

LUT	Static and dynamic parameters	Tables	Elements	Type of element
LUT_16_8	`fastLut_16_8_t`	1	16384	uchar
LUT_16_8_C	`fastLut_16_8_C_t`	3	16384	uchar
LUT_16_16	`fastLut_16_t`	1	16384	ushort
LUT_16_16_C	`fastLut_16_C_t`	3	16384	ushort
LUT_16_16_BAYER	`fastLut_16_16_Bayer_t`	3	16384	ushort
LUT_16_16_FR	`fastLut_16_FR_t`	1	65536	ushort
LUT_16_16_FR_C	`fastLut_16_FR_C_t`	3	65536	ushort
LUT_16_16_FR_BAYER	`fastLut_16_FR_Bayer_t`	3	65536	ushort

LUT changes bit depth of pipeline surface if LUT's input bit depth is not equal to output bit depth.

16-bit LUTs have only 16384 values in a table. Size of LUT's table is limited by GPU resources. 14 significant bits of input value are used to identify element in LUT, and two less significant bits of output are calculated via linear interpolation.

Full range 16-bit LUT have 65536 values in a table and so does not use linear interpolation. It is based on texture memory instead of shared memory in non-full range LUTs. Non-full range LUTs has beter performance then its full range version.

4.20.8 *LUT RGB 3D*

RGB 3D LUT is used to map one color space to another. In general 3D LUT is uniform 3D grid of RGB values. Often this grid is called cube because it has the same number of elements in all directions. Input RGB value is defined elementary cube in grid. Trilinear interpolation is used to calculate output RGB value based on the elementary cube and input RGB value.

Current FASTVIDEO SDK supports arbitrary RGB 3D LUT size with up to 65 elements in one dimension and even more. Structure `fastRGBLut_3D_t` could be both static and dynamic parameter for the filter. It contains cube 1D size and pointer to LUT. Memory ordering of elements is according to Adobe CUBE format. This ordering is the opposite of the typical in-memory order of multi-dimensional tables. An equivalent index would be

$$r + N \cdot g + N \cdot N \cdot b,$$

where r, g, b are the Red, Green, and Blue indices in the range 0 to N–1.

Component supports `FAST_RGB12`, `FAST_RGB16` surfaces. Example of RGB 3D LUT you can find in `ComponentSample`.

4.20.9 *LUT HSV 2D/3D*

HSV 3D LUT is used to map one color space to another through HSV transformation. That component is compatible with lookup table specified in Adobe Digital Negative Format.

In general HSV LUT is uniform 2D/3D grid of 3-component vectors. Each vector contains transformation value for channels H, S, V, one element for one channel. Type of transformation value is float. Type of transformation is defined per channel (H, S, V) globally. There are three type of transformations: replace, addition, multiplication. In the case of replace operation, value from input is replaced by new value from appropriate element from the vector. In the case of addition operation, new value is the sum of input value and value from the vector. In the case of multiplication operation new value is the product of input value and value from the vector.

Unlike RGB 3D LUT, HSV 3D LUT grid is not a cube. Number of elements per each axis can be different. Also there is 2D case when number of elements per V axis is 1. 2D LUTs with H = 1 or S = 1 are not supported.

Process steps:

1. Convert RGB pixel to HSV, where H in $[0, 360]$, S in $[0, 1]$, V in $[0, 1]$.
2. Find elementary cube in 3D LUT included input value.
3. Calculate transformation vector by trilinear interpolation of the elementary cube and input RGB value.
4. Apply transformation operation to input HSV pixel with transformation vector.
5. Convert new HSV pixel to RGB.

Structure `fastHsvLut3D_t` could be both static and dynamic parameter for the filter. It contains LUT size for each axis, LUT pointer and transformation operation for each channel. Memory ordering of elements in LUT is according to lookup table ordering at Adobe DNG format. This ordering is the opposite to the typical in-memory order of multi-dimensional tables. An equivalent index would be

$$\mathrm{V} + \mathrm{dimV} \cdot \mathrm{H} + \mathrm{dimV} \cdot \mathrm{dimH} \cdot \mathrm{S}.$$

Filter supports `FAST_RGB12`, `FAST_RGB16` surfaces. Example of RGB 3D LUT you can find in ComponentSample.

4.20.10 *Median filter*

Median filter group contains one Median filter with window 3×3. There is no parameters for filter. The subcomponent supports `FAST_RGB12`, `FAST_RGB16`, `FAST_I12`, `FAST_I16` surfaces.

4.20.11 *SAM (subtract and multiply)*

SAM filter is a vector operation transforming every pixel according to the equation:

$$(x - A) \times B, \tag{1}$$

where x – pixel value, A and B are matrices with the same dimensions as image size. Matrix B is called BlackShiftMatrix, matrix A is called CorrectionMatrix.

There are two SAM filters: SAM and SAM16. Structures `fastSam_t` and `fastSam16_t` are static/dynamic parameters for appropriate filters. They contain pointers on both matrices. Black shift matrix has `char` type in `fastSam_t` and `short` type in `fastSam_t`. Correction Matrix has `float` type in both structures. Component SAM supports all grayscale formats. Component SAM16 supports all grayscale formats except `FAST_I8`. SAM filter has better performance than SAM16 filter. So if black shift value does not exceed char limits, better to use SAM.

4.20.12 *Tone Curve*

Tone Curve filter change image tone according tone curve. Filter algorithm is taken from Adobe DNG SDK. Tone curve is defined as a LUT table with 1024 values. Interval for tone curve is $[0, 1]$. Structure `fastToneCurve_t` is a static or dynamic parameter for

the filter. It contains LUT of tone curve. Component supports only `FAST_RGB16` surfaces. Example of linear tone curve is defined in defaultToneCurve.h in ComponentsSample folder.

4.20.13 *White Balance*

White Balance filter supports `FAST_I8`, `FAST_I12`, `FAST_I16` surfaces for bayer filtered image. Structure `fastWhiteBalance_t` defines static and dynamic parameters for the filter. It contains white balance matrix and bayer pattern. White balance matrix defines by four values: R, G1, G2, B. Bayer patter contains two green values. G1 defines value for green pixel in the first row, G2 defines value for green value in the second row. Filter multiplies values from white balance matrix on respective values in the image.

4.21 *HDR Builder component*

The component downscales and upscales an image. Image scale factor could be defined in two ways:

1. By defining width of resized image with preserved image aspect ratio.
2. By defining any width and height of resized image.

In the first case, hight of resized image is automatically calculated by image height and scale factor. Resized height is returned by component to unify rounding process.

In the second case, image aspect ratio is not preserved. User has to define resized image height as well.

Both cases are used both for downscale and upscale.

The only supported algorithm of resize is Lanczos. Component supports `FAST_I12` surfaces.

4.22 *Resizer component*

The component downscales and upscales an image. Image scale factor could be defined in two ways:

1. By defining width of resized image with preserved image aspect ratio.
2. By defining any width and height of resized image.

In the first case, hight of resized image is automatically calculated by image height

and scale factor. Resized height is returned by component to unify rounding process.

In the second case, image aspect ratio is not preserved. User has to define resized image height as well.

Both cases are used both for downscale and upscale.

The only supported algorithm of resize is Lanczos. Component supports `FAST_RGB8`, `FAST_I8`, `FAST_RGB12`, `FAST_I12`, `FAST_RGB16`, `FAST_I16` surfaces.

4.23 *Bayer Splitter and Bayer Merger components*

The main reason why these components were included in SDK is better performance in common task of saving frames from a camera in real time applications. Camera frame is Bayer filtered so in common case color has to be restored by Debayer component and encoded by JPEG Encoder. Encoding each Bayer frame to JPEG directly is not a good idea. In general, it saves time by excluding Debayer from the pipeline but quality suffers greatly. JPEG compression algorithm utilizes the fact that brightness in real picture changed smoothly. This allows to drop height frequency data to get better image compression. Bayer image has a lot of high frequency data because in one block we have merged data from three color channels. As a results, JPEG compressed Bayer image has lower compression ratio and worse quality. To solve that issue, we have to split Bayer image on four planes with pixels from appropriate channels (R, G1, G2, B). Thus one Bayer plane is similar to color channel downsampled by two.

The Bayer Splitter component splits Bayer image on four planes and concatenates them in one column (from top to bottom). Now splitted Bayer image is ready be compressed to JPEG. Height of every concatenated plane is aligned to 8. It is important for JPEG compression because each plane does not interfere with another. Position of plane in the column depends on pixel's position in the pattern and doesn't depend on Bayer pattern.

Height of original image can not be taken from height of splitted Bayer filtered image, so the original height has to be stored to JPEG file in EXIF section. EXIF section is defined by `SplitterExif_t` structure in `ExifInfo.hpp`. It contains original image width, height and bayer pattern. EXIF section ID is 0xFFE1.

The Bayer Merger component restores original image from splitted Bayer image and EXIF section information.

4.24 *SDI import and export components*

Serial Digital Interface (SDI) is a family of *digital video* interfaces. They are used for transmission of uncompressed, unencrypted digital video signals.

SDI Import component from FASTVIDEO SDK allows to feed pipeline with data directly from video interface. There are two types of SDI Import component: one import data from host, another from device memory. Device import component is designed for NVDEC (NVIDIA hardware accelerated video decoder) integration which stores decoded frame to device memory directly.

SDI Export component of SDK allows to store data from the pipeline in appropriate SDI format. There are two types of SDI Export components: one export data to host and another to device memory. Device export component is designed for NVENC (NVIDIA hardware accelerated video encoder) integration which gets encoded frame from device memory directly.

SDI interface supports multiple video formats listed in `fastSDIFormat_t`. Name in `fastSDIFormat_t` consists of three parts: FAST_SDI prefix, format name and color transformation suffix. Color transformations to convert RGB to YCbCr and vice versa. There are four suffixes: `BT601_FR`, `BT601`, `BT709`, `BT2020`. Color transformations will be described later.

In the future the number of supported formats will be increased by user demand. A list of supported formats for import/export is presented in the following table.

Name	**Import from**		**Export to**	
	Host	**Device**	**Host**	**Device**
NV12	+	+	+	+
YV12	+	+	+	+
420_8_YCbCr_PLANAR	+	+	+	+
P010	+	+	+	+
420_10_YCbCr_PLANAR	+	+	+	+

Continued from previous page

Name	Import from		Export to	
	Host	**Device**	**Host**	**Device**
444_8_YCbCr_PLANAR	+	+	+	+
444_10_YCbCr_PLANAR	+	+	+	+
422_8_CbYCrY	+	+	+	+
422_8_CrYCbY	+	+	+	+
422_10_CbYCrY_PACKED	+	−	+	−
RGBA	+	+	+	+
RGB_10_BMR10L	+	−	+	−
RGB_10_BMR10B	+	−	+	−
RGB_12_BMR12B	+	−	+	−
RGB_12_BMR12L	+	−	+	−

Information about supported YCbCr formats is presented in the next table. Layout defines how pixels or blocks of pixels reside in memory and which pixels/subpixels are contained by block of pixels. Layouts also include color ordering which means order of color subpixels in block of pixels. All layouts will be described later.

Subsampling defines chroma subsampling type applied to YCbCr image. Byte per value defines number of bytes for each subpixel. Bits per value defines number of valuable bits. Zero defines which bits will be zero if subpixel uses less bits than possible. For example, format has two bytes per value but uses only 10 bits. In this case 10 valuable bits can be moved to most significant bits or to less significant bits. Less significant bits and most significant bits will be zeroed appropriately. So MSB in Zero column means

that value moved to less significant bits and most significant bits are zero.

Name	**Layout**	**Sub-sampling**	**Bytes per value**	**Bits depth**	**Zero**
NV12	Y + MixedCbCr	420	1	8	
P010	Y + MixedCbCr	420	2	10	LSB
YV12	Planar YCrCb	420	1	8	
420_8_YCbCr_PLANAR	Planar YCrCb	420	1	8	
420_10_YCbCr_PLANAR	Planar YCbCr	420	2	10	MSB
422_8_CbYCrY	Pixel422 CbYCrY	422	1	8	
422_8_CrYCbY	Pixel422 CrYCbY	422	1	8	
444_8_YCbCr_PLANAR	Planar YCbCr	444	1	8	
444_10_YCbCr_PLANAR	Planar YCbCr	444	2	10	LSB

Information about supported RGB formats is presented in the following table. All supported RGB formats are pixel formats. Bits per value defines number of valuable bits. Packed means if pixels share one byte. In unpacked format one byte contains only one pixel.

Name	**Packed**	**Bits depth**
RGBA	-	8
RGB_10_BMR10L	+	10
RGB_10_BMR10B	+	10

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Name	**Packed**	**Bits depth**
RGB_12_BMR12L	+	12
RGB_12_BMR12B	+	12

The following table shows source surface formats for export and destination surface formats for import. Also it shows additional static parameters.

Name	**Export from surface formats**	**Import to surface format**	**Export static parameter**
NV12	FAST_RGB8	FAST_RGB8	
YV12	FAST_RGB8	FAST_RGB8	
420_8_YCbCr_PLANAR	FAST_RGB8	FAST_RGB8	
P010	FAST_RGB12, FAST_RGB16	FAST_RGB12	fastSDIYCbCrExport_t
420_10_YCbCr_PLANAR	FAST_RGB12, FAST_RGB16	FAST_RGB12	fastSDIYCbCrExport_t
422_8_CbYCrY	FAST_RGB8	FAST_RGB8	
422_8_CrYCbY	FAST_RGB8	FAST_RGB8	
422_10_CbYCrY_PACKED	FAST_RGB12, FAST_RGB16	FAST_RGB12	fastSDIYCbCrExport_t
444_8_YCbCr_PLANAR	FAST_RGB8	FAST_RGB8	
444_10_YCbCr_PLANAR	FAST_RGB12, FAST_RGB16	FAST_RGB12	fastSDIYCbCrExport_t
RGBA	FAST_RGB8	FAST_RGB8	fastSDIRGBAExport_t

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Name	**Export from surface formats**	**Import to surface format**	**Export static parameter**
RGB_10_BMR10L	FAST_RGB12, FAST_RGB16	FAST_RGB12	
RGB_10_BMR10B	FAST_RGB12, FAST_RGB16	FAST_RGB12	
RGB_12_BMR12L	FAST_RGB12, FAST_RGB16	FAST_RGB12	
RGB_12_BMR12B	FAST_RGB12, FAST_RGB16	FAST_RGB12	

10-bit format can be exported from 12-bit and 16-bit surface formats. The SDI component automatically converts every pixel value to a target bit depth. In some cases in the surface we could store image with lower bit depth than surface format defined. For example, in 12-bit format we can store 10-bit data. Structure `fastSDIYCbCrExport_t` allows to path arbitrary bits depth for correct automatic convertion.

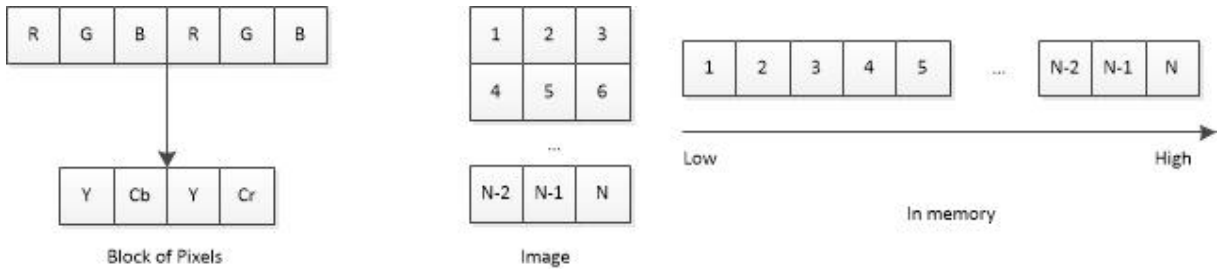


Fig. 6. Layout Pixel 422 YCbCr

Lets discuss SDI YCbCr format layout. There are three layouts: Pixel 422, Planar YCbCr, Y + Mixed CbCr. Also there is packed YCbCr format.

Layout Pixel 422 is a simple YCbCr format with 422 subsampling. Block of pixels contains 2 pixels (2 columns per 1 row) or 4 Bytes. We have individual Y component for each source pixel and average color components – Cb and Cr. Figure 6 shows block of pixels in source image and its position in memory.

Notation CbYCrY means that 4 Bytes in block from less to most significant Bytes contain CbY1CrY2 subpixels, CrYCbY respectively CrY1CbY2.

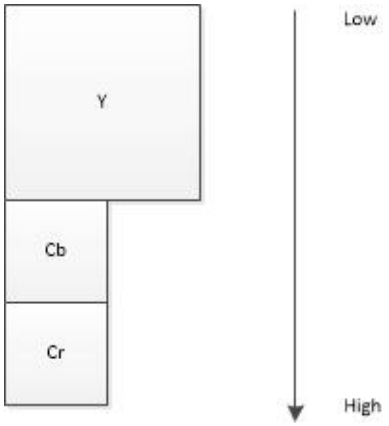


Fig. 7. Layout Planar YCbCr with 420 subsampling

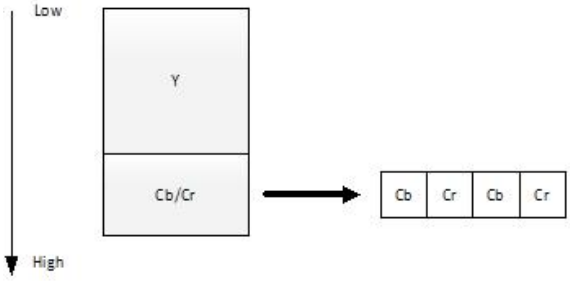


Fig. 8. Layout Y + Mixed CbCr

Layout Planar YCbCr supports all type of subsampling (4:4:4, 4:2:2, 4:2:0 and etc). There are three planes: Y, Cb, Cr. Luminance plane (Y) has the same size as original image. Chrominance planes (Cb and Cr) are downscaled respectively to subsampling. For example for 4:2:0, chrominance value corresponds to one block (2 rows by 2 columns) of original image. Figure 7 shows color planes for 4:2:0 subsampling in memory.

Layout Y + Mixed CbCr is YCbCr hybrid format with 4:2:0 subsampling. There are two planes: Y, Cb/Cr. Luminance plane (Y) has the same size as original image. Each chrominance value corresponds to one block (2 rows by 2 columns) of original image. Combined Cb/Cr plane contains alternated Cb and Cr pixels. So Cb/Cr plane width is equal to original image width and its height is downscaled by two times. Figure 8 shows color planes in memory array.

Packed format 422_10_CbYCrY has 10 bits per value. It is alias for Black Magic 'v210' 4:2:2. Pixel pattern is repeated each 32 bytes. So image width has to be aligned on 6 pixels bound. Figure 9 shows pexel pattern in memory.

There are unpacked and packed RGB and RGBA formats. Pixel RGBA is simple format with 4 bytes per pixel for better OpenGL integration. Less significant byte in int

is R then G and B. Most significant byte in it is Alpha channel. Alpha channel value can be filled by zero or FF. It is defined by fastSDIRGBAExport_t structure.

Packed RGB format used for 10 and 12 bits images. Current list of supported packed RGB formats are RGB_10_BMR10L, RGB_10_BMR10B, RGB_12_BMR12L, RGB_12_BMR12B. Formats ended by suffix L use little endian byte order. Formats ended by suffix B use big endian byte order. These formats were added to SDK to integrate with Blackmagic DeckLink API.

Packed RGB formats RGB_10_BMR10L and RGB_10_BMR10B have 10 bits per value and 4 bytes per pixel. There is no align limitation on image width.

Packed RGB formats RGB_12_BMR12L and RGB_12_BMR12B have 12 bits per value and 45 bytes per 8 pixels. So image width has to be aligned on 8 pixels bound.

Word 0																															
Byte 3								Byte 2								Byte 1								Byte 0							
X	X	Cr0										Y0										Cb0									
x	x	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0

Word 1																															
Byte 3								Byte 2								Byte 1								Byte 0							
X	X	Y2										Cb2										Y1									
x	x	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0

Word 2																															
Byte 3								Byte 2								Byte 1								Byte 0							
X	X	Cb4										Y3										Cr2									
x	x	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0

Word 3																															
Byte 3								Byte 2								Byte 1								Byte 0							
X	X	Y5										Cr4										Y4									
x	x	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0

Fig. 9. 422_10_CbYCrY (bmdFormat10BitYUV : 'v210' 4:2:2 Representation)

Word																													
Byte 3								Byte 2								Byte 1								Byte 0							
R								R		G						G				B				B						X	X
9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	x	x

Fig. 10. RGB_10_BMR10L (bmdFormat10BitRGBXLE : 'R10l' 4:4:4 raw)

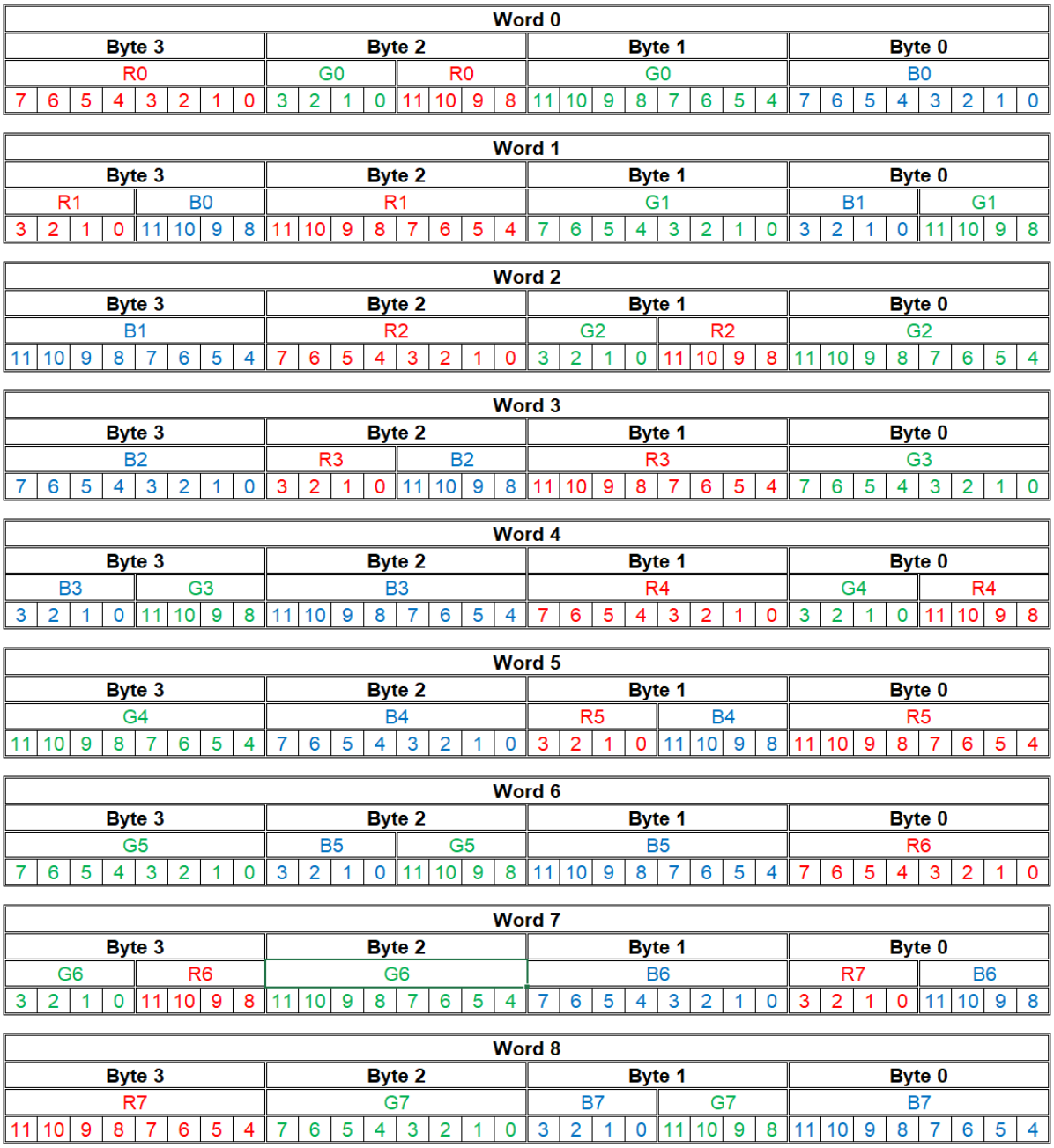
Word																													
Byte 3								Byte 2								Byte 1								Byte 0							
B						X	X	G				B				R		G						R							
5	4	3	2	1	0	x	x	3	2	1	0	9	8	7	6	1	0	9	8	7	6	5	4	9	8	7	6	5	4	3	2

Fig. 11. RGB_10_BMR10B (bmdFormat10BitRGBX : 'R10b' 4:4:4 raw)

By default all extracted or imported data store in continuous region of device or host memory. Each row in the plane of layout is aligned to the closest 4 Bytes boundary. Pitch means the size of image row in Bytes. Pitch for each plane depends on plane's width. So, for example, pitches for Y and Cb/Cr planes are different for Planar YCbCr with 4:2:0 subsampling layout.

Packed format 422_8_CbYCrY, 422_8_CrYCbY, 422_10_CbYCrY_PACKED support CopyPacked method for import. This method allows to override row pitch. CopyPacked maethod for export will be added by user request.

SDI component supports import from memory layout where each plane stored in separate memory blocks. Also the same functionality there is for export to memory. This is implemented by function with suffix `Copy3`. Functions take three pointers on `fastChannelDescription_t` structure which describes plane or channel. Each channel has its own pointer, pitch, width and height.



Word 0																															
Byte 3								Byte 2								Byte 1								Byte 0							
R0								G0				R0				G0								B0							
7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0

Word 1																															
Byte 3								Byte 2								Byte 1								Byte 0							
R1				B0				R1								G1								B1				G1			
3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8

Word 2																															
Byte 3								Byte 2								Byte 1								Byte 0							
B1								R2								G2				R2				G2							
11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4

Word 3																															
Byte 3								Byte 2								Byte 1								Byte 0							
B2								R3				B2				R3								G3							
7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0

Word 4																															
Byte 3								Byte 2								Byte 1								Byte 0							
B3				G3				B3								R4								G4				R4			
3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8

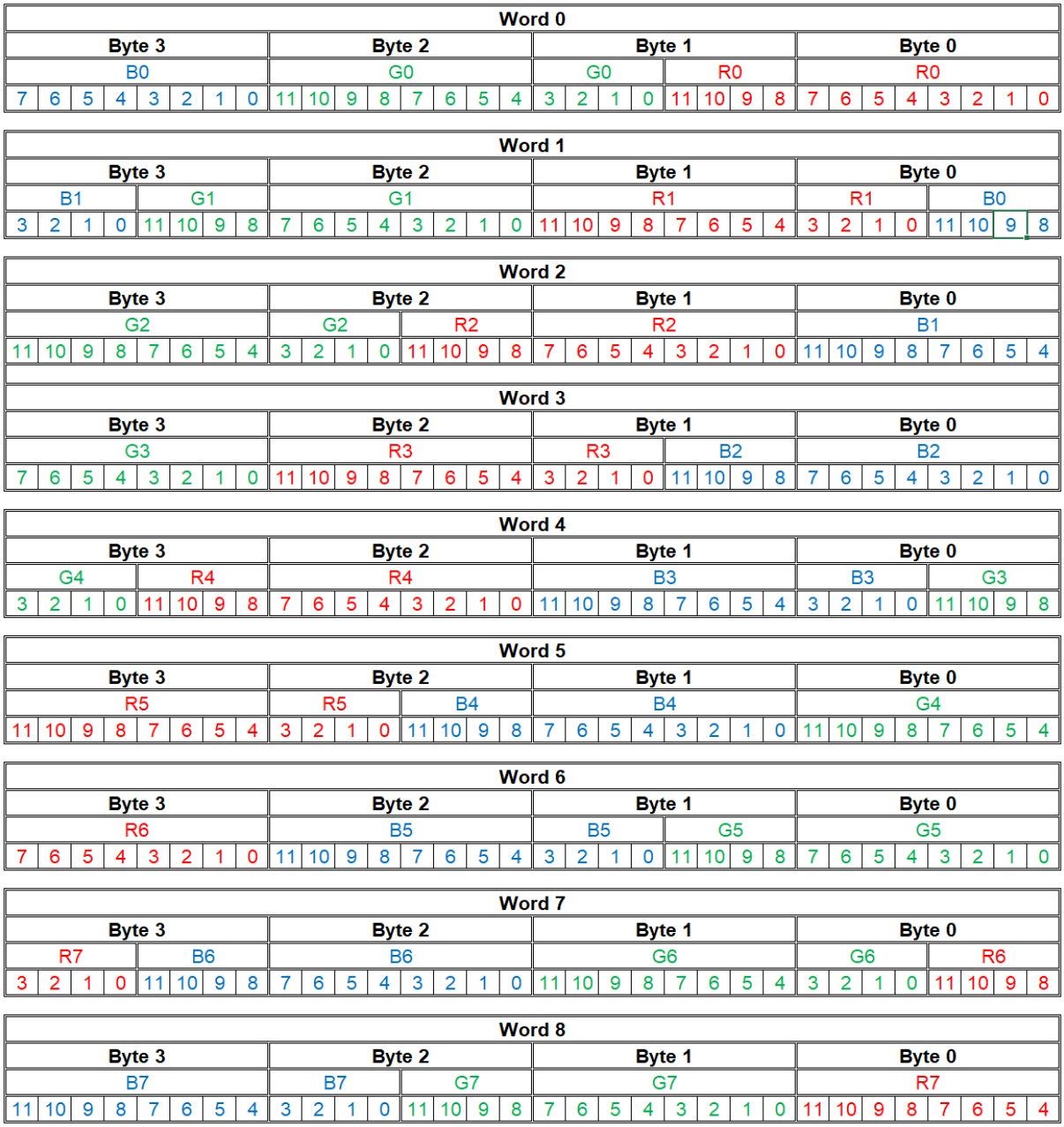
Word 5																															
Byte 3								Byte 2								Byte 1								Byte 0							
G4								B4								R5				B4				R5							
11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4

Word 6																															
Byte 3								Byte 2								Byte 1								Byte 0							
G5								B5				G5				B5								R6							
7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0

Word 7																															
Byte 3								Byte 2								Byte 1								Byte 0							
G6				R6				G6								B6								R7				B6			
3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8

Word 8																															
Byte 3								Byte 2								Byte 1								Byte 0							
R7								G7								B7				G7				B7							
11	10	9	8	7	6	5	4	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	11	10	9	8	7	6	5	4

Fig. 12. RGB_12_BMR12L (bmdFormat12BitRGBLE : 'R12L')



Word 0																															
Byte 3								Byte 2								Byte 1								Byte 0							
B0								G0								G0				R0				R0							
7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0

Word 1																															
Byte 3								Byte 2								Byte 1								Byte 0							
B1				G1				G1								R1								R1				B0			
3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8

Word 2																															
Byte 3								Byte 2								Byte 1								Byte 0							
G2								G2				R2				R2								B1							
11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4

Word 3																															
Byte 3								Byte 2								Byte 1								Byte 0							
G3								R3								R3				B2				B2							
7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0

Word 4																															
Byte 3								Byte 2								Byte 1								Byte 0							
G4				R4				R4								B3								B3				G3			
3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8

Word 5																															
Byte 3								Byte 2								Byte 1								Byte 0							
R5								R5				B4				B4								G4							
11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4

Word 6																															
Byte 3								Byte 2								Byte 1								Byte 0							
R6								B5								B5				G5				G5							
7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0

Word 7																															
Byte 3								Byte 2								Byte 1								Byte 0							
R7				B6				B6								G6								G6				R6			
3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8

Word 8																															
Byte 3								Byte 2								Byte 1								Byte 0							
B7								B7				G7				G7								R7							
11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4

Fig. 13. RGB_12_BMR12B (bmdFormat12BitRGBLE : 'R12B')

Table 8. SDI formats supported Copy3

Name	Import from		Export to	
	Host	**Device**	**Host**	**Device**
NV12	+	+	+	+
YV12	+	+	+	+
420_8_YCbCr_PLANAR	+	+	+	+
P010	+	+	+	+
420_10_YCbCr_PLANAR	+	+	+	+
444_8_YCbCr_PLANAR	+	+	+	+
444_10_YCbCr_PLANAR	+	+	+	+

There are three types of color transformations to convert RGB to YCbCr and vice versa: BT601, BT709, BT2020. Also there are two modes: the first for digital television and the second for video processing on PC. Modes are differed by output value range. For digital television Y is in $[16, 235]$, Cb/Cr is in $[16, 240]$. For PC (other name for these modes is full range) Y, Cb, Cr are in $[0, 255]$. Range values are defined for 8-bit data. Conversion formulas are also defined for 8-bit data.

- **BT601**
  - RGB to YCbCr

$$\mathrm{Y} = 0.2568 \cdot \mathrm{R} + 0.5041 \cdot \mathrm{G} + 0.0979 \cdot \mathrm{B} + 16,$$

$$\mathrm{Cb} = -0.1482 \cdot \mathrm{R} - 0.2910 \cdot \mathrm{G} + 0.4392 \cdot \mathrm{B} + 128,$$

$$\mathrm{Cr} = 0.4392 \cdot \mathrm{R} - 0.3678 \cdot \mathrm{G} - 0.0714 \cdot \mathrm{B} + 128.$$

  - YCbCr to RGB

$$\mathrm{R} = 1.1644 \cdot (\mathrm{Y} - 16) + 1.5960 \cdot (\mathrm{Cr} - 128),$$

$$\mathrm{G} = 1.1644 \cdot (\mathrm{Y} - 16) - 0.8130 \cdot (\mathrm{Cr} - 128) – 0.3918 \cdot (\mathrm{Cb} - 128),$$

$$\mathrm{B} = 1.1644 \cdot (\mathrm{Y} - 16) + 2.0172 \cdot (\mathrm{Cb} – 128).$$

- **BT601 (full range, FR)**
  - RGB to YCbCr

$$\mathrm{Y} = 0.2990 \cdot \mathrm{R} + 0.5870 \cdot \mathrm{G} + 0.1140 \cdot \mathrm{B} + 16,$$

$$\mathrm{Cb} = -0.1687 \cdot \mathrm{R} - 0.3313 \cdot \mathrm{G} + 0.5 \cdot \mathrm{B} + 128,$$

$$\mathrm{Cr} = 0.5 \cdot \mathrm{R} - 0.4187 \cdot \mathrm{G} - 0.0813 \cdot \mathrm{B} + 128.$$

  - YCbCr to RGB

$$\mathrm{R} = 1.0 \cdot \mathrm{Y} + 1.4020 \cdot (\mathrm{Cr} - 128),$$

$$\mathrm{G} = 1.0 \cdot \mathrm{Y} - 0.7141 \cdot (\mathrm{Cr} - 128) – 0.3441 \cdot (\mathrm{Cb} - 128),$$

$$\mathrm{B} = 1.0 \cdot \mathrm{Y} + 1.7720 \cdot (\mathrm{Cb} – 128).$$

- **BT709**

– RGB to YCbCr

$$Y = 0.1826 \cdot R + 0.6142 \cdot G + 0.0620 \cdot B + 16,$$

$$Cb = -0.1006 \cdot R - 0.3386 \cdot G + 0.4392 \cdot B + 128,$$

$$Cr = 0.4392 \cdot R - 0.3989 \cdot G - 0.0403 \cdot B + 128.$$

– YCbCr to RGB

$$R = 1.1644 \cdot (Y - 16) + 1.7927 \cdot (Cr - 128),$$

$$G = 1.1644 \cdot (Y - 16) - 0.5329 \cdot (Cr - 128) – 0.2132 \cdot (Cb - 128),$$

$$B = 1.1644 \cdot (Y - 16) + 2.1124 \cdot (Cb – 128).$$

- **BT2020**
  – RGB to YCbCr

$$Y = 0.2256 \cdot R + 0.5823 \cdot G + 0.0509 \cdot B + 16,$$

$$Cb = -0.1227 \cdot R - 0.3166 \cdot G + 0.4392 \cdot B + 128,$$

$$Cr = 0.4392 \cdot R - 0.4039 \cdot G - 0.0353 \cdot B + 128.$$

– YCbCr to RGB

$$R = 1.1644 \cdot (Y - 16) + 1.6787 \cdot (Cr - 128),$$

$$G = 1.1644 \cdot (Y - 16) - 0.6504 \cdot (Cr - 128) – 0.1873f \cdot (Cb - 128),$$

$$B = 1.1644 \cdot (Y - 16) + 2.1418 \cdot (Cb – 128).$$

4.25 *RAW import component*

A camera raw image file contains minimally processed data from the image sensor of either a digital camera, a motion picture film scanner, or other image scanner. Raw image bitdepth is in range from 10 to 16 bits. Raw image could be packed. It is grayscale image with one plane overlaid with a color filter array (for example Bayer filter).

RAW Import component of FASTVIDEO SDK allows to feed pipeline with data directly from a camera. There are two types of RAW Import component one import data from host another from device memory. Device import component is designed for a camera that supports GPU Direct technology.

RAW Import supports multiple RAW formats listed in `fastRawFormat_t`. Currenly RAW import supports two formats. There are FAST_RAW_XIMEA12, FAST_RAW_PTG12. Formats FAST_RAW_XIMEA12, FAST_RAW_PTG12 are imported as FAST_I12 surface. In the future the number of supported formats will be increased by user demand.

Word 0																													
Byte 3								Byte 2								Byte 1				Byte 0									
Pixel 2								Pixel 1								Pixel 0													
7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0

Word 1																													
Byte 3								Byte 2								Byte 1				Byte 0									
Pixel 5								Pixel 4								Pixel 3								Pixel 2					
3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8

Word 2																													
Byte 3								Byte 2								Byte 1				Byte 0									
Pixel 7								Pixel 6								Pixel 5													
11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4	3	2	1	0	11	10	9	8	7	6	5	4

Fig. 14. FAST_RAW_XIMEA12

Word 0																													
Byte 3								Byte 2								Byte 1				Byte 0									
Pixel 2								Pixel 1								Pixel 0				Pixel 1				Pixel 0					
11	10	9	8	7	6	5	4	11	10	9	8	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	7	6	5	4

Word 1																													
Byte 3								Byte 2								Byte 1				Byte 0									
Pixel 4				Pixel 5				Pixel 4								Pixel 3								Pixel 2				Pixel 3			
3	2	1	0	3	2	1	0	11	10	9	8	7	6	5	4	11	10	9	8	7	6	5	4	3	2	1	0	3	2	1	0

Word 2																													
Byte 3								Byte 2								Byte 1				Byte 0									
Pixel 7								Pixel 6				Pixel 7				Pixel 6								Pixel 5					
11	10	9	8	7	6	5	4	3	2	1	0	3	2	1	0	11	10	9	8	7	6	5	4	11	10	9	8	7	6	5	4

Fig. 15. FAST_RAW_PTG12

Pixel pattern is repeated each 12 bytes for FAST_RAW_XIMEA12, FAST_RAW_PTG12. So image width has to be aligned on 8 pixels bound and pitch has to be aligned on 12 bytes bound.

4.26 *Surface converter component*

Component converts bit depth and surface type. There are four types of conversions: bit depth, RGB channel select, RGB to grayscale by brightness, grayscale to grayscale RGB, grayscale to RGB, and bayer to RGB.

Bit depth conversion changes bit depth of surface by left or right shift input pixels. When source value has smaller bit depth than destination, then left shift is used. Inserted bits are populated by zero. When source value has greater bit depth than destination, right logical shift is used.

Acceptable conversions
FAST_I8,10,12,14,16 → FAST_I8,12,16,
FAST_RGB8,12,16 → FAST_RGB8,12,16.

Select channel filter allows to get any channel from RGB and save it as grayscale image.

RGB to grayscale conversion takes all RGB channels with appropriate coefficient to create grayscale image. Coefficients are user defined, so any type of RGB to grayscale can be used.

Grayscale to grayscale RGB conversion creates RGB image with equal color channels.

Grayscale to RGB conversion creates RGB image by three times copy from source buffer.

Bayer to RGB conversion creates RGB image colorize image according Bayer pattern.

4.27 *Histogram component*

An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. Histograms are widely used in image processing and computer vision. Histogram component calculates three types of histograms: common, bayer, parade. Enum `fastHistogramType_t` contains all supported types.

Common types defines ordinary histogram, calculated for a whole image. Component generates one histogram for grayscale image and three histograms for RGB image.

Number of bins is usually equal to a number of tone levels. But number of bins has significant influence on performance. So use less bins as possible.

Bayer type histogram interprets grayscale image as Bayer filtered image with defined pattern. Bayer pattern is additional input parameter. Component generates three histograms for Bayer image, for each color in pattern, respectively. Also there is an option when each green pixel in pattern has its own histogram (`FAST_HISTOGRAM_BAYER_G1G2`).

Parade contains multiple histograms for each color. In general case, it gives three color histograms for each image columns. Also there is an option to calculate parade with predefined step to skip several columns.

Structure `fastHistogramBayer_t` could be both static and dynamic parameter for bayer type histogram. Structure `fastHistogramParade_t` could be both static and dynamic parameter for parade histogram.

4.28 *NPP component*

NVIDIA Performance Primitive (NPP) is a large library which provides GPU-accelerated image, video, and signal processing functions. With over 5000 primitives for image and signal processing, you can easily perform multiple tasks.

In FASTVIDEO SDK exits some components, which are based on NPP functions. Some components are wrapper for NPP functions, some components add additional functionality.

There are four NPP-based SDK components: NppFilter, NppGeometry, NppResize, NppRotate.

NppFilter component currently supports gaussian sharpen and unsharp mask filters. Gaussian sharpen filter based on gaussian blur kernel. It is applied to all RGB channels separately. Filter gaussian sharpen is a wrapper for nppiFilterGaussAdvancedBorder*.

Unsharp mask is a smart sharpening filter. It's also based on gaussian blur but it is applied only to Y channel of YCbCr image. Chrominance channels are not changed. Also it has additional parameters: threshold, amount, envelope. Threshold controls the minimum brightness change that will be sharpened or how far apart adjacent tonal values have to be before the filter does anything. Amount is how much contrast is added at the edges. Envelope function allows to make Amount parameter depend on pixel brightness. Amount has maximum value in the center of pixel brightness range. And minimum value on the border of range. This is to reduce over saturation for bright and dark areas.

Envelope function is defined like that:

$$\mathsf{envelope} = \exp\left(\mathsf{coef} \times \left(\frac{\mathsf{value} - \mathsf{median}}{\mathsf{sigma}}\right)^{\mathsf{rank}}\right)$$

where

- value – pixel brightness in range $[0; 1]$,
- median – median value in range $[0; 1]$,

- sigma - variance value in range $[0; 1]$,
- rank has to be even,
- coef is negative value.

NppGeometry component currently supports image remap operation. Remap operation is a wrapper for nppiRemap* functions.

NppResize component resize image with selected interpolation mode. This component is a wrapper for nppiRotate* functions.

NppRotate component rotates an image around the origin $(0, 0)$ and then shifts it. This component is a wrapper for nppiRotate* functions.

4.29 *Auxiliary functions*

Auxiliary functions give access to internal pipeline information to help user to identify and solve some software issues.

Function `fastGetDeviceSurfaceBufferInfo` extracts information from device surface buffer about surface format, maximal image width, height and pitch, current image width, height and pitch. This information allows to control surface and image size, which could be changed in the pipeline. Surface format and maximum image size in device surface buffer are initialized after component creation. Image size and pitch are initialized after call of transform function.

If create function of component returns `FAST_UNSUPPORTED_SURFACE` then one should call `fastGetDeviceSurfaceBufferInfo` and check whether the component supports current surface format.

If transform function of component returns `FAST_INVALID_SIZE` this means that image size is lager than maxWidth and maxHeight, which were assigned to component on creation. User has to call `fastGetDeviceSurfaceBufferInfo` and check image size.

Most functions from FASTVIDEO SDK are asynchronous. Only functions that copy from device memory to host are synchronous. Such a behavior is the result of asynchronous nature of CUDA kernel call. Asynchronous call allows to increase performance but results in problem with error handling. Failed function can return not own error but error that was raised in any function before. So it is impossible to determine what function is crashed.

Global option Interface Synchronization adds to the end of all interfaces method `cudaDeviceSyncronize` call. This localizes problem in one interface method. Error can not pass bound between calls. Function `fastEnableInterfaceSynchronization` enables

and disables Interface Synchronization. By default InterfaceSynchronization is disabled. If InterfaceSynchronization is enabled, performance is degraded greatly. So use this option only for debug purposes.

4.30 *Trace functions*

SDK Trace stores to file all parameters of all called FASTVIDEO SDK functions and their returned statuses. All public fields of device surface buffer are serialized in the trace module as well.

Trace helps user to check all parameters and to find errors during creation or transform phases. FASTVIDEO support team can request trace file to reproduce a problem. Trace file is an ordinary text file so user can verify that there is no private information in its content.

To enable trace function `fastTraceCreate` has to be called with trace file name/path. Function `fastTraceClose` flushes buffers and closes trace file. Name of trace file is a global option.

Some of failures are raised by structural exception like segmentation fault or stack destroying or other and cannot be catch by C++ try catch. In this case user cannot call `fastTraceClose` to close trace file correctly and will loose some trace information. To avoid loosing trace information user has to enable trace flush global option. If trace flush is enabled, every trace write will be stored to file. Function `fastTraceEnableFlush` enables and disables trace flush option.

4.31 *Sample Applications*

There are the following sample applications in SDK:

- `BayerCompressionSample`,
- `CameraMultiSample`,
- `CameraSample`,
- `ComponentsSample`,
- `DebayerJpegSample`,
- `DebayerSample`,
- `DenoiseSample`,
- `FfmpegSample`,
- `HistogramSamplem`,

- `ImageConverterSample`,
- `J2kDecoderSample`,
- `J2kEncoderSample`,
- `JpegAsyncSample`,
- `JpegSample`,
- `MuxSample`,
- `NppSample`,
- `PhotoHostingSample`,
- `RawImportSample`,
- `ResizeSample`,
- `SDIConverterSample`.

All sample applications can process single file or folder. In the case of folder, multiple files are processed in a loop.

Every console application has help shown by empty command line or -help parameter. There is .cmd file for each application demonstrated the whole application functionality. These files are located in the ./bin/ directory.

The `BayerCompressionSample` demonstrates how to split, compress, decompress and merge Raw Bayer data for camera application.

The `CameraMultiSample` demonstrates pipeline processed image from two cameras. Adjustable parameters are individual for each camera. Processed images have been stored to the two separate motion JPEG files.

The `CameraSample` demonstrates how to implement full image processing pipeline for data from a camera, including visualizing via OpenGL. The application also demonstrates pixel correction operation and LUT transform, etc. CameraSample is the only demo project that need CUDA SDK to be installed.

The `ComponentsSample` demonstrates various components of SDK that does not included in other samples. For more information see sample help.

The `DebayerSample` demonstrates how to work with API of Debayer component. Class `Debayer (Debayer.h, Debayer.cpp)` encapsulates API calls for Debayer.

The `DebayerJpegSample` demonstrates how to integrate Debayer with JPEG Encoder.

The `DenoiseSample` demonstrates Denoiser component.

The `FfmpegSample` demonstrates image compression to Motion JPEG and decompression from Motion JPEG.

The `HistogramSample` demonstrates Histogram component.

The `ImageConverterSample` converts 8 bits PGM/PPM to 12/16 bits PGM/PPM and vice versa. Also the ImageConverterSample converts 12/16 bits PGM to supported RAW and vice versa.

The `J2KDecoderSample` demonstrates JPEG2000 decoder functionality.

The `J2kEncoderSample` demonstrates JPEG2000 encoder functionality.

The `JpegAsyncSample` demonstrates JPEG encoder functionality in asynchronous mode.

`JpegSample` demonstrates how to work with API of JPEG Encoder/Decoder components of SDK. Classes `Encoder (Encoder.h, Encoder.cpp)` and `Decoder (Decoder.h, Decoder.cpp)` encapsulate API calls for JPEG Encoder and JPEG Decoder respectively. In addition, application demonstrates pixel correction operation and LUT transform for JPEG Encoder.

The `MuxSample` demonstrates Multiplexer componets.

The `NppSample` demonstrates NPP components of SDK.

The `PhotoHostingSample` demonstrates how to integrate in one pipeline the following five components: JPEG Decoder, Crop, Resizer, Image Filter, JPEG Encoder.

The `RawImportSample` demonstrates file import in RAW format (XIMEA and PTG versions).

The `SDIConverterSample` demonstrates how to import SDI image into pipeline and how to export SDI image from pipeline to host memory.

Next table links components and samples. The first column is component or subcomponent name. The second column is sample project name. The third column is name of file in a sample project. File contains minimum pipeline to component demonstration. There are two files with .h and .cpp extension with the same name.

Table 9. List of sample applications for components

Component	**Sample**	**File**
Affine Transformation (4.18, 5.15)	ComponentsSample	Affine
Bayer Merger (4.23, 5.21)	BayerCompressionSample	DecoderMerger
Bayer Splitter (4.23, 5.20)	BayerCompressionSample	SplitterEncoder

Table 9. List of sample applications for components

Component	Sample	File
BGRX import (*, *)	ComponentsSample	BGRXImport
Crop Component (4.19, 5.16)	ComponentsSample	Crop
Debayer (4.10, 5.7). Include multi-thread	DebayerSample	Debayer
JPEG2000 Decoder in batch mode and multi-thread (4.15, 5.14)	J2KDecoderSample	J2kDecoderBatch
JPEG2000 Decoder in single mode (4.15, 5.14)	J2KDecoderSample	J2kDecoderOneImage
JPEG2000 Encoder in batch mode and multi-thread (4.15, 5.13)	J2KEncoderSample	J2kEncoderBatch
JPEG2000 Encoder in single mode (4.15, 5.13)	J2KEncoderSample	J2kEncoderOneImage
JPEG Encoder (8/12-bits) (4.13, 5.12, 5.9). Include multi-thread	JpegSample	Encoder
JPEG Encoder. Asynchronous version (4.13, 5.12, 5.9)	JpegAsyncSample	EncoderAsync
JPEG Decoder (4.13, 5.12, 5.10). Include multi-thread	JpegSample	Decoder
JPEG Decoder for 12-bits images (4.14, 5.12, 5.11)	JpegSample	DecoderCpu

Table 9. List of sample applications for components

Component	**Sample**	**File**
HDR Builder (4.21, 5.19)	HdrSample	HdrBuilder
Histogram: common, bayer, parade (4.27, 5.27)	HistogramSample	Histogram
Image Filters. Bad Pixel Correction (*, 5.17)	ComponentsSample	BadPixelCorrection
Image Filters. Base Color Correction (4.20.1, 5.17)	ComponentsSample	BaseColorCorrection
Image Filters. Bayer Black Shift (4.20.2, 5.17)	ComponentsSample	BayerBlackShift
Image Filters. Binning filter (4.20.3, 5.17)	ComponentsSample	Binning
Image Filters. Flat-field correction (4.20.4, 5.17)	ComponentsSample	Ffc
Image Filters. Defringe (*, *)	ComponentsSample	Defringe
Image Filters. LUT. HSV 3D (4.20.9, 5.17)	ComponentsSample	HSVLut3D
Image Filters. LUT. RGB 3D (4.20.8, 5.17)	ComponentsSample	RGBLut3D
Image Filters. LUT (LUT_12_*, LUT_16_*) (4.20.7, 5.17)	ComponentsSample	Lut16

Table 9. List of sample applications for components

Component	Sample	File
Image Filters. LUT (LUT_8_8) (4.20.7, 5.17)	ComponentsSample	Lut8
Image Filters. LUT (LUT_8_8_C) (4.20.7, 5.17)	ComponentsSample	Lut8C
Image Filters. LUT (LUT_*_16_BAYER) (4.20.7, 5.17)	ComponentsSample	LutBayer
Image Filters. Median (4.20.10, 5.17)	ComponentsSample	Median
Image Filters. SAM (4.20.11, 4.20.7, 5.17)	ComponentsSample	Sam
Image Filters. Tone Curve (4.20.12, 5.17)	ComponentsSample	ToneCurve16
MJPEG Decoder (4.17, 4.13, 5.10)	FfmpegSample	FfmpegDecoder
MJPEG Encoder (4.17, 4.13, 5.9)	FfmpegSample	FfmpegEncoder
MJPEG Encoder. Asynchronous (4.17, 4.13, 5.9)	FfmpegSample	FfmpegEncoderAsync
Mux (*, 5.23)	MuxSample	DebayerMux
NPP Filter. Gaussian Filter (4.28, 5.28)	NppSample	Gauss

Table 9. List of sample applications for components

Component	Sample	File
NPP Filter. Unsharp Mask (4.28, 5.28)	NppSample	UnsharpMask
NPP Geometry. Perspective (4.28, 5.29)	NppSample	Perspective
NPP Geometry. Remap (4.28, 5.29)	NppSample	Remap
NPP Geometry. Remap by channel (4.28, 5.29)	NppSample	Remap3
NPP Resize (4.28, 5.30)	NppSample	Resize2
NPP Rotate (4.28, 5.31)	NppSample	Rotate
Raw Import (XIMEA12, PTG12, from device) (*, *)	RawImportSample	RawImportFromDevice
Raw Import (XIMEA12, PTG12, from host) (*, *)	RawImportSample	RawImportFromHost
Resize (4.22, 5.18)	ResizeSample	Resize
SDI Export (to device buffer) (4.24, 5.24)	SDIConverterSample	SDIExportToDevice
SDI Export with custom YUV (to host buffer) (4.24, 5.24)	SDIConverterSample	SDIExportToHost
SDI Import with custom YUV (from device buffer) (4.24, 5.24)	SDIConverterSample	SDIImportFromDevice

Table 9. List of sample applications for components

Component	Sample	File
SDI Import with custom YUV (from host buffer) (4.24, 5.24)	SDIConverterSample	SDIImportFromHost
Spatial Denoiser (*, 5.8)	DenoiseSample	Denoise
Surface Convertion. Bit Depth (4.26, 5.26)	ComponentsSample	BitDepthConverter
Surface Convertion. Select Channel From RGB (4.26, 5.26)	ComponentsSample	SelectChannel
Surface Convertion. Gray To RGB (4.26, 5.26)	ComponentsSample	GrayToRgb
Surface Convertion. RGB To Gray (4.26, 5.26)	ComponentsSample	RgbToGray

4.32 *How to create your own applications with that SDK*

It's a good idea to start from doing some tests with command-line sample applications, which come with FASTVIDEO SDK. This is important to be sure that you understand all parameters, have right input image and final image is fine in terms of quality.

Then one could start from source code analysis of our sample applications to build your own software. At this point one can work with images on HDD/SSD to reproduce working solution with good image quality.

Next step is an attempt to work with your data which reside in a system memory or GPU memory. You can copy data from HDD/SSD to system memory and check the performance.

In the case if you have packed data from a camera, we suggest to switch to 8-bit

camera mode to exclude packing, at least at the beginning. At this stage you need to create your software which is working with camera data in system memory. Unpacking could be added later, as soon as your application is working.

4.33 *Demo Applications*

Apart from sample applications in the FASTVIDEO SDK, you can get ready-to-use demo applications from the following site https://www.fastcompression.com at download section. You can find there the following software for Windows:

- CUDA Debayer – command-line application for debayering (all bayer patterns, 8/12/16-bit data, demosaicing algorithms HQLI, DFPD, MG;
- CUDA JPEG Codec – command-line application for JPEG compression and decompression;
- CUDA J2K Codec – command-line application for J2K encoding and decoding;
- CUDA Resize – command-line application for resize.

Fast CinemaDNG Processor (for Windows and Linux) – GUI application for realtime processing of CinemaDNG image series and MLV video on GPU.

You can get more info at https://www.fastcinemadng.com

5 Fastvideo SDK API

5.1 *Statuses*

All SDK functions return result status of `fastStatus_t` type.

- FAST_OK – There is no error during function execution.
- FAST_TRIAL_PERIOD_EXPIRED – Trial period expired for demo version of SDK. All functions are shut down.
- FAST_INVALID_DEVICE – Device with selected index does not exist or device is non NVIDIA device or device is non CUDA-compatible device.
- FAST_INCOMPATIBLE_DEVICE – Device is CUDA-compatible, but its compute compatibility is below 3.0, thus device is considered to be incompatible with SDK.
- FAST_INSUFFICIENT_DEVICE_MEMORY – Available device memory is not enough to allocate new buffer.
- FAST_INSUFFICIENT_HOST_MEMORY – Available host memory is not enough to allocate new buffer.
- FAST_INVALID_HANDLE – Component handle is invalid or has inappropriate type.
- FAST_INVALID_VALUE – Some parameter of the function called is invalid or combination of input parameters are unacceptable.
- FAST_UNAPPLICABLE_OPERATION – This operation can not be applied to the current type of data.
- FAST_INVALID_SIZE – Image dimension is invalid.
- FAST_UNALIGNED_DATA – Buffer base pointers or pitch are not properly aligned.
- FAST_INVALID_TABLE – Invalid quantization / Huffman table.
- FAST_BITSTREAM_CORRUPT – JPEG bitstream is corrupted and can not be decoded.
- FAST_EXECUTION_FAILURE – Device kernel execution failure.
- FAST_INTERNAL_ERROR – Internal error, non-kernel software execution failure.
- FAST_UNSUPPORTED_SURFACE – Current component does not support this type of surface. Check documentation.
- FAST_IO_ERROR – Failed to read/write file.
- FAST_INVALID_FORMAT – Invalid file format.
- FAST_UNSUPPORTED_FORMAT – File format is not supported by the current

version of SDK.

- FAST_END_OF_STREAM – Error related motion JPEG decoding. Unexpected end of stream.
- FAST_MJPEG_THREAD_ERROR – Error related motion JPEG encoding/decoding. General error in worker thread.
- FAST_TIMEOUT – Error related motion JPEG encoding/decoding or other video coding. Timeout in worker thread.
- FAST_MJPEG_OPEN_FILE_ERROR – Error related motion JPEG encoding/decoding. Could not open file.
- FAST_UNKNOWN_ERROR – Unrecognized error.

5.2 *Master SDK and secondary library initialization*

5.2.1 *fastInit*

```
fastStatus_t fastInit (
  unsigned affinity,
  bool openGlMode)
```

Sets GPU device to work with.

Parameters:

affinity[in] – affinity mask. "1" in less significant bit of affinity mask denotes to use GPU with device Id = 1. "1" in next bit denotes to use GPU with device Id = 2 and so on.

openGlMode[in] – if openGlMode set to be true, then FASTVIDEO SDK is initialized to work with OpenGL application. In other case FASTVIDEO SDK is initialized to work with ordinary CUDA application.

Notes:

If device is not found or device is not NVIDIA device or device does not support CUDA, function will return status FAST_INVALID_DEVICE.

If device has compute compatibility below 3.0, function will return status FAST_INCOMPATIBLE_DEVICE.

Statuses:

- FAST_OK,
- FAST_INVALID_DEVICE,
- FAST_INTERNAL_ERROR,
- FAST_INCOMPATIBLE_DEVICE.

5.2.2 *fastGetSdkParametersHandle*

```
fastStatus_t fastGetSdkParametersHandle (
    fastSdkParametersHandle_t *handle)
```

Gets handle of SDK global options.

Parameters:

handle[out] – pointer to global options handle.

Statuses:

- FAST_OK.

5.2.3 *fastLibraryInit*

```
fastStatus_t fast*LibraryInit (
    fastSdkParametersHandle_t handle)
```

Inits secondary library of component by SDK global options.

Parameters:

handle[in] – global options handle.

Statuses:

- FAST_OK.

5.3 *Trace and Auxiliary functions*

5.3.1 *fastGetDeviceSurfaceBufferInfo*

```
fastStatus_t fastGetDeviceSurfaceBufferInfo (
    fastDeviceSurfaceBufferHandle_t buffer,
    fastDeviceSurfaceBufferInfo_t *devBuffer)
```


Gets public information from device surface buffer.

Parameters:

buffer[in] – handle of device surface buffer;

devBuffer[out] – pointer to structure with public information.

Notes:

Structure fastDeviceSurfaceBufferInfo_t contains the following fields:

- surfaceFmt – type of surface. Value is fastSurfaceFormat_t enum integer values. Values 13 and 14 are internal representations of FAST_RGB12 and FAST_RGB16 formats respectively. Value is defined after component creation.
- maxWidth – maximum width of processed image. Value is defined after component creation.
- maxHeight – maximum height of processed image. Value is defined after component creation.
- maxPitch – pitch for maximal image. Value is defined after component creation.
- width – width of currently processed image. Value is defined after call of transform function.
- height – height of currently processed image. Value is defined after call of transform function.
- pitch – pitch of currently processed image. Value is defined after call of transform function.

Statuses:

- FAST_OK.

5.3.2 *fastEnableInterfaceSynchronization*

```
fastStatus_t fastEnableInterfaceSynchronization (
  bool isEnabled)
```

Sets value of interface synchronization in global option.

Parameters:

isEnabled[in] – option value.

Notes:

Global option Interface Synchronization adds to the end of all interfaces method cudaDeviceSyncronize call. This localizes problem in one interface method. Asynchronous error can not pass bound between calls.

Statuses:

- FAST_OK.

5.3.3 *fastTraceCreate*

```
fastStatus_t fastTraceCreate (
  const char *fileName)
```

Opens trace file.

Parameters:

fileName[in] – file path or file name for trace file.

Notes:

If file cannot be opened or created function returns FAST_IO_ERROR.

Statuses:

- FAST_OK,
- FAST_IO_ERROR.

5.3.4 *fastTraceClose*

```
fastStatus_t fastTraceClose()
```

Closes current trace file.

Statuses:

- FAST_OK.

5.3.5 *fastTraceEnableFlush*

```
fastStatus_t fastTraceEnableFlush (bool enableFlush)
```


Sets value of trace flush in global option.

Parameters:

enableFlush[in] – option value.

Notes:

If trace flush is enabled, every trace write will be stored to file immediately.

Statuses:

- FAST_OK.

5.4 *Memory management functions*

5.4.1 *fastMalloc*

```
fastStatus_t fastMalloc (
  void **buffer,
  size_t size)
```

Allocates page-locked memory on CPU.

Parameters:

buffer[out] – pointer to allocated memory;

size[in] – size of allocated memory in Bytes.

Notes:

Page-locked memory cannot be moved from RAM to swap file. It increases PCI-Express I/O speed of GPU over conventional memory.

If system can not allocate page-locked memory, then function will return status FAST_INSUFFICIENT_HOST_MEMORY.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.4.2 *fastFree*

```
fastStatus_t fastFree (void *buffer)
```


Frees page-locked memory.

Parameters:

buffer[in] – pointer to allocated memory.

Statuses:

- FAST_OK,
- FAST_INTERNAL_ERROR.

5.4.3 *fastGetDevices*

```
fastStatus_t fastGetDevices (
  fastDeviceProperty **devices,
  int *count)
```

5.5 *Pipeline import functions*

5.5.1 *fastImportFromHostCreate*

```
fastStatus_t fastImportFromHostCreate (
  fastImportFromHostHandle_t *handle,
  fastSurfaceFormat_t surfaceFmt,
  unsigned maxWidth,
  unsigned maxHeight,
  fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates ImportFromHostAdapter and returns associated handle.

Parameters:

handle[out] – pointer to created ImportFromHostAdapter handle;

surfaceFmt[in] – defines input pixel format;

maxWidth[in] – maximum image width in pixels;

maxHeight[in] – maximum image height in pixels;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastImportFromHostCreate allocates all necessary buffers in GPU memory. In case GPU does not have enough free memory, fastImportFromHostCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY.

5.5.2 *fastImportFromHostGetAllocatedGpuMemorySize*

```
fastStatus_t fastImportFromHostGetAllocatedGpuMemorySize (
    fastImportFromHostHandle_t handle,
    unsigned *allocatedGpuSizeInBytes)
```

Returns requested GPU memory for ImportFromHostAdapter.

Parameters:

handle[in]	–	ImportFromHostAdapter handle;
allocatedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for ImportFromHostAdapter.

Statuses:

- FAST_OK.

5.5.3 *fastImportFromHostCopy*

```
fastStatus_t fastImportFromHostCopy (
    fastImportFromHostHandle_t handle,
    void* h_src,
    unsigned width,
    unsigned pitch,
    unsigned height)
```

Copies image from CPU buffer to pipeline.

Parameters:

handle[in] – ImportFromHostAdapter handle;

h_src[in] – pointer on CPU buffer with image data;

width[in] – image width in pixels;

pitch[in] – size of image row in Bytes;

height[in] – image height in pixels.

Notes:

Buffer h_src has to be allocated with fastMalloc. Buffer allocated by original malloc also can be used, but copy speed will degrade.

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.5.4 *fastImportFromHostDestroy*

```
fastStatus_t fastImportFromHostDestroy (
  fastImportFromHostHandle_t handle)
```

Destroys ImportFromHostAdapter.

Parameters:

handle[in] – ImportFromHostAdapter handle.

Statuses:

- FAST_OK.

5.5.5 *fastImportFromDeviceCreate*

```
fastStatus_t fastImportFromDeviceCreate (
  fastImportFromDeviceHandle_t *handle,
  fastSurfaceFormat_t surfaceFmt,
  unsigned maxWidth,
  unsigned maxHeight,
```


fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates ImportFromDeviceAdapter and returns associated handle.

Parameters:

handle[out] – pointer to created ImportFromDeviceAdapter handle;

surfaceFmt[in] – defines input pixel format;

maxWidth[in] – maximum image width in pixels;

maxHeight[in] – maximum image height in pixels;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastImportFromDeviceCreate allocates all necessary buffers in GPU memory. In case GPU does not have enough free memory, then fastImportFromDeviceCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY.

5.5.6 *fastImportFromDeviceGetAllocatedGpuMemorySize*

fastStatus_t fastImportFromDeviceGetAllocatedGpuMemorySize (
fastImportFromDeviceHandle_t handle,
unsigned *allocatedGpuSizeInBytes)

Returns requested GPU memory for ImportFromDeviceAdapter.

Parameters:

handle[in] – ImportFromDeviceAdapter handle;

allocatedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for ImportFromDeviceAdapter.

Statuses:

- FAST_OK.

5.5.7 *fastImportFromDeviceCopy*

fastStatus_t fastImportFromDeviceCopy (
fastImportFromDeviceHandle_t handle,
void* d_src,
unsigned width,
unsigned pitch,
unsigned height)

Copies image from GPU buffer to pipeline.

Parameters:

handle[in] – Import From Device Adapter handle;

d_src[in] – pointer on Device buffer with image;

width[in] – image width in pixels;

pitch[in] – size of image row in Bytes;

height[in] – image height in pixels.

Notes:

Buffer d_src has to be allocated in Device memory by cudaMalloc.

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.5.8 *fastImportFromDeviceDestroy*

fastStatus_t fastImportFromDeviceDestroy (fastImportFromDeviceHandle_t handle)

Destroys ImportFromDeviceAdapter.

Parameters:

handle[in] – ImportFromDeviceAdapter handle.

Statuses:

- FAST_OK.

5.6 *Pipeline export functions*

5.6.1 *fastExportToHostCreate*

```
fastStatus_t fastExportToHostCreate (
  fastExportToHostHandle_t *handle,
  fastSurfaceFormat_t *surfaceFmt,
  fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Creates ExportToHostAdapter and returns associated handle.

Parameters:

handle[out] – pointer to created ExportToHostAdapter handle;

surfaceFmt[out] – pipeline output surface format;

srcBuffer[in] – linked buffer from previous component.

Statuses:

- FAST_OK.

5.6.2 *fastExportToHostGetAllocatedGpuMemorySize*

```
fastStatus_t fastExportToHostGetAllocatedGpuMemorySize (
  fastExportToHostHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Gets ExportToHostAdapter GPU memory usage.

Parameters:

handle[in] – ExportToHostAdapter handle;

requestedGpuSizeInBytes[out] – memory usage in Bytes.

Statuses:

- FAST_OK.

5.6.3 *fastExportToHostChangeSrcBuffer*

```
fastStatus_t fastExportToHostChangeSrcBuffer (
  fastExportToHostHandle_t handle,
  fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in] – ExportToHostAdapter handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.6.4 *fastExportToHostCopy*

```
fastStatus_t fastExportToHostCopy (
  fastExportToHostHandle_t handle,
  void* h_dst,
  unsigned width,
  unsigned pitch,
  unsigned height,
  fastExportParameters_t *parameters)
```

Copies image from pipeline to CPU buffer.

Parameters:

handle[in] – ExportToHostAdapter handle;

h_dst[in] – pointer on Host buffer for image;

width[in] – image width in pixels;

pitch[in] – size of image row in Bytes;

height[in] – image height in pixels;

parameters[in] – export parameters.

Notes:

Buffer h_dst has to be allocated with fastMalloc. Buffer, which is allocated by original malloc also can be used, but copy speed will degrade. If size of h_dst is not enough, then the function will fail with segmentation fault.

Export Parameters allows to convert RGB color format to BGR color format. In other case parameters have to be null. To convert color format to BGR convert member of fastExportParameters_t have to set in FAST_CONVERT_BGR.

Statuses:

- FAST_OK.

5.6.5 *fastExportToHostDestroy*

```
fastStatus_t fastExportToHostDestroy (fastExportToHostHandle_t handle)
```

Destroys ExportToHostAdapter.

Parameters:

handle[in] – ExportToHostAdapter handle.

Statuses:

- FAST_OK.

5.6.6 *fastExportToDeviceCreate*

```
fastStatus_t fastExportToDeviceCreate (
    fastExportToDeviceHandle_t *handle,
    fastSurfaceFormat_t *surfaceFmt,
    fastDeviceSurfaceBufferHandle_t srcBuffer)
```


Creates ExportToDeviceAdapter and returns associated handle.

Parameters:

handle[out] – pointer to created ExportToDeviceAdapter handle;

surfaceFmt[out] – pipeline output surface format;

srcBuffer[in] – linked buffer from previous component.

Statuses:

- FAST_OK.

5.6.7 *fastExportToDeviceCopy*

```
fastStatus_t fastExportToDeviceCopy (
  fastExportToDeviceHandle_t handle,
  void* d_dst,
  unsigned width,
  unsigned pitch,
  unsigned height,
  fastExportParameters_t *parameters)
```

Copies image from pipeline to GPU buffer.

Parameters:

handle[in] – ExportToDeviceAdapter handle;

d_dst[in] – pointer on Device buffer for image;

width[in] – image width in pixels;

pitch[in] – size of image row in Bytes;

height[in] – image height in pixels;

parameters[in] – export parameters.

Notes:

Buffer d_dst has to be allocated in Device memory by cudaMalloc. If size of d_dst is not enough, then function will fail with segmentation fault.

Export Parameters allows to convert RGB color format to BGR color format. In other case parameters have to be null. To convert color format to BGR convert member of fastExportParameters_t have to set in FAST_CONVERT_BGR.

Statuses:

- FAST_OK.

5.6.8 *fastExportToDeviceGetAllocatedGpuMemorySize*

```
fastStatus_t fastExportToDeviceGetAllocatedGpuMemorySize (
    fastExportToDeviceHandle_t handle,
    unsigned *requestedGpuSizeInBytes)
```

Gets ExportToDeviceAdapter GPU memory usage.

Parameters:

handle[in]	–	ExportToDeviceAdapter handle;
requestedGpuSizeInBytes[out]	–	memory usage in Bytes.

Statuses:

- FAST_OK.

5.6.9 *fastExportToDeviceChangeSrcBuffer*

```
fastStatus_t fastExportToDeviceChangeSrcBuffer (
    fastExportToDeviceHandle_t handle,
    fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in]	–	ExportToHostAdapter handle;
srcBuffer[in]	–	new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.6.10 *fastExportToDeviceDestroy*

fastStatus_t fastExportToDeviceDestroy (fastExportToDeviceHandle_t handle)

Destroys ExportToDeviceAdapter.

Parameters:

handle[in] – ExportToDeviceAdapter handle.

Statuses:

- FAST_OK.

5.7 *Debayer functions*

5.7.1 *fastDebayerCreate*

```
fastStatus_t fastDebayerCreate (
  fastDebayerHandle_t *handle,
  fastDebayerType_t debayerType,
  unsigned maxWidth,
  unsigned maxHeight,
  fastDeviceSurfaceBufferHandle_t srcBuffer,
  fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates Debayer and returns associated handle.

Parameters:

handle[out]	–	pointer to created Debayer handle;
debayerType[in]	–	debayer algorithm (HQLI, L7, DFPD, MG, BINNING_{2x2, 4x4, 8x8});
maxHeight[in]	–	maximum image height in pixels;
maxWidth[in]	–	maximum image width in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastCreateDebayerHandle allocates all necessary buffers in GPU memory. In case GPU does not have enough free memory, then fastCreateDebayerHandle will return FAST_INSUFFICIENT_DEVICE_MEMORY.

Maximum dimensions of the image are set to Debayer during creation. Thus if transformation result exceeds the maximum value, then error status FAST_INVALID_SIZE will be returned.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.7.2 *fastDebayerGetAllocatedGpuMemorySize*

```
fastStatus_t fastDebayerGetAllocatedGpuMemorySize (
  fastDebayerHandle_t handle,
  unsigned * requestedGpuSizeInBytes)
```

Returns requested GPU memory for Debayer.

Parameters:

handle[in]	–	Debayer handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Debayer.

Statuses:

- FAST_OK.

5.7.3 *fastDebayerChangeSrcBuffer*

```
fastStatus_t fastDebayerChangeSrcBuffer (
    fastDebayerHandle_t handle,
    fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer

Parameters:

handle[in] – Debayer handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.7.4 *fastDebayerTransform*

```
fastStatus_t fastDebayerTransform (
    fastDebayerHandle_t handle,
    fastBayerPattern_t bayerFmt,
    unsigned width,
    unsigned height)
```

Restores image colors.

Parameters:

handle[in] – Debayer handle;

bayerFmt[in] – bayer pattern;

height[in] – image height in pixels;

width[in] – image width in pixels.

Notes:

The procedure takes Bayer image from input linked buffer, restores colors based on pattern and algorithm and then stores color image to output linked buffer.

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.7.5 *fastDebayerDestroy*

```
fastStatus_t fastDebayerDestroy (debayerHandle_t handle)
```

Destroys Debayer handle.

Parameters:

handle[in] – Debayer handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.8 *Denoise functions*

5.8.1 *fastDenoiseCreate*

```
fastStatus_t fastDenoiseCreate (
  fastDenoiseHandle_t *handle,
```



```
    fastSurfaceFormat_t surfaceFmt,
    void *staticDenoiseParameters,
    unsigned maxWidth,
    unsigned maxHeight,
    fastDeviceSurfaceBufferHandle_t srcBuffer,
    fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates Denoise and returns associated handle.

Parameters:

handle[out]	–	pointer to created Denoise handle;
surfaceFmt[in]	–	image surface format;
staticDenoiseParameters[in]	–	static parameters for Denoise;
maxHeight[in]	–	maximum image height in pixels;
maxWidth[in]	–	maximum image width in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastCreateDenoiseHandle allocates all necessary buffers in GPU memory. In case GPU does not have enough free memory, then fastCreateDenoiseHandle will return FAST_INSUFFICIENT_DEVICE_MEMORY.

Maximum dimensions of the image are set to Denoise during creation. Thus if transformation result exceeds the maximum value, then error status FAST_INVALID_SIZE will be returned.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Structure denoise_static_parameters_t contains static parameters for Denoise:

```
typedef struct {
  fastDenoiseThresholdFunctionType_t function;
  fastWaveletType_t wavelet;
} denoise_static_parameters_t
```

where

- function – type of threshold function. All threshold functions are enumerated in fastDenoiseThresholdFunctionType_t;
- wavelet – type of used wavelet. All wavelets are enumerated in fastWaveletType_t.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.8.2 *fastDenoiseGetAllocatedGpuMemorySize*

```
fastStatus_t fastDenoiseGetAllocatedGpuMemorySize (
  fastDenoiseHandle_t handle,
  unsigned *allocatedGpuSizeInBytes)
```

Returns requested GPU memory for Denoise.

Parameters:

handle[in]	–	Denoise handle;
allocatedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Denoise.

Statuses:

- FAST_OK.

5.8.3 *fastDenoiseChangeSrcBuffer*

```
fastStatus_t fastDenoiseChangeSrcBuffer (
  fastDenoiseHandle_t handle,
  fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in] – Denoise handle;

srcBuffer[in] – new source buffer

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.8.4 *fastDenoiseTransform*

```
fastStatus_t fastDenoiseTransform (
  fastDenoiseHandle_t handle,
  void *denoiseParameters,
  unsigned width,
  unsigned height)
```

Denoises image.

Parameters:

handle[in] – Denoise handle;

denoiseParameters[in] – dynamic parameters for Denoise;

height[in] – image height in pixels;

width[in] – image width in pixels.

Notes:

The procedure takes the image from input linked buffer, filters the image based on dynamic parameters and then stores the image to output linked buffer.

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Structure denoise_parameters_t contains dynamic parameters for Denoise.

```
typedef struct {
```



```
    int dwt_levels;
    float enhance[3];
    float threshold[3];
    float threshold_per_level[33];
} denoise_parameters_t
```

where

- dwt_levels – number of DWT transforms (maximum is 11);
- enhance[3] – gains for each channel of YCbCr. Applied after threshold function to wavelet coefficient.
- threshold[3] – basic thresholds for Y, Cb and Cr channels respectively;
- threshold_per_level[33] – individual relative thresholds for each wavelet band. The first three values in the array correspond to values of Y, Cb and Cr of the first band. Resulting threshold for each wavelet band of channel is multiplication of threshold by respective threshold_per_level.

Resulting threshold is applied to wavelet coefficient through threshold function multipliers for threshold_per_level for Y, Cb and Cr. Total threshold is equal to the result of

$$\text{threshold\_per\_level} \times \text{threshold}$$

for each band and each color channel.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.8.5 *fastDenoiseTransformBayerPlanes*

```
fastStatus_t fastDenoiseTransformBayerPlanes (
    fastDenoiseHandle_t handle,
    void *denoiseParameters,
```


unsigned width,
unsigned height)

Denoises separated planes of Bayer filtered image.

Parameters:

handle[in]	–	Denoise handle;
denoiseParameters[in]	–	dynamic parameters for Denoise;
height[in]	–	image height in pixels;
width[in]	–	image width in pixels.

Notes:

The procedure process separated planes of Bayer filtered image prepared by Bayer Splitter component. It filters each planes separately. Resulted planes have to be merged to the one image by Bayer Merger component. Calling the function on normal gray scale image will cause image destruction. So the only way of using denoise component with the function is as part of pipeline where preceding component is Bayer Splitter and following component is Bayer Merger component.

Dynamic parameters and generated error

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.8.6 *fastDenoiseDestroy*

fastStatus_t fastDenoiseDestroy (fastDenoiseHandle_t handle)

Destroys Denoise handle.

Parameters:

handle[in] – Denoise handle.

Notes:

Procedure frees component's device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.9 *JPEG Encoder functions*

5.9.1 *fastJpegEncoderCreate*

```
fastStatus_t fastJpegEncoderCreate (
  fastJpegEncoderHandle_t *handle,
  unsigned maxHeight,
  unsigne maxWidth,
  fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Creates JPEG 8 or 12 bits Encoder and returns associated handle.

Parameters:

handle[out] – pointer to created JPEG Encoder handle;

maxHeight[in] – maximum image height in pixels;

maxWidth[in] – maximum image width in pixels;

srcBuffer[in] – linked buffer from previous component.

Notes:

It is important to note that there is no additional parameters to enable 12-bit encoder. The same encoder component and interface functions are used for both 8 and 12 bit encoder. Encoder type is selected automatically by bit depth of input surface.

Function fastJpegEncoderCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastJpegEncoderCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Maximum dimensions of the image are set to Encoder during creation. Thus if

encoded image exceeds the maximum value, then error status FAST_INVALID_SIZE will be returned.

Gray image (FAST_I8) can be encoded by color encoder (FAST_RGB8). In this case Encoder converts gray image to color image by duplicating gray channel to all color channels.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.9.2 *fastJpegEncoderGetAllocatedGpuMemorySize*

```
fastStatus_t fastJpegEncoderGetAllocatedGpuMemorySize (
    fastJpegEncoderHandle_t handle,
    unsigned *allocatedGpuSizeInBytes)
```

Returns requested GPU memory for JPEG Encoder.

Parameters:

handle[in]	–	JPEG Encoder handle;
allocatedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for JPEG Encoder.

Statuses:

- FAST_OK.

5.9.3 *fastJpegEncoderChangeSrcBuffer*

```
fastStatus_t fastJpegEncodeChangeSrcBuffer (
```


fastJpegEncoderHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)

Sets new source buffer.

Parameters:

handle[in] – JPEG Encoder handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.9.4 *fastJpegEncode*

fastStatus_t fastJpegEncode (
fastJpegEncoderHandle_t handle,
unsigned quality,
fastJfifInfo_t *jfifInfo)

Encodes surface to JPEG and store to host memory.

Parameters:

handle[in] – JPEG Encoder handle;

quality[in] – memory size in Bytes;

jfifInfo[in] – pointer to fastJfifInfo_t struct that contains all necessary information for JPEG encoding. For more detail see JPEG Encoder Description.

Notes:

The procedure takes surface from previous component of the pipeline through input linked buffer and encodes it accordingly addition parameters from jfifInfo. JPEG bytestream is placed to h_Bytestream buffer in jfifInfo.

Buffer for JPEG bytestream in jfifInfo has to be allocated before call. Its recom-

mended size is

$$\text{surfaceHeight} \times \text{surfacePitch4}.$$

Real JPEG bytestream size is calculated during compression and put to bytestreamSize in jfifInfo. If size of h_Bytestream is not enough, then procedure returns status FAST_INTERNAL_ERROR.

Members of jfifInfo exifSectionsCount and exifSections have to be initialized by 0.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNALIGNED_DATA,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.9.5 *fastJpegEncodeAsync*

```
fastStatus_t fastJpegEncode
(fastJpegEncoderHandle_t handle,
unsigned quality,
fastJfifInfoAsync_t *jfifInfo)
```

Encodes surface to JPEG and store to device memory.

Parameters:

handle[in] – JPEG Encoder handle;

quality[in] – adjusts output JPEG file size and quality. Quality is an integer value from 1 to 100 where 100 means the best quality and maximum file size of compressed image.

jfifInfo[in] – pointer to fastJfifInfoAsync_t struct that contains all necessary information for JPEG encoding. For more detail see JPEG Encoder description.

Notes:

The procedure takes surface from previous component of the pipeline through in-

put linked buffer and encodes it accordingly addition parameters from jfifInfo. JPEG bytestream is placed to d_Bytestream buffer in jfifInfo. Memory for d_Bytestream is allocated by jpeg encoder.

Members of jfifInfo exifSectionsCount and exifSections have to be initialized by 0.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNALIGNED_DATA,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.9.6 *fastJpegEncodeWithQuantTable*

```
fastStatus_t fastJpegEncodeWithQuantTable (
  fastJpegEncoderHandle_t handle,
  fastJpegQuantState_t *quantTable,
  fastJfifInfo_t *jfifInfo)
```

Encodes surface to JPEG with defined quantization table and store to host memory.

Parameters:

handle[in]	–	JPEG Encoder handle;
quantTable[in]	–	user defined quantization table;
jfifInfo[in]	–	pointer to fastJfifInfo_t struct that contains all necessary information for JPEG encoding. For more detail see JPEG Encoder Description.

Notes:

The procedure takes surface from previous component of the pipeline through input linked buffer and encodes it accordingly addition parameters from jfifInfo. JPEG bytestream is placed to h_Bytestream buffer in jfifInfo.

Buffer for JPEG bytestream in jfifInfo has to be allocated before call. Its recom-

mended size is

$$\text{surfaceHeight} \times \text{surfacePitch4}.$$

Real JPEG bytestream size is calculated during compression and put to bytestreamSize in jfifInfo. If size of h_Bytestream is not enough, then procedure returns status FAST_INTERNAL_ERROR.

Members of jfifInfo exifSectionsCount and exifSections have to be initialized by 0.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNALIGNED_DATA,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.9.7 *fastJpegEncodeAsyncWithQuantTable*

```
fastStatus_t fastJpegEncodeAsyncWithQuantTable (
  fastJpegEncoderHandle_t handle,
  fastJpegQuantState_t *quantTable,
  fastJfifInfoAsync_t *jfifInfo)
```

Encodes surface to JPEG with defined quantization table and store to device memory.

Parameters:

handle[in]	–	JPEG Encoder handle;
quantTable[in]	–	user defined quantization table;
jfifInfo[in]	–	pointer to fastJfifInfoAsync_t struct that contains all necessary information for JPEG encoding. For more detail see JPEG Encoder description.

Notes:

The procedure takes surface from previous component of the pipeline through input linked buffer and encodes it accordingly addition parameters from jfifInfo. JPEG

bytestream is placed to d_Bytestream buffer in jfifInfo. Memory for d_Bytestream is allocated by jpeg encoder.

Members of jfifInfo exifSectionsCount and exifSections have to be initialized by 0.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNALIGNED_DATA,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.9.8 *fastJpegEncoderDestroy*

```
fastStatus_t fastJpegEncoderDestroy (fastJpegEncoderHandle_t handle)
```

Destroys JPEG encoder.

Parameters:

handle[in] – JPEG encoder handle.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.10 *JPEG Decoder functions*

5.10.1 *fastJpegDecoderCreate*

```
fastStatus_t fastJpegDecoderCreate (
    fastJpegDecoderHandle_t *handle,
    fastSurfaceFormat_t surfaceFmt,
    unsigned maxWidth,
    unsigned maxHeight,
```


bool checkBytestream,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates JPEG Decoder and returns associated handle.

Parameters:

handle[out]	–	pointer to created JPEG Decoder;
surfaceFmt[in]	–	type of surface (decoded image). Surface is output for decoder.
maxWidth[in]	–	maximum image width in pixels;
maxHeight[in]	–	maximum image height in pixels;
checkBytestream[in]	–	
dstBuffer[out]	–	pointer for linked buffer for next component (output buffer of current component).

Notes:

Function fastJpegDecoderCreate allocates all necessary buffers in GPU memory. Thus in case GPU does not have enough free memory, then fastJpegDecoderCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Maximum dimensions of the image are set to Decoder during creation. Thus if transformation result exceeds the maximum value, then error status FAST_INVALID_SIZE will be returned.

Only FAST_RGB8 and FAST_I8 surface formats are supported in other case FAST_UNSUPPORTED_SURFACE will be returned.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.10.2 *fastJpegDecoderGetAllocatedGpuMemorySize*

fastStatus_t fastJpegDecoderGetAllocatedGpuMemorySize (

fastJpegDecoderHandle_t handle,
unsigned *requestedGpuSizeInBytes)

Returns requested GPU memory for JPEG Decoder.

Parameters:

handle[in] – JPEG Decoder handle;

allocatedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for JPEG Decoder.

Statuses:

- FAST_OK.

5.10.3 *fastJpegDecode*

fastStatus_t fastJpegDecode (fastJpegDecoderHandle_t handle,
fastJfifInfo_t *jfifInfo)

Decodes JPEG to surface.

Parameters:

handle[in] – pointer to JPEG Decoder;

jfifInfo[in] – pointer to fastJfifInfo_t struct that contains all necessary information for JPEG decoding. For more detail see JPEG Encoder description.

Notes:

The procedure takes JPEG bytestream from h_Bytestream buffer in jfifInfo. Additional parameters for decoding are also taken from jfifInfo. Decoded surface is placed to output linked buffer and the following component of the pipeline consumes it. Struct fastJfifInfo_t for Decoder is populated by JfifLoad fuctions: fastJfifLoadFromFile and fastJfifLoadFromMemory.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,

- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_BITSTREAM_CORRUPT.

5.10.4 *fastJpegDecoderDestroy*

fastStatus_t fastJpegDecoderDestroy (fastJpegDecoderHandle_t handle)

Destroys JPEG Decoder.

Parameters:

handle[in] – pointer to JPEG Decoder.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.11 *JPEG CPU Decoder functions*

5.11.1 *fastJpegCpuDecoderCreate*

```
fastStatus_t fastJpegDecoderCreate (
    fastJpegCpuDecoderHandle_t *handle,
    fastSurfaceFormat_t surfaceFmt,
    unsigned maxWidth,
    unsigned maxHeight,
    fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates JPEG CPU Decoder and returns associated handle.

Parameters:

handle[out] – pointer to created JPEG CPU Decoder;

surfaceFmt[in] – type of surface (decoded image). Surface is output for decoder;

maxWidth[in] – maximum image width in pixels;

maxHeight[in] – maximum image height in pixels;

dstBuffer[out] – pointer for linked buffer for next component (output buffer of current component).

Notes:

Function fastJpegCpuDecoderCreate allocates all necessary buffers in GPU memory. Thus in case GPU does not have enough free memory, then fastJpegDecoderCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Only FAST_RGB12 and FAST_I12 surface formats are supported in other case FAST_UNSUPPORTED_SURFACE will be returned.

Maximum dimensions of the image are set to Decoder during creation. Thus if transformation result exceeds the maximum value, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.11.2 *fastJpegCpuDecoderGetAllocatedGpuMemorySize*

```
fastStatus_t fastJpegCpuDecoderGetAllocatedGpuMemorySize (
  fastJpegDecoderHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for JPEG CPU Decoder.

Parameters:

handle[in] – JPEG Cpu Decoder handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for JPEG Decoder.

Statuses:

- FAST_OK.

5.11.3 *fastJpegCpuDecode*

```
fastStatus_t fastJpegCpuDecode (
  fastJpegDecoderHandle_t handle,
  unsigned char *srcJpegStream,
  const long jpegStreamSize,
  fastJfifInfo_t *jfifInfo)
```

Decodes JPEG to surface.

Parameters:

handle[in] – pointer to JPEG Decoder;

srcJpegStream[in] – pointer to buffer with entire jpeg file;

jpegStreamSize[in] – buffer size in Bytes;

jfifInfo[out] – pointer to fastJfifInfo_t struct that takes jpeg parameters of decoded file.

Notes:

The procedure takes JPEG file from srcJpegStream. There are no additional parameters necessary for decoding. Decoded surface is placed to output linked buffer and the following component of the pipeline consumes it. Struct fastJfifInfo_t is populated by fastJpegCpuDecode with parameters of decoded jpeg file.

Fields populated in fastJfifInfo_t are

- width,
- height,
- bitsPerChannel,

- huffmanState (for luminance and chrominance),
- quantState (for luminance and chrominance),
- jpegFmt,
- restartInterval.

Decoder returns FAST_IO_ERROR if 8-bit jpeg will be supplied as input.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_BITSTREAM_CORRUPT.

5.11.4 *fastJpegDecoderDestroy*

```
fastStatus_t fastJpegCpuDecoderDestroy
(fastJpegCpuDecoderHandle_t handle)
```

Destroys JPEG CPU Decoder.

Parameters:

handle[in] – pointer to JPEG CPU Decoder.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.12 *JPEG I/O functions*

5.12.1 *fastJfifLoadFromFile*

```
fastStatus_t fastJfifLoadFromFile (
  const char *filename,
```

fastJfifInfo_t *jfifInfo)

Loads JPEG image from disk to memory.

Parameters:

filename[in] – path to JPEG file;

jfifInfo[in] – pointer to structure with parsed JPEG file.

Notes:

If JPEG file is not found, procedure returns FAST_IO_ERROR. If format of JPEG file is not supported (for example 12-bit JPEG) function returns FAST_UNSUPPORTED_FORMAT. If any errors occur during file parsing function returns FAST_INVALID_FORMAT and puts the error description to stderr.

Buffer h_Bytestream in jfifInfo should be allocated before the procedure call and its size in Bytes should be set to bytestreamSize from jfifInfo. Buffer h_Bytestream should be allocated by fastMalloc. If size of h_Bytestream is smaller than size of bytestream of loaded image, then the function will return FAST_INVALID_SIZE.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_IO_ERROR,
- FAST_UNSUPPORTED_FORMAT,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.12.2 *fastJfifHeaderLoadFromFile*

```
fastStatus_t fastJpegLoadFromFile (
  const char *filename,
  fastJfifInfo_t *jfifInfo)
```

Loads JPEG image header from disk to memory.

Parameters:

filename[in] – path to JPEG file;

jfifInfo[in] – pointer to structure with parsed JPEG file.

Notes:

If JPEG file is not found, procedure returns FAST_IO_ERROR. If format of JPEG file is not supported (for example 12-bit JPEG) function returns FAST_UNSUPPORTED_FORMAT. If any errors occur during file parsing function returns FAST_INVALID_FORMAT and puts the error description to stderr.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_IO_ERROR,
- FAST_UNSUPPORTED_FORMAT,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.12.3 *fastJfifBytestreamLoadFromFile*

```
fastStatus_t fastJpegLoadFromFile (
  const char *filename,
  fastJfifInfo_t *jfifInfo)
```

Loads JPEG image bytestream from disk to memory.

Parameters:

filename[in] – path to JPEG file;

jfifInfo[in] – pointer to structure with parsed JPEG file.

Notes:

Structure fastJfifInfo_t has to be populated by previous call fastJpegLoadHeader*.

Structure Buffer h_Bytestream in jfifInfo should be allocated before the procedure call and its size in Bytes should be set to bytestreamSize from jfifInfo. Buffer h_Bytestream should be allocated by fastMalloc. If size of h_Bytestream is smaller than size of bytestream of loaded image, then the function will return FAST_INVALID_SIZE.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_IO_ERROR,
- FAST_UNSUPPORTED_FORMAT,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.12.4 *fastJfifLoadFromMemory*

```
fastStatus_t fastJfifLoadFromMemory (
    unsigned char *inputStream,
    unsigned inputStreamSize,
    fastJfifInfo_t *jfifInfo)
```

Loads JPEG image from buffer into memory.

Parameters:

inputStream[in]	–	pointer to buffer with JPEG file;
inputStreamSize[in]	–	size of buffer with JPEG file in Bytes;
jfifInfo[in]	–	pointer to structure with parsed JPEG file.

Notes:

If JPEG file format is not supported (for example 12-bit JPEG) function will return FAST_UNSUPPORTED_FORMAT. If any errors occurs during file parsing function will return FAST_INVALID_FORMAT and error description is put to stderr.

Buffer h_Bytestream in jfifInfo should be allocated before the procedure call and its size in Bytes should be set to bytestreamSize in jfifInfo. Buffer h_Bytestream should be allocated by fastMalloc. If size of h_Bytestream is smaller than size of bytestream of loaded image, then the function will return FAST_INVALID_SIZE.

Buffer inputStream and h_Bytestream in jfifInfo must not overlap.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,

- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_FORMAT,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.12.5 *fastJfifLoadHeaderFromMemory*

```
fastStatus_t fastJfifLoadFromMemory (
    unsigned char *inputStream,
    unsigned inputStreamSize,
    fastJfifInfo_t *jfifInfo)
```

Loads JPEG image header from buffer into memory.

Parameters:

inputStream[in]	–	pointer to buffer with JPEG file;
inputStreamSize[in]	–	size of buffer with JPEG file in Bytes;
jfifInfo[in]	–	pointer to structure with parsed JPEG file.

Notes:

If JPEG file format is not supported (for example 12-bit JPEG) function will return FAST_UNSUPPORTED_FORMAT. If any errors occurs during file parsing function will return FAST_INVALID_FORMAT and error description is put to stderr.

Buffer inputStream and h_Bytestream in jfifInfo must not overlap.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_FORMAT,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.12.6 *fastJfifLoadBytestreamFromMemory*

```
fastStatus_t fastJfifLoadFromMemory (
    unsigned char *inputStream,
```



```
    unsigned inputStreamSize,
    fastJfifInfo_t *jfifInfo)
```

Loads JPEG image bytestream from buffer into memory.

Parameters:

inputStream[in]	–	pointer to buffer with JPEG file;
inputStreamSize[in]	–	size of buffer with JPEG file in Bytes;
jfifInfo[in]	–	pointer to structure with parsed JPEG file.

Notes:

Structure fastJfifInfo_t has to be populated by previous call fastJpegLoadHeader*.

Buffer h_Bytestream in jfifInfo should be allocated before the procedure call and its size in Bytes should be set to bytestreamSize from jfifInfo. Buffer h_Bytestream should be allocated by fastMalloc. If size of h_Bytestream is smaller than size of bytestream of loaded image, then the function will return FAST_INVALID_SIZE.

Buffer inputStream and h_Bytestream in jfifInfo must not overlap.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_FORMAT,
- FAST_INSUFFICIENT_HOST_MEMORY.

5.12.7 *fastJfifStoreToFile*

```
fastStatus_t fastJfifStoreToFile (
    const char*filename,
    fastJfifInfo_t *jfifInfo)
```

Serializes JPEG bytestream to file.

Parameters:

filename[in] – path to JPEG file;

jfifInfo[in] – pointer to structure with parsed JPEG file.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_IO_ERROR.

5.12.8 *fastJfifStoreToMemory*

```
fastStatus_t fastJfifStoreToMemory (
    unsigned char *outputStream,
    unsigned *outputStreamSize,
    fastJfifInfo_t *jfifInfo)
```

Serializes JPEG bytestream to memory buffer.

Parameters:

outputStream[out] – pointer to buffer for JPEG format serialization. Buffer is allocated by customer application.

outputStreamSize[out] – size of buffer for JPEG format serialization in Bytes;

jfifInfo[in] – pointer to structure with parsed JPEG file.

Notes:

Buffer for serialization has to be allocated before call. Its size is

$$\text{surfaceHeight} \times \text{surfaceWidth} \times \text{numberOfChannels}.$$

Real size of serialized file will be returned in outputStreamSize.

Buffer outputStream and h_Bytestream in jfifInfo must not overlap.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,

- FAST_UNKNOWN_ERROR.

5.13 *JPEG2000 Encoder functions*

5.13.1 *fastEncoderJ2kLibraryInit*

```
fastStatus_t fastEncoderJ2kLibraryInit (
  fastSdkParametersHandle_t handle)
```

Initializes fastEncoderJ2k library before any other call to encoder function/procedure.

Parameters:

handle [in] – pointer to SDK global options handle

Statuses:

- FAST_OK

5.13.2 *fastEncoderJ2kCreate*

```
fastStatus_t fastEncoderJ2kCreate (
  fastEncoderJ2kHandle_t *handle,
  fastEncoderJ2kStaticParameters_t *parameters,
  fastSurfaceFormat_t surfaceFmt,
  unsigned maxWidth,
  unsigned maxHeight,
  unsigned maxBatchSize,
  fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Creates JPEG2000 Encoder and returns associated handle.

Parameters:

handle[out] – pointer to the created JPEG2000 Encoder handle;

parameters[in] – structure, which specifies encoder parameters (lossy/lossless compression algorithm, number of DWT levels, codeblock size, maximum quality coefficient etc.)

surfaceFmt[in] – surface format of input image;

maxWidth[in] – maximum image width in pixels;

maxHeight[in] – maximum image height in pixels;

maxBatchSize[in] – maximum number of simultaneously processed images in batch;

srcBuffer[in] – linked buffer from the previous component.

Notes:

The same encoder component and interface functions/procedures are used for both lossy and lossless compression.

The procedure fastEncoderJ2kCreate allocates all necessary buffers in GPU memory. So, if GPU does not have enough free memory, then fastEncoderJ2kCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Maximum dimensions of the images should be specified for Encoder creation. Thus, if size of an input image exceeds the maximum size, then error status FAST_INVALID_SIZE will be returned.

If encoder does not support the specified surface format, then the function will return FAST_UNSUPPORTED_SURFACE.

Setting maxBatchSize value to 1 allows the single mode of processing only, while minimizing amount of the allocated memory. When higher performance is needed, use greater values of maxBatchSize for encoding in the batch mode, although it will require much more GPU memory. In that case the single mode will remain available.

StructurefastEncoderJ2kStaticParameters_t is static parameter for JPEG2000 Encoder.

```
typedef struct {
  bool lossless;
  bool pcrdEnabled;
  bool noMCT;
  bool yuvSubsampledFormat;
  int overwriteSurfaceBitDepth;
```



```
    int outputBitDepth;
    int dwtLevels;
    int codeblockSize;
    float maxQuality;
    bool info;
    int tileWidth;
    int tileHeight;
    int tier2Threads;
    int ss1_x, ss1_y, ss2_x, ss2_y, ss3_x, ss3_y;
} fastEncoderJ2kStaticParameters_t
```

where

- lossless – this parameter switches between reversible/lossless (when true) and irreversible/lossy (when false) compression. It affects the following stages: Multi-Component Transformation (MCT), Quantization, Discrete Wavelet Transform (DWT). In the lossless mode the reconstructed image should be fully identical to the original. In the lossy mode each of those three optional stages introduces some distortions. Small distortions on MCT and DWT stages of lossy compression are due to rounding of floating point arithmetic. Lossy compression algorithm allows fine control of the amount of distortions via Quantization and PCRD (truncation of codeblocks after compression), which are unavailable in the lossless mode.

  In lossless mode the lossless version of MCT is used (specified for 3 component images only), and integer-valued DWT transformation with CDF 5/3 wavelet is used. Lossy mode implies lossy version of MCT and floating point-values DWT transformation (with CDF 9/7 wavelet).

  This parameter can significantly affect size of compressed bytestream, compression speed and amount of GPU memory required.
- pcrdEnabled – this parameter enables or disables truncation of codeblocks using PCRD (Post-Compression Rate-Distortion) algorithm, which allows forcible fitting of compressed bytestreams to the given size (or bitrate). PCRD is useful in cases where certain specification should be respected (e.g., Digital Cinema Profile). The corresponding size limit should be specified via parameter targetStreamSize of fastEncoderJ2kDynamicParameters_t structure.

  PCRD, when enabled, slightly increases encoding time (but much less compared to the similar feature of the classic JPEG), so it is recommended to use quantiza-

tion (see maxQuality parameter) instead to get maximum compression speed when reduced image quality is acceptable and there is no strict limit on the size of compressed image. This parameter is ignored in the lossless mode.

- noMCT – this parameter disables (when true) or enables Multi-Component Transformation (MCT). MCT is applicable only to 3 components, so this option is ignored when image has 2 or 1 components. The main purpose of MCT is reducing the correlations (if any) amongst the image components, which increases compression performance in most cases. It can be useful to disable it when components are already decorrelated (e.g. when image is already in YUV color space).
- yuvSubsampledFormat – this parameter enables (when true) encoding of image with subsampled components. When subsampling is not used, it should be false.
- overwriteSurfaceBitDepth – this parameter allows changing bit depth of the source image before compression. The supported values are currently limited to 9–16 bits, and the original surface format must have 9–16 bits per component too. For example, it can be useful when encoding 10-bit images, because there is no FAST_RGB10 surface format in Fastvideo SDK.
- outputBitDepth – this parameter allows changing bit depth of the compressed image compared to the input image. The supported values are currently limited to 9–16 bits, and the original surface format must have 9–16 bits per component too. For example, it can be useful when there is no need to retain 16-bit depth of the original image, while it is beneficial to reduce bit rate and processing time.
- dwtLevels – number of Discrete Wavelet Transformation (DWT) levels (also known as decomposition levels). The supported values are from 0 up to 11. Such decomposition is used for two reasons: increasing efficiency of compression (quality / bytestream size ratio), ability to transmit and/or quickly decode lower resolution version of an image. Each successive decomposition level adds factor of two smaller resolution. So, for example, 6 decomposition levels for 4K (4096×2160) image means 7 resolution levels are available to decoder down to 128×34. The largest difference of compression ratio is for 0 and 1 values of dwtLevels parameter and each successive level gives less and less efficiency gain. The effect of number of decomposition levels on encoding time decreases too. 5–6 levels of decomposition seem to be a good choice for 4K images.
- codeblockSize – size (width and height) of codeblocks. The only supported values are 64, 32 and 16, which correspond to the square codeblock sizes: 64×64, 32×32, 16×16, respectively. Image (more accurately, image subbands) is partitioned into

codeblocks for the following reasons:

1. fine control of quality / bytestream size ratio;
2. it allows parallel encoding/decoding of multiple codeblocks on multiple CPU/GPU cores for better speed;
3. it allows fast access to arbitrary regions of the image, which can be useful for partial viewing and editing;
4. it allows Region of interest (ROI) coding, when certain region(s) should be stored with minimal loss of quality;
5. it allows high robustness to errors (errors introduced by noisy communication channel or unreliable storage device).

Less size of codeblocks means more codeblocks means more metadata should be encoded and stored, which slightly affects compression ratio and can significantly affect compression speed (due to partial load of GPU cores when there is too few codeblocks). From the perspective of compressed image size, the codeblock size 64×64 is always the best choice, but the difference from size 32×32 and 16×16 is often insignificant. From the perspective of encoding/decoding speed, codeblock size 16×16 is optimal for low resolution images, 32×32 – for the most standard images (2K, 4K, 8K), and 64x64 – for larger images, depending on GPU type and acceptable batch size (in the batch mode).

- maxQuality – maximum image quality coefficient. The supported values are from 0 to 1.0, where 1.0 means no quantization and smaller values used to get more quantized image with less bytestream size. This is the main instrument to finely control compression ratio (considering that smaller bytestream size means greater quality loss), which also significantly affects encoding time and the amount of GPU memory required. Its value is ignored in the lossless mode.

  It directly (but non-linearly) determines quantization coefficients and therefore distortion of compressed image. The optimal value depends on image itself and on quality requirements (which are different for different usage types). Quality losses mainly depend on image content (complexity), but they also depend on image size, number of color components and bit depth.

  This parameter should be used in pair with the parameter quality of fastEncoderJ2kDynamicParameters_t structure, where the quality specified for every individual image can not be greater than the maxQuality value due to its effect on memory requirements.

  This parameter can be used in PCRD mode too (with parameters pcrdEnabled,

targetStreamSize). It can be useful to decrease encoding time, when target size is significantly lower than size of bytestream without quantization.This parameter is ignored in the lossless mode.

- info – this parameter enables or disables collecting of additional info during encoding process (e.g., time measurement of different encoding stages). The collected info is passed via fastEncoderJ2kReport_t structure after encoding. Disabling this parameter will slightly increase encoding speed.
- tileWidth – tile width in pixels. You can specify any integer value, but only values less than maximum image width can be useful. Zero means no tiling (single tile).

  Tiling is optional and should not be used when no necessary due to quality losses at the boundaries between tiles (except when lossless mode is enabled). Each tile is processed fully separately in encoder/decoder. There are two main reasons to use tiling: shortage of GPU memory when encoding very large images and ability to decode and/or process parts of large images. Tiling is currently supported in the single image mode only.
- tileHeight – tile height in pixels. You can specify any integer value, but only values less than maximum image height can be useful. Zero means no tiling (single tile).

  Tiling is optional and should not be used when no necessary due to quality losses at the boundaries between tiles (except when lossless mode is enabled). Each tile is processed fully separately in encoder/decoder. There are two main reasons to use tiling: shortage of GPU memory when encoding very large images and ability to decode and/or process parts of large images. Tiling is currently supported in the single image mode only.
- tier2Threads – number of CPU threads for Tier-2 stage processing. The supported values start from 1. It affects compression speed only. The optimal value depends on the number of subbands (i.e. number of decomposition levels and color components), number of codeblocks and number of available CPU cores. 3–4 threads seem to be an optimal choice for CPU with 4 or more logical cores in most standard cases.
- ss1_x, ss1_y, ss2_x, ss2_y, ss3_x, ss3_ – parameters for specifying the horizontal and vertical subsampling factors for each of three image components. It is supposed, that the input image has no subsampling. Subsampling is disabled when all these values equal to 1. The 4:2:2 subsampling mode can be set with values 1, 1, 2, 1, 2, 1. The 4:2:0 subsampling mode can be set with values 1, 1, 2, 2, 2, 2. If you need to encode already subsampled image, then you have to upsample it and set the required values of these parameters.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_UNSUPPORTED_SURFACE,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.13.3 *fastEncoderJ2kGetAllocatedGpuMemorySize*

```
fastStatus_t fastEncoderJ2kGetAllocatedGpuMemorySize (
  fastEncoderJ2kHandle_t handle,
  unsigned long long *allocatedGpuSizeInBytes)
```

The function returns the GPU memory size allocated for JPEG2000 Encoder.

Parameters:

handle[in]	–	JPEG2000 Encoder handle;
allocatedGpuSizeInBytes[out]	–	size of allocated GPU memory in bytes

Statuses:

- FAST_OK.

5.13.4 *fastEncoderJ2kTransform*

```
fastStatus_t fastEncoderJ2kTransform (
  fastEncoderJ2kHandle_t handle,
  fastEncoderJ2kDynamicParameters_t *parameters,
  unsigned width,
  unsigned height,
  fastEncoderJ2kOutput_t *output,
  fastEncoderJ2kReport_t *report)
```

Encodes surface to JPEG2000 format, stores the result into host memory and returns report.

Parameters:

handle[in] – JPEG2000 Encoder handle;

parameters[in] – structure, which specifies parameters for the current image: if JP2 file header is needed, quality coefficient, target stream size in bytes (optional). Note that the value of quality coefficient should not exceed the value of maxQuality field of fastEncoderJ2kStaticParameters_t structure passed to fastEncoderJ2kCreate;

width[in] – image width in pixels;

height[in] – image height in pixels;

output[in/out] – structure, where output JP2/J2K bytestream is copied to, taking into account the specified buffer size;

report[out] – structure, where measured duration of each encoding stage and some other values (e.g., codeblock count) are written to.

Notes:

The procedure takes surface from previous component of the pipeline through input linked buffer and encodes it accordingly to the parameters specified during encoder creation.

JPEG2000 bytestream is placed to output → byteStream buffer.

Buffer for JPEG2000 bytestream must be allocated before call. Real JPEG2000 bytestream size is calculated during compression and put to output → streamSize field. If bufferSize is too small, then the stream is truncated, and the truncated flag is set.

Structure fastEncoderJ2kDynamicParameters_t is passed to functions fastEncoderJ2kTransform and fastEncoderJ2kAddImageToBatch for encoding individual images.

```
typedef struct {
  bool writeHeader;
  float quality;
  long targetStreamSize;
} fastEncoderJ2kDynamicParameters_t
```

where

- writeHeader – this parameter enables or disables writing of JP2 file header to the output. JP2 Header is useful (but not required) for individual images, while it is usually disabled when encoding video sequences (where multiple frames should be

stored in a single file). Files with JP2 Header have extension ".jp2", while files with individual images without JP2 Header usually (it is not standardized) have extension ".jpc" or ".j2k".

- quality – this parameter allows controlling file size for individual images on quantization stage. The supported values are from 0 to 1.0, but the value should not exceed the value of maxQuality parameter specified for the current encoder instance due to its effect on memory requirements. This parameter should be used in pair with the parameter maxQuality of fastEncoderJ2kStaticParameters_t structure.

  This parameter can be used in PCRD mode too (with parameters pcrdEnabled, targetStreamSize). It can be useful to decrease encoding time, when target size is significantly lower than size of bytestream without quantization. This parameter is ignored in the lossless mode.
- targetStreamSize – this parameter is used when pcrdEnabled is true only. It allows to forcibly control maximum bytestream size (in bytes) by truncation of encoded codeblocks using PCRD algorithm. Set this parameter to zero when PCRD should be disabled (here you have option to enable it only for some of the processed images). PCRD, when enabled, slightly increases encoding time (but much less compared to the similar feature of the classic JPEG), so it is recommended to use quantization (see quality parameter) instead to get maximum compression speed when reduced image quality is acceptable. It is normal to get significantly greater compression ratio when low values of this parameter are chosen, because PCRD can shrink file size only (via truncation of codeblocks) and not increase. This parameter is ignored in the lossless mode.

Structure fastEncoderJ2kReport_t is returned by functions fastEncoderJ2kTransform, fastEncoderJ2kTransformBatch and fastEncoderJ2kGetNextEncodedImage after encoding.

```
typedef struct {
  double s1_preprocessing;
  double s2_dwt;
  double s3_tier1;
  double s4_pcrd;
  double s5_gathering;
  double s6_copy;
  double s7_tier2;
  double s8_write;
```



```
    double elapsedTime;
    int codeblockCount;
    int maxCodeblockLength;
    int copySize;
    int outputSize;
} fastEncoderJ2kReport_t
```

- s1_preprocessing – duration (in seconds) of the first stage of encoding, namely "preprocessing". It is filled when info parameter is enabled.
- s2_dwt – duration (in seconds) of the second stage of encoding, namely "DWT decomposition". It is filled when info parameter is enabled.
- s3_tier1 – duration (in seconds) of the third stage of encoding, namely "Tier-1". It is filled when info parameter is enabled.
- s4_pcrd – duration (in seconds) of the fourth stage of encoding, namely "PCRD". It is filled when info parameter is enabled.
- s5_gathering – duration (in seconds) of the fifth stage of encoding, namely "gathering of codeblocks". It is filled when info parameter is enabled.
- s6_copy - duration (in seconds) of the sixth stage of encoding, namely "copy GPU–¿CPU". It is filled when info parameter is enabled.
- s7_tier2 – duration (in seconds) of the seventh stage of encoding, namely "Tier-2". It is filled when info parameter is enabled.
- s8_write - duration (in seconds) of the eighth stage of encoding, namely "writing output". It is filled when info parameter is enabled.
- elapsedTime – total duration (in seconds) of encoding of single image. It is filled when info parameter is enabled.
- codeblockCount – total number of codeblocks for the current image. It allows estimating degree of parallelization of encoding algorithms and size of metadata in output.
- maxCodeblockLength – this field stores maximum length of byte stream of encoded codeblock. It allows estimating maximum local complexity of the current image.
- copySize – size (in bytes) of data copied from GPU to CPU.
- outputSize – size (in bytes) of output byte stream.

Statuses:

- FAST_OK,

- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INVALID_SIZE,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.13.5 *fastEncoderJ2kFreeSlotsInBatch*

```
fastStatus_t fastEncoderJ2kFreeSlotsInBatch (
  fastEncoderJ2kHandle_t handle,
  int *value)
```

The function returns the number of free slots in batch for JPEG2000 Encoder.

Parameters:

handle[in] – JPEG2000 Encoder handle;

value[out] – number of free slots.

Statuses:

- FAST_OK.

5.13.6 *fastEncoderJ2kUnprocessedImagesCount*

```
fastStatus_t fastEncoderJ2kUnprocessedImagesCount (
  fastEncoderJ2kHandle_t handle,
  int *value)
```

The function returns the number of unprocessed images in batch for JPEG2000 Encoder.

Parameters:

handle[in] – JPEG2000 Encoder handle;

value[out] – number of unprocessed images.

Statuses:

- FAST_OK.

5.13.7 *fastEncoderJ2kAddImageToBatch*

```
fastStatus_t fastEncoderJ2kAddImageToBatch (
  fastEncoderJ2kHandle_t handle,
  fastEncoderJ2kDynamicParameters_t *parameters,
  unsigned width,
  unsigned height)
```

Adds image to queue for batch processing (if free slots are available).

Parameters:

handle[in] – JPEG2000 Encoder handle;

parameters[in] – structure, which specifies parameters for the current image: if JP2 file header is needed, quality coefficient, target stream size in bytes (optional). Note that the value of quality coefficient should not exceed the value of maxQuality field of fastEncoderJ2kStaticParameters_t structure passed to fastEncoderJ2kCreate;

width[in] – image width in pixels;

height[in] – image height in pixels.

Notes:

The procedure takes surface from the previous component of the pipeline through input linked buffer and adds it to queue for subsequent batch processing. When this procedure returns control, the input buffer can be used to store another image or be disposed.

The maximum number of the free slots is equal to the value of maxBatchSize parameter passed to fastEncoderJ2kCreate.

The availability of free slots in the batch can be checked using fastEncoderJ2kFreeSlotsInBatch function.

The input buffer can be reused immediately after a call to fastEncoderJ2kAddImageToBatch.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INVALID_SIZE,

- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.13.8 *fastEncoderJ2kTransformBatch*

```
fastStatus_t fastEncoderJ2kTransformBatch (
  fastEncoderJ2kHandle_t handle,
  fastEncoderJ2kOutput_t *output,
  fastEncoderJ2kReport_t *report)
```

Encodes multiple surfaces to JPEG2000 format by using batch processing.

Parameters:

handle[in] – JPEG2000 Encoder handle;

output[in/out] – structure, where the first output JP2/J2K bytestream is copied to, taking into account the specified buffer size;

report[out] – structure, where elapsed time is written to.

Notes:

The procedure takes all surfaces, which have been added using fastEncoderJ2kAddImageToBatch procedure, encodes them and stores the first of the resulted JPEG2000 bytestreams into host memory. The rest bytestreams can be obtained via fastEncoderJ2kGetNextEncodedImage function.

Buffer for the returned JPEG2000 bytestream must be allocated before call. Actual JPEG2000 bytestream size is calculated during compression and put to output → streamSize field. If bufferSize is too small, then the stream is truncated, and the truncated flag is set.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INVALID_SIZE,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,

- FAST_UNKNOWN_ERROR.

5.13.9 *fastEncoderJ2kGetNextEncodedImage*

```
fastStatus_t fastEncoderJ2kGetNextEncodedImage (
  fastEncoderJ2kHandle_t handle,
  fastEncoderJ2kOutput_t *output,
  fastEncoderJ2kReport_t *report,
  int *imagesLeft)
```

Returns the next compressed image during batch processing.

Parameters:

handle[in]	–	JPEG2000 Encoder handle;
output[in/out]	–	structure, where the successive output JP2/J2K bytestream is copied to, taking into account the specified buffer size;
imagesLeft[out]	–	number of compressed images, which can be returned by successive calls;
report[out]	–	structure, where elapsed time is written to.

Notes:

The procedure stores the successive resulted JPEG2000 bytestream into host memory, if there is at least one compressed bytestream left after the previous calls.

Buffer for the returned JPEG2000 bytestream must be allocated before call. Real JPEG2000 bytestream size is calculated during compression and put to output → streamSize field. If bufferSize is too small, then the stream is truncated, and the truncated flag is set.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.13.10 *fastEncoderJ2kDestroy*

fastStatus_t fastEncoderJ2kDestroy (
fastEncoderJ2kHandle_t handle)

Destroys JPEG2000 Encoder.

Parameters:

handle[in] – JPEG2000 Encoder handle.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.14 *JPEG2000 Decoder functions*

5.14.1 *fastDecoderJ2kLibraryInit*

fastStatus_t fastDecoderJ2kLibraryInit (
fastSdkParametersHandle_t handle)

Initializes fastDecoderJ2k library before any other call to encoder function/procedure.

Parameters:

handle [in] – pointer to SDK global options handle

Statuses:

- FAST_OK

5.14.2 *fastDecoderJ2kPredecode*

fastStatus_t fastDecoderJ2kPredecode (
fastJ2kImageInfo_t *imageInfo,
unsigned char *byteStream,
long streamSize)

Predecode JPEG2000 image.

Parameters:

imageInfo [out] – structure with obtained image parameters;

byteStream [in] – source buffer with compressed image data;

streamSize [in] – source data length.

Notes: The function gets basic parameters of the image, such as image size, number of components, maximum bit depth etc., from the JPEG2000 main header without decoding the image. **Statuses:**

- FAST_OK.

5.14.3 *fastDecoderJ2kCreate*

```
fastStatus_t fastDecoderJ2kCreate (
  fastDecoderJ2kHandle_t *handle,
  fastDecoderJ2kStaticParameters_t *staticParameters,
  fastSurfaceFormat_t surfaceFmt,
  unsigned maxWidth,
  unsigned maxHeight,
  unsigned maxBatchSize,
  fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates JPEG Decoder and returns associated handle.

Parameters:

handle[out] – pointer to the created JPEG2000 Decoder handle;

staticParameters[in] – structure, which specifies decoder parameters (main image parameters, number of decoded resolution levels, maximum tile size, maximum stream size, truncation parameters, window parameters etc.)

surfaceFmt[in] – type of surface for decoded image;

maxWidth[in] – maximum image width in pixels;

maxHeight[in] – maximum image height in pixels;

maxBatchSize[in] – maximum number of simultaneously processed images in batch;

dstBuffer[out] – pointer for output buffer of the current component (which is also linked buffer for the next component).

Notes:

Function fastDecoderJ2kCreate allocates all necessary buffers in GPU memory. Thus in case GPU does not have enough free memory, then fastDecoderJ2kCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Maximum dimensions of the image are set to Decoder during creation. Thus, if size of the decoded image exceeds the maximum size, then error status FAST_INVALID_SIZE will be returned.

Structure fastDecoderJ2kStaticParameters_t is passed to function fastDecoderJ2kCreate when creating JPEG2000 Decoder.

```
typedef struct {
  int verboseLevel;
  int maxTileWidth;
  int maxTileHeight;
  int ResolutionLevels;
  int DecodePasses;
  size_t maxStreamSize;
  bool truncationMode;
  float truncationRate;
  int truncationLength;
  int windowX0;
  int windowY0;
  int windowWidth;
  int windowHeight;
  bool enableROI;
  bool enableMemoryReallocation;
  fastJ2kImageInfo_t *imageInfo;
} fastDecoderJ2kStaticParameters_t
```

- verboseLevel – this parameter controls output of additional info during decoding process. The supported values are 0 (additional output is disabled) and 1 (time measurement is enabled). Higher values are reserved for debugging. The collected info is passed via fastDecoderJ2kReport_t structure after decoding. Disabling this parameter will slightly increase decoding speed.
- maxTileWidth – maximum width for each tile. It affects the amount of GPU memory

required. Zero value means it will become equal to maxSrcWidth parameter.

- maxTileHeight – maximum height for each tile. It affects the amount of GPU memory required. Zero value means it will become equal to nfmaxSrcHeight parameter.
- ResolutionLevels – this parameter allows reducing number of decoded resolution levels. The supported values are from 1 to 12. It can be used to speedup decoding when lesser image resolution is acceptable (e.g., when viewing 4K video on 2K display). Zero value means all resolution levels will be decoded.
- DecodePasses – this parameter allows reducing number of decoded passes of each codeblock. The supported values are from 1 to 48, but total number of passes of an image equals to 1 + 3 * (bit depth). It can be used to speedup decoding when lesser image quality is acceptable.

  Each bitplane of a codeblock is encoded in three passes except the first bitplane, which is encoded in a single pass. Each subsequent pass adds less details to the image, so we can skip some of the tail passes to decrease Tier-1 decoding time while losing invisible or minor details of the image.

  The number of passes may differ for various codeblocks, but this parameter is applied to all of them in such a way that each codeblock is truncated proportionally to its number of passes. This approach allows reaching greater performance/quality ratio than approach with truncating only codeblocks with more passes.
- maxStreamSize – this parameter allow allocating memory for encoded image (input bytestream) with a reserve. It can be useful to avoid memory reallocation when decoding multiple images with different size of their bytestreams.
- truncationMode – enables or disables truncation of input byte stream.
- truncationRate – target bitrate (independent of image size) for truncation mode. It only affects decoding when truncationMode is true. Only one of two parameters (truncationRate, truncationLength) should be used (i.e. have positive value).
- truncationLength – target stream length in bytes for truncation mode. It only affects decoding when truncationMode is true. Only one of two parameters (truncationRate, truncationLength) should be used (i.e. have positive value).
- windowX0, windowY0, windowWidth, windowHeight – these four parameters allow decoding rectangular region of the image (faster than decoding the whole image).
- enableROI - enables or disables processing of ROI (Region Of Interest) information.
- enableMemoryReallocation - enables or disables memory reallocation during each call of fastDecoderJ2kTransform or fastDecoderJ2kTransformBatch procedures when necessary. When decoding of an image requires more memory and this parameter

is disabled, FAST_INSUFFICIENT_DEVICE_MEMORY error will be returned.

- ImageInfo - this parameter is used to provide information needed to determine size of memory to be allocated: tile size, codeblock size, number of components, etc.

```
typedef struct {
  fastSurfaceFormat_t decoderSurfaceFmt;
  J2kCapability_t capabilities;
  unsigned width;
  unsigned height;
  unsigned tileWidth;
  unsigned tileHeight;
  unsigned codeblockWidth;
  unsigned codeblockHeight;
  unsigned resolutionLevels;
  size_t streamSize;
  bool subsamplingUsed;
  int componentCount;
  fastJ2kComponentInfo_t components[8];
} fastJ2kImageInfo_t
```

- decoderSurfaceFmt - this field stores the surface format of an image, determining number of components and maximum bit depth of these components;
- capabilities - this field denotes capabilities that a decoder needs to properly decode the codestream according to the JPEG 2000 standard (Rsiz marker). Only few values are compatible with Part I of the standard;
- width, height – dimensions of the image;
- tileWidth, tileHeight – tile size in the encoded image;
- codeblockWidth, codeblockHeight - codeblock size in the encoded image;
- resolutionLevels – number of resolution levels in the encoded image;
- streamSize – size of byte stream of the encoded image;
- subsamplingUsed - shows is subsampling of some components is used;
- componentCount - number of components;
- components - bit depth and subsampling parameters of each component.

```
typedef struct {
  int bitDepth;
```



```
    int subsamplingX;
    int subsamplingY;
} fastJ2kComponentInfo_t
```

- bitDepth – bit depth of a particular component;
- subsamplingX, subsamplingY – horizontal and vertical subsampling of a particular component.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_UNSUPPORTED_SURFACE,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.14.4 *fastDecoderJ2kGetAllocatedGpuMemorySize*

```
fastStatus_t fastDecoderJ2kGetAllocatedGpuMemorySize (
    fastDecoderJ2kHandle_t handle,
    unsigned long long *allocatedGpuSizeInBytes)
```

Returns the GPU memory size allocated for JPEG2000 Decoder.

Parameters:

handle[in]	–	JPEG2000 Decoder handle;
allocatedGpuSizeInBytes[out]	–	memory size in Bytes.

Statuses:

- FAST_OK.

5.14.5 *fastDecoderJ2kTransform*

```
fastStatus_t fastDecoderJ2kTransform (
    fastDecoderJ2kHandle_t handle,
    unsigned char *byteStream,
```



```
    long streamSize,
    fastDecoderJ2kReport_t *report)
```

Decodes JPEG2000 image to surface and returns report.

Parameters:

handle[in] – pointer to JPEG2000 Decoder;

byteStream[in] – input bytestream with compressed image;

streamSize[in] – size of input bytestream;

report[out] – structure, where measured duration of each decoding stage and some other values (e.g., codeblock count, output image parameters) are written to.

Notes:

The procedure takes JPEG2000 bytestream and decodes it. The decoded surface is placed to the output linked buffer and the following component of the pipeline can consume it.

```
typedef struct {
    double s0_init;
    double s1_tier2;
    double s2_copy;
    double s3_tier1;
    double s4_roi;
    double s5_dequantize;
    double s6_dwt;
    double s7_postprocessing;
    double elapsedTime;
    int codeblockCount;
    int copyToGpu_size;
    int copyToHost_size;
    long long inStreamSize;
    long long outStreamSize;
    int width;
    int height
```



```
    int channels
    int bitsPerChannel;
    int tileCount;
    int tilesX;
    int tilesY;
    int resolutionLevels;
    int cbX
    int cbY;
    ProgressionType progressionType;
    WaveletType dwtType;
    MCT_Type mctType;
} fastDecoderJ2kReport_t
```

- s0_init – duration of the initialization stage of decoding. It is filled when verboseLevel equals to 1 or greater values;
- s1_tier2 – duration of the first stage of decoding, namely "Tier-2". It is filled when verboseLevel equals to 1 or greater values;
- s2_copy – duration of the second stage of decoding, namely "Copy CPU-¿GPU". It is filled when verboseLevel equals to 1 or greater values.
- s3_tier1 – duration of the third stage of decoding, namely "Tier-1". It is filled when verboseLevel equals to 1 or greater values;
- s4_roi – duration of the fourth stage of decoding, namely "ROI". It is filled when verboseLevel equals to 1 or greater values;
- s5_dequantize - duration of the fifth stage of decoding, namely "Dequantize". It is filled when verboseLevel equals to 1 or greater values;
- s6_dwt - duration of the sixth stage of decoding, namely "Inverse DWT". It is filled when verboseLevel equals to 1 or greater values;
- s7_postprocessing - duration of the seventh stage of decoding, namely "Post-processing". It is filled when verboseLevel equals to 1 or greater values;
- elapsedTime - total duration (in seconds) of decoding of single image. It is filled when verboseLevel equals to 1 or greater values;
- codeblockCount - total count of codeblocks in the image;
- copyToGpu_size - size (in bytes) of data copied from CPU to GPU;
- copyToHost_size - size (in bytes) of data copied from GPU to CPU;
- inStreamSize - size (in bytes) of input stream;

- outStreamSize - size (in bytes) of output stream;
- width - image width;
- height - image height;
- channels - number of color components;
- bitsPerChannel - bit depth in every color component;
- tileCount - total tile count;
- tilesX - horizontal number of tiles;
- tilesY - vertical number of tiles;
- resolutionLevels - number of resolution levels (it is number of DWT levels plus one);
- cbX - horizontal size of all codeblocks (except codeblocks at the right boundary);
- cbY - vertical size of all codeblocks (except codeblocks at the bottom boundary);
- progressionType – type of progression order in byte stream. The Standard defines 5 different orders, where LRCP (layer-resolution-component-position) is specified as the default order;
- dwtType – type of wavelet used in DWT stage (usually, CDF 9/7 for lossy compression and CDF 5/3 for lossless compression);
- mctType – type of Multi-Component Transformation (lossy, lossless or none).

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INVALID_SIZE,
- FAST_BITSTREAM_CORRUPT,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.14.6 *fastDecoderJ2kFreeSlotsInBatch*

```
fastStatus_t fastDecoderJ2kFreeSlotsInBatch (
  fastDecoderJ2kHandle_t handle,
  int *value)
```

Returns the number of free slots in batch for JPEG2000 Decoder.

Parameters:

handle[in] – JPEG2000 Decoder handle;

value[out] – number of free slots.

Statuses:

- FAST_OK.

5.14.7 *fastDecoderJ2kUnprocessedImagesCount*

```
fastStatus_t fastDecoderJ2kUnprocessedImagesCount (
  fastDecoderJ2kHandle_t handle,
  int *value)
```

Returns the number of unprocessed images in batch for JPEG2000 Decoder.

Parameters:

handle[in] – JPEG2000 Decoder handle;

value[out] – number of unprocessed images.

Statuses:

- FAST_OK.

5.14.8 *fastDecoderJ2kAddImageToBatch*

```
fastStatus_t fastDecoderJ2kAddImageToBatch (
  fastDecoderJ2kHandle_t handle,
  unsigned char *byteStream,
  long streamSize)
```

Adds image to queue for batch processing (if free slots are available) and returns immediately.

Parameters:

handle[in] – JPEG2000 Decoder handle;

byteStream[in] – input bytestream with compressed image;

streamSize[in] – size of input bytestream.

Notes:

The procedure takes JPEG2000 bytestream and adds it to queue for batch processing using fastDecoderJ2kTransformBatch procedure. When this procedure returns control, the input buffer can be used to store another image or be disposed.

The maximum number of the free slots is equal to the value of maxBatchSize parameter passed to fastEncoderJ2kCreate.

The availability of free slots in the batch can be checked using fastDecoderJ2kFreeSlotsInBatch function.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INVALID_SIZE,
- FAST_BITSTREAM_CORRUPT,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.14.9 *fastDecoderJ2kTransformBatch*

```
fastStatus_t fastDecoderJ2kTransformBatch (
  fastDecoderJ2kHandle_t handle,
  fastDecoderJ2kReport_t *report)
```

Decodes multiple JPEG2000 images to surfaces using batch processing.

Parameters:

handle[in] – JPEG2000 Decoder handle;

report[out] – structure, where measured duration of each decoding stage and some other values (e.g., codeblock count, output image parameters) are written to.

Notes:

The procedure takes all images, which have been added using fastDecoderJ2kAddImageToBatch procedure, decodes them and stores the first of the resulted surfaces. The decoded surface is placed to the output linked buffer and the following component of the pipeline can con-

sume it. The rest surfaces should be obtained via fastDecoderJ2kGetNextDecodedImage function.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_VALUE,
- FAST_INVALID_SIZE,
- FAST_BITSTREAM_CORRUPT,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.14.10 *fastDecoderJ2kGetNextDecodedImage*

```
fastStatus_t fastDecoderJ2kGetNextDecodedImage (
  fastDecoderJ2kHandle_t handle,
  fastDecoderJ2kReport_t *report,
  int *imagesLeft)
```

Returns the next decoded surface during batch processing.

Parameters:

handle[in]	–	JPEG2000 Decoder handle;
report[out]	–	structure, where measured duration of each decoding stage and some other values (e.g., codeblock count, output image parameters) are written to;
imagesLeft[out]	–	number of compressed images, which can be returned by successive calls.

Notes:

The procedure stores the successive decoded image into the output linked buffer, if there is at least one decoded image left after the previous calls.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,

- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_UNKNOWN_ERROR.

5.14.11 *fastDecoderJ2kDestroy*

```
fastStatus_t fastDecoderJ2kDestroy (
  fastDecoderJ2kHandle_t handle)
```

Destroys JPEG2000 Decoder.

Parameters:

handle[in] – pointer to JPEG2000 Decoder.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.15 *Affine functions*

5.15.1 *fastAffineCreate*

```
fastStatus_t fastAffineCreate
(fastAffineHandle_t *handle,
fastAffineType_t affineType,
unsigned maxWidth,
unsigned maxHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates Affine transformation component and returns associated handle.

Parameters:

handle[out] – pointer to created Affine component;

affineType[in] – type of affine transformation;

maxWidth[in] – maximum input image width in pixels;

maxHeight[in] – maximum input image height in pixels;

srcBuffer[in] – linked buffer from previous component;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastAffineCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastAffineCreate will return FAST_INSUFFICIENT_DEVICE_MEMORY.

There are 5 currently supported affine transformations: Flip, Flop, Rotate 180, Rotate 90 to left, Rotate 90 to right. All affine transformations are applicable for gray and for color images. Rotation 90 left and Rotation 90 right change image dimensions: width becomes height, height becomes width. So maxWidth and maxHeight of the following component have to be properly adjusted.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.15.2 *fastAffineGetAllocatedGpuMemorySize*

```
fastStatus_t fastAffineGetAllocatedGpuMemorySize
(fastAffineHandle_t handle,
unsigned *allocatedGpuSizeInBytes)
```

Returns requested GPU memory for Affine transformation component.

Parameters:

handle[in]	–	Affine component handle;
allocatedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Affine component.

Statuses:

- FAST_OK.

5.15.3 *fastAffineChangeSrcBuffer*

```
fastStatus_t fastAffineChangeSrcBuffer
(fastAffineHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in]	–	Affine component handle;
srcBuffer[in]	–	new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.15.4 *fastAffineTransform*

```
fastStatus_t fastAffineTransform
(fastAffineHandle_t handle,
unsigned width,
unsigned height)
```


Performs current Affine transformation.

Parameters:

handle[in] – Affine component handle;

width[in] – image width in pixels;

height[in] – image height in pixels.

Notes:

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.15.5 *fastAffineDestroy*

```
fastStatus_t fastAffineDestroy
(fastAffineHandle_t handle)
```

Destroys Affine component handle.

Parameters:

handle[in] – Affine component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.16 *Crop functions*

5.16.1 *fastCropCreate*

fastStatus_t fastCropCreate
(fastCropHandle_t *handle,
unsigned maxSrcWidth,
unsigned maxSrcHeight,
unsigned maxDstWidth,
unsigned maxDstHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates Crop component and returns associated handle.

Parameters:

handle[out] – pointer to created Crop component;

maxSrcWidth[in] – maximum input image width in pixels;

maxSrcHeight[in] – maximum input image height in pixels;

maxDstWidth[in] – maximum destination (cropped) image width in pixels;

maxDstHeight[in] – maximum destination (cropped) image height in pixels;

srcBuffer[in] – linked buffer from previous component;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastCropCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastCropCreate will return FAST_INSUFFICIENT_DEVICE_MEMORY.

Parameter maxDstWidth has to be not more than maxSrcWidth, and maxDstHeight has to be not more than maxSrcHeight. In other case fastCropCreate will return FAST_INVALID_SIZE.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.16.2 *fastCropGetAllocatedGpuMemorySize*

fastStatus_t fastCropGetAllocatedGpuMemorySize
(fastCropHandle_t handle,
unsigned *requestedGpuSizeInBytes)

Returns requested GPU memory for Crop component.

Parameters:

handle[in]	–	Crop component handle;
allocatedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Crop component.

Statuses:

- FAST_OK.

5.16.3 *fastCropChangeSrcBuffer*

fastStatus_t fastCropChangeSrcBuffer
(fastCropHandlet handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)

Sets new source buffer.

Parameters:

handle[in]	–	Crop component handle;
srcBuffer[in]	–	new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.16.4 *fastCropTransform*

fastStatus_t fastCropTransform
(fastCropHandle_t handle,
unsigned width,
unsigned height,
unsigned leftTopCoordsX,
unsigned leftTopCoordsY,
unsigned croppedWidth,
unsigned croppedHeight)

Performs current Crop transformation.

Parameters:

handle[in]	–	Crop component handle;
width[in]	–	input image width in pixels;
height[in]	–	input image height in pixels;
leftTopCoordsX[in]	–	coordX in pixels for left top corner of cropped image in input image;
leftTopCoordsY[in]	–	coordY in pixels for left top corner of cropped image in input image;
croppedWidth[in]	–	cropped image width in pixels;
croppedHeight[in]	–	cropped image width in pixels.

Notes:

If size of input image or size of cropped image greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Also

$$\text{leftTopCoordsX} + \text{croppedWidth}$$

has to be not more than width and

$$\text{leftTopCoordsY} + \text{croppedHeight}$$

has to be not more than height. In other case function returns FAST_INVALID_SIZE

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.16.5 *fastCropDestroy*

```
fastStatus_t fastCropDestroy
(fastCropHandle_t handle)
```

Destroys Crop component handle.

Parameters:

handle[in] – Crop component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.17 *Image Filter functions*

5.17.1 *fastImageFilterCreate*

fastStatus_t fastImageFilterCreate
(fastImageFiltersHandle_t *handle,
fastImageFilterType_t filterType,
void *staticFilterParameters,
unsigned maxWidth,
unsigned maxHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates ImageFilter component and returns associated handle.

Parameters:

handle[out]	–	pointer to created ImageFilter component;
filterType[in]	–	type of image filter;
staticFilterParameters[in]	–	static parameters for image filter;
maxWidth[in]	–	maximum image width in pixels;
maxHeight[in]	–	maximum image height in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastImageFilterCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastImageFilterCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Next table shows structure type for staticFilterParameters depends on filter type. It also shows can static parameter be null or not.

Filter Type	**Static Parameter Type**	**Can be NULL**
BASE_COLOR_CORRECTION	fastBaseColorCorrection_t	yes
BAYER_BLACK_SHIFT	fastBayerBlackShift_t	yes
BINNING	fastBinning_t	yes
COLOR_SATURATION_{HSL,HSV}	fastColorSaturation_t	yes
GAUSSIAN_SHARPEN	no	yes
HSV_LUT_3D	fastHSVLut_3D_t	yes
LUT_8_8	fastLut_8_t	yes
LUT_8_8_C	fastLut_8_C_t	yes
LUT_8_{12,16}	fastLut_8_16_t	yes
LUT_8_16_BAYER	fastLut_8_16_Bayer_t	yes
LUT_8_{12,16}_C	fastLut_8_16_C_t	yes
LUT_10_16_BAYER	fastLut_10_16_Bayer_t	yes
LUT_12_8	fastLut_12_8_t	yes
LUT_12_8_C	fastLut_12_8_C_t	yes
LUT_12_{12,16}	fastLut_12_t	yes
LUT_12_16_BAYER	fastLut_12_16_Bayer_t	yes
LUT_12_{12,16}_C	fastLut_12_C_t	yes
LUT_14_16_BAYER	fastLut_14_16_Bayer_t	yes

Continued from previous page

Filter Type	**Static Parameter Type**	**Can be NULL**
LUT_16_8	fastLut_16_8_t	yes
LUT_16_8_C	fastLut_16_8_C_t	yes
LUT_16_16	fastLut_16_t	yes
LUT_16_16_BAYER	fastLut_16_16_Bayer_t	yes
LUT_16_16_C	fastLut_16_C_t	yes
LUT_16_16_FR	fastLut_16_FR_t	yes
LUT_16_16_FR_BAYER	fastLut_16_FR_Bayer_t	yes
LUT_16_16_FR_C	fastLut_16_FR_C_t	yes
RGB_LUT_3D	fastRGBLut_3D_t	yes
FFC	fastFFC_t	yes
SAM	fastSam_t	yes
SAM16	fastSam16_t	yes
TONE_CURVE	fastToneCurve_t	yes
WHITE_BALANCE	fastWhiteBalance_t	yes

Filter FAST_GAUSSIAN_SHARPEN has no static parameters, so staticFilterParameters has to be null.

Structure fastSam_t is a static parameter for SAM filter.

```
typedef struct {
```



```
    unsigned char *blackShiftMatrix;
    float *correctionMatrix;
} fastSam_t
```

where

- blackShiftMatrix – pointer to black shift matrix (or B matrix);
- correctionMatrix – pointer to correction matrix (or A matrix).

Matrices have to be allocated by fastMalloc. Matrix's height is equal to image height. Matrix's width is equal to image width snapped up to the nearest four fold value. After image filter destroy matrices, they have to be deallocated by fastFree.

Structure fastBinning_t is a static parameter for BINNING filter.

```
typedef struct{
    fastBinningMode_t mode;
    unsigned factorX;
    unsigned factorY;
} fastBinning_t
```

where

- mode – type of binning operation;
- factorX – binning factor X;
- factorY – binning factor Y.

Structure fastFFC_t is a static parameter for FFC filter.

```
typedef struct{
    unsigned short divider;
    unsigned short* correctionMatrix;
} fastFFC_t
```

where

- divider – divider;
- correctionMatrix – pointer to sparsed correction matrix.

Matrix have to be allocated by fastMalloc. Matrix's width and height is can be calculated as (size / 4 + 1) where size is width and height of original image. After image

filter destroy matrices, they have to be deallocated by fastFree.

Structure fastBayerBlackShift_t is a static parameter for BAYER_BLACK_SHIFT filter.

```
typedef struct{
  float R;
  float G;
  float B;
  fastBayerPattern_t bayerPattern;
} fastBayerBlackShift_t
```

where

- R – shift constant for R channel;
- G – shift constant for G channel;
- B – shift constant for B channel;
- bayerPattern – sbayer pattern.

Structure fastBaseColorCorrection_t is a static parameter for BASE_COLOR_CORRECTION filter.

```
typedef struct{
  float matrix[12];
  int whiteLevel[3];
} fastBaseColorCorrection_t
```

where

- matrix – color correction matrix;
- whiteLevel – white level for RGB. If current pixel value greater than white value then white value will be taken.

Structure fastWhiteBalance_t is a static parameter for FAST_WHITE_BALANCE filter.

```
typedef struct{
  float R;
  float G1;
  float G2;
  float B;
```



```
    fastBayerPattern_t bayerPattern;
} fastWhiteBalance_t
```

where

- R,G1,G2,B – values of white balance matrix;
- bayerPattern – bayer pattern.

Structure fastColorSaturation_t is a static parameter for COLOR_SATURATION_{HSL, HSV} filter.

```
typedef struct{
    float Lut[3][1024];
    fastColorSaturationOperationType_t operation[3];
    fastColorSaturationChannelType_t sourceChannel[3];
} fastColorSaturation_t
```

where

- sourceChannel[3] – define channel associated with index. If sourceChannel[0] = FAST_CHANNEL_H, then operation[0], Lut[0] contain information for H channel.
- Lut[3] – transformation Luts;
- operation[3] – transformation operation.

Structures fastLut_{8,12,16}_t, fastLut_8_16_t, fastLut_{12,16}_8_t, fastLut_,16_FR_t is a static parameter for single table LUT filters.

```
typedef struct {
    <lut value type> lut[<lut table size>];
}fastLut_*_t
```

where

- lut – LUT table;
- <lut value type> – type of element in LUT Table {unsigned char, unsigned short}.
- <lut table size> – number of element in LUT Table. See table 3.

Structures fastLut_{8, 10, 12, 14}_16_Bayer_t, fastLut_16_Bayer_t, fastLut_16_FR_Bayer_t is a static parameter for Bayer LUT filters. They have three LUT tables, one for each color.


```
typedef struct {
  unsigned short lut_R[<lut table size>];
  unsigned short lut_G[<lut table size>];
  unsigned short lut_B[<lut table size>];
  fastBayerPattern_t pattern;
}fastLut_*_Bayer_t
```

where

- lut_R – LUT table for Red channel of Bayer pattern;
- lut_G – LUT table for Green channel of Bayer pattern;
- lut_B – LUT table for Blue channel of Bayer pattern;
- <lut table size> – number of element in LUT Table. See table 3.

Structures fastLut_{8,12,16}_C_t, fastLut_8_16_C_t, fastLut_{12,16}_8_C_t, fastLut_,16_FR_C_t is a static parameter for color table LUT filters. They have three LUT tables, one for each color.

```
typedef struct {
  <lut value type> lut_R[<lut table size>];
  <lut value type> lut_G[<lut table size>];
  <lut value type> lut_B[<lut table size>];
}fastLut_*_C_t
```

where

- lut_R – LUT table for Red channel;
- lut_G – LUT table for Green channel
- lut_B – LUT table for Blue channel
- <lut value type> – type of element in LUT Table {unsigned char, unsigned short}.
- <lut table size> – number of element in LUT Table. See table 3.

Structure fastRGBLut_3D_t is a static parameter for FAST_RGB_LUT_3D filter.

```
typedef struct {
  fastRGB16_t *lut;
  unsigned size1D;
}fastRGBLut_3D_t
```


where

- size1D – linear cube size;
- lut – pointer to 3D LUT.

Ordering of elements in 3D LUT is the opposite to the typical in-memory order of multi-dimensional tables. An equivalent index would be

$$r + N \times g + N \times N \times b,$$

where r, g, b are the Red, Green, and Blue indices in the range from 0 to N–1.

Memory for 3D LUT have to be allocated by fastMalloc. After image filter destroy matrices, they have to be deallocated by fastFree.

Structure fastHSVLut_3D_t is a static parameter for FAST_HSV_LUT_3D filter.

```
typedef struct{
  unsigned int dimH;
  unsigned int dimS;
  unsigned int dimV;
  fastColorSaturationOperationType_t operationH;
  fastColorSaturationOperationType_t operationS;
  fastColorSaturationOperationType_t operationV;
  fastHSVfloat_t *Lut;
} fastHsvLut3D_t
```

where

- dimH – number of elements per H axis;
- dimS – number of elements per S axis;
- dimV – number of elements per V axis. To define 2D LUT, dimV has to be 1.
- operationH – transformation operation for H channel;
- operationS – transformation operation for S channel;
- operationV – transformation operation for V channel;
- lut – pointer to 2D/3D LUT.

Ordering elements in 3D LUT is the opposite to the typical in-memory order of multi-dimensional tables. An equivalent index would be

$$\mathsf{V} + \mathsf{dimV} \times \mathsf{H} + \mathsf{dimV} \times \mathsf{dimH} \times \mathsf{S}.$$

Memory for 3D LUT has to be allocated by fastMalloc. After image filter destroy

matrices, they have to be deallocated by fastFree.

Statuses:

- FAST_OK;
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.17.2 *fastImageFiltersGetAllocatedGpuMemorySize*

```
fastStatus_t fastImageFiltersGetAllocatedGpuMemorySize
(fastImageFiltersHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for ImageFilter component.

Parameters:

handle[in]	–	ImageFilter handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for ImageFilter component.

Statuses:

- FAST_OK.

5.17.3 *fastImageFiltersChangeSrcBuffer*

```
fastStatus_t fastImageFiltersChangeSrcBuffer
(fastImageFiltersHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in] – Image Filter handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.17.4 *fastImageFiltersTransform*

```
fastStatus_t fastImageFiltersTransform
(fastImageFiltersHandle_t handle,
void *filterParameters,
unsigned width,
unsigned height)
```

Performs current ImageFilter transformation.

Parameters:

handle[in] – ImageFilter component handle;

filterParameters[in] – filter parameters for current image;

width[in] – image width in pixels;

height[in] – image height in pixels.

Notes:

If image size is greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Pointer filterParameters can point to the following structures:

- fastGaussianFilter_t,
- fastBaseColorCorrection_t,
- fastWhiteBalance_t,
- fastToneCurve_t,

- fastColorSaturation_t,
- fastSam_t,
- fastSam16_t

and to all LUT structures.

Structure fastGaussianFilter is dynamic parameter for FAST_GAUSSIAN_SHARPEN filter.

```
typedef struct{
  double sigma;
} fastGaussianFilter_t
```

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.17.5 *FastImageFiltersDestroy*

```
fastStatus_t fastImageFiltersDestroy
(fastImageFiltersHandle_t handle)
```

Destroys ImageFilter component handle.

Parameters:

handle[in] – ImageFilter component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.18 *Resize functions*

5.18.1 *fastResizerCreate*

```
fastStatus_t fastResizerCreate
(fastResizerHandle_t *handle,
unsigned maxSrcWidth,
unsigned maxSrcHeight,
unsigned maxDstWidth,
unsigned maxDstHeight,
double maxScaleFactor,
float shiftX,
float shiftY,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates Resize and returns associated handle.

Parameters:

handle[out] – pointer to created Resizer component;

maxSrcWidth [in] – maximum input image width in pixels;

maxSrcHeight[in] – maximum input image height in pixels;

maxDstWidth[in] – maximum destination (cropped) image width in pixels;

maxDstHeight[in] – maximum destination (cropped) image height in pixels;

maxScaleFactor[in] – maximum scale factor (relation between source and destination dimensions);

shiftX[in] – shift between source and destination grids by x coordinate. Currently ignored, should be 0,0;

shiftY[in] – shift between source and destination grids by y coordinate. Currently ignored, should be 0,0;

srcBuffer[in] – linked buffer from previous component;

dstBuffer[out] – pointer to created Resizer component;

handle[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastResizeCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastResizeCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Parameter maxDstWidth has to be not more than maxSrcWidth, and maxDstHeight has to be not more than maxSrcHeight. In other case fastResizeCreate returns FAST_INVALID_SIZE. Also maxSrcWidth/maxDstWidth and maxSrcHeight/maxDstHeight have to be less or equal to maxScaleFactor. In other cases fastResizeCreate returns FAST_INVALID_SIZE.

If resize component is used only for upscaling maxScaleFactor should be set at any value greater than one.

Min values for maxDstWidth and maxDstHeight are 32.

Max value for maxScaleFactor is 40.

Max values for maxSrcWidth and maxSrcHeight are 65536.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.18.2 *fastResizerGetAllocatedGpuMemorySize*

```
fastStatus_t fastResizerGetAllocatedGpuMemorySize
(fastResizerHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for Resizer component.

Parameters:

handle[in] – Resizer handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Resizer component.

Statuses:

- FAST_OK.

5.18.3 *fastResizerChangeSrcBuffer*

fastStatus_t fastResizerChangeSrcBuffer
(fastResizerHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer))

Sets new source buffer.

Parameters:

handle[in] – Resizer handle;

srcBuffer [in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.18.4 *fastResizerTransform*

fastStatus_t fastResizerTransform
(fastResizerHandle_t handle,
fastResizeType_t resizeType,
unsigned width,
unsigned height,

unsigned resizedWidth,
unsigned *resizedHeight)

Resizes current image with preserving aspect ratio.

Parameters:

handle[in] – Resizer handle;

resizeType[in] – type of resize. Currently only FAST_LANCZOS resize is supported.

width[in] – input image width in pixels;

height[in] – input image height in pixels;

resizedWidth[in] – width of resized image in pixels;

resizedHeight[out] – height of resized image in pixels.

Notes:

If size of input image or size of resized image are greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Height of resized image is calculated by the function and then customer application gets it in resizedHeight.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.18.5 *fastResizerTransformStretch*

fastStatus_t fastResizerTransformStretch
(fastResizerHandle_t handle,
fastResizeType_t resizeType,
unsigned width,

unsigned height,
unsigned resizedWidth,
unsigned resizedHeight)

Resizes current image without preserving aspect ratio.

Parameters:

handle[in] – Resizer handle;

resizeType[in] – type of resize. Currently only FAST_LANCZOS resize is supported.

width[in] – input image width in pixels;

height[in] – input image height in pixels;

resizedWidth[in] – width of resized image in pixels;

resizedHeight[in] – height of resized image in pixels.

Notes:

If size of input image or size of resized image are greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Function allows upscale one dimension and downscale other dimension.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.18.6 *fastResizerDestroy*

fastStatus_t fastResizerDestroy
(fastResizerHandle_t handle)

Destroys Resizer component.

Parameters:

handle[in] – Resizer component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.19 *HDR Builder functions*

5.19.1 *fastHdrBuilderCreate*

```
fastStatus_t fastHdrBuilderCreate
(fastHDRBuilderHandle_t *handle,
fastHDRBuilderFormat_t hdrFormat,
void* staticParameters,
unsigned maxWidth,
unsigned maxHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates HDR Builder and returns associated handle.

Parameters:

handle[out] – pointer to created HDR Builder component;

hdrFormat [in] – ;

staticParameters[in] – pointer to structure with additional parameters. List of supported structures: fastHdrGray_3x12_t;

maxWidth[in] – maximum width of image in pixels

maxHeight[in] – maximum height of image in pixels;

srcBuffer[in] – linked buffer from previous component;

dstBuffer[out] – pointer to created Resizer component;

handle[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastHdrBuilderCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastHdrBuilderCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.19.2 *fastHdrBuilderGetAllocatedGpuMemorySize*

```
fastStatus_t fastHdrBuilderGetAllocatedGpuMemorySize
(fastHDRBuilderHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for HDR Builder component.

Parameters:

handle[in] – HDR Builder handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for HDR Builder component.

Statuses:

- FAST_OK.

5.19.3 *fastHdrBuilderChangeSrcBuffer*

fastStatus_t fastHdrBuilderChangeSrcBuffer
(fastHDRBuilderHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer))

Sets new source buffer.

Parameters:

handle[in] – HDR Builder handle;

srcBuffer [in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.19.4 *fastHdrBuilderFill*

fastStatus_t fastHdrBuilderFill
(fastHDRBuilderHandle_t handle,
fastHDRImageExposure_t hdrImageExposure)

Set exposure buffer according parameters.

Parameters:

handle[in] – HDR Builder handle;

hdrImageExposure[in] – exposure type. Currently supports: HDR_EXPOSURE_X1, HDR_EXPOSURE_X4, HDR_EXPOSURE_X16.

Notes:

If size of input image or size of resized image are greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Height of resized image is calculated by the function and then customer application

gets it in resizedHeight.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE.

5.19.5 *fastHdrBuilderFillAndTransform*

```
fastStatus_t fastHdrBuilderFillAndTransform
(fastHDRBuilderHandle_t handle,
fastHDRImageExposure_t hdrImageExposure,
void* dynamicParameters,
unsigned width,
unsigned height)
```

Fill the last exposure and transform image.

Parameters:

handle[in]	–	HDR Builder handle;
hdrImageExposure[in]	–	exposure type. Currently supports: HDR_EXPOSURE_X1, HDR_EXPOSURE_X4, HDR_EXPOSURE_X16.
width[in]	–	input image width in pixels;
height[in]	–	input image height in pixels.

Notes:

If size of input image or size of resized image are greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Function allows upscale one dimension and downscale other dimension.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE.

5.19.6 *fastHdrBuilderDestroy*

fastStatus_t fastHdrBuilderDestroy
(fastHDRBuilderHandle_t handle)

Destroys HDR Builder component.

Parameters:

handle[in] – HDR Builder component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.20 *Bayer Splitter functions*

5.20.1 *fastBayerSplitterCreate*

fastStatus_t fastBayerSplitterCreate
(fastBayerSplitterHandle_t *handle,
unsigned maxSrcWidth,
unsigned maxSrcHeight,
unsigned *maxDstWidth,
unsigned *maxDstHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates BayerSplitter component and returns associated handle.

Parameters:

handle[out] – pointer to created BayerSplitter component;

maxSrcWidth[in] – maximum input image width in pixels;

maxSrcHeight[in] – maximum input image height in pixels;

maxDstWidth[out] – maximum width of splitted Bayer image in pixels;

maxDstHeight[out] – maximum height of splitted Bayer image in pixels;

srcBuffer[in] – linked buffer from previous component;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastBayerSplitterCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, fastBayerSplitterCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Output parameters maxDstWidth and maxDstHeight are used by next pipeline component to determine its maxWidth and maxHeight. Intended next component is JPEG Encoder.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.20.2 *fastBayerSplitterGetAllocatedGpuMemorySize*

```
fastStatus_t fastBayerSplitterGetAllocatedGpuMemorySize
(fastBayerSplitterHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for BayerSplitter component.

Parameters:

handle[in] – BayerSplitter component handle;

equestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for BayerSplitter component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.20.3 *fastBayerSplitterChangeSrcBuffer*

```
fastStatus_t fastBayerSplitterChangeSrcBuffer
(fastBayerSplitterHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in] – BayerSplitter component handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.20.4 *fastBayerSplitterSplit*

```
fastStatus_t fastBayerSplitterSplit
(fastBayerSplitterHandle_t handle,
unsigned srcWidth,
unsigned srcHeight,
unsigned *dstWidth,
```


unsigned *dstHeight)

Function splits Bayer image on four planes.

Parameters:

handle[in] – BayerSplitter component handle;

srcWidth[in] – maximum input image width in pixels;

srcHeight[in] – maximum input image height in pixels;

dstWidth[out] – width of splitted Bayer image in pixels;

dstHeight[out] – height of splitted Bayer image in pixels.

Notes:

If image size is greater than maximum value on creation error status, FAST_INVALID_SIZE will be returned.

Output parameters dstWidth and dstHeight are passed to the next component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.20.5 *fastBayerSplitterDestroy*

fastStatus_t fastBayerSplitterDestroy
(fastBayerSplitterHandle_t handle)

Destroys BayerSplitter component.

Parameters:

handle[in] – BayerSplitter component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.21 *Bayer Merger functions*

5.21.1 *fastBayerMergerCreate*

fastStatus_t fastBayerMergerCreate
(fastBayerMergerHandle_t *handle,
unsigned maxDstWidth,
unsigned maxDstHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates BayerMerger component and returns associated handle.

Parameters:

handle[out]	–	pointer to created BayerMerger component;
maxDstWidth[in]	–	maximum width of restored Bayer image in pixels;
maxDstHeight[in]	–	maximum height of restored Bayer image in pixels;
srcBuffer[in]	–	linked buffer from the previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastBayerMergerCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastBayerMergerCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

The function is different from other create functions because it takes maximum size of output image. BayerMerger takes splitted Bayer image and transforms it to normal Bayer image. It is more convenient for user to operate with size of restored (output) than splitted (input) image.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE.

5.21.2 *fastBayerMergerGetAllocatedGpuMemorySize*

```
fastStatus_t fastBayerMergerGetAllocatedGpuMemorySize
(fastBayerMergerHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Restores Bayer image from splitted image.

Parameters:

handle[in]	–	BayerMerger component handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for BayerMerger component.

Statuses:

- FAST_OK.

5.21.3 *fastBayerMergerChangeSrcBuffer*

```
fastStatus_t fastBayerMergerChangeSrcBuffer
( fastBayerMergerHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in]	–	BayerMerger component handle;
srcBuffer[in]	–	new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.21.4 *fastBayerMergerMerge*

```
fastStatus_t fastBayerMergerMerge
(fastBayerMergerHandle_t handle,
unsigned width,
unsigned height)
```

Returns requested GPU memory for BayerMerger component.

Parameters:

handle[in] – BayerMerger component handle;

width[in] – restored (original) image width in pixels;

height[in] – restored (original) image height in pixels.

Notes:

If image size is greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Restored Image width and height are taken from EXIF section, defined by SplitterExif_t structure in ExifInfo.hpp. Section is parsed by ParseSplitterExif function from ExifInfo.hpp.

Statuses:

- FAST_OK.

5.21.5 *fastBayerMergerDestroy*

```
fastStatus_t fastBayerMergerDestroy
(fastBayerMergerHandle_t handle)
```

Destroys BayerMerger component.

Parameters:

handle[in] – BayerMerger component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.22 *Timer functions*

5.22.1 *fastGpuTimerCreate*

```
fastStatus_t fastGpuTimerCreate
(fastGpuTimerHandle_t *handle)
```

Creates Timer and returns associated handle.

Parameters:

handle[out] – pointer to created Timer handle.

Notes:

Allocates necessary buffers in GPU memory. In case GPU does not have enough free memory returns FAST_INSUFFICIENT_DEVICE_MEMORY.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.22.2 *fastGpuTimerStart*

```
fastStatus_t fastGpuTimerStart
(fastGpuTimerHandle_t handle)
```


Inserts start event into GPU stream.

Parameters:

handle[in] – Timer handle pointer.

Notes:

Inserts start event into GPU stream.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.22.3 *fastGpuTimerStop*

```
fastStatus_t fastGpuTimerStop
(fastGpuTimerHandle_t handle)
```

Inserts stop event into GPU stream.

Parameters:

handle[in] – Timer handle pointer.

Notes:

Inserts stop event into GPU stream.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.22.4 *fastGpuTimerGetTime*

```
fastStatus_t fastGpuTimerGetTime
(fastGpuTimerHandle_t *handle,
float *elapsed)
```


Synchronizes CPU thread with stop event and calculates time elapsed between start and stop events.

Parameters:

handle[in] – Timer handle pointer;

elapsed[out] – time elapsed.

Notes:

Synchronizes CPU thread with stop event and calculates time elapsed between start and stop events.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.22.5 *fastGpuTimerDestroy*

```
fastStatus_t fastDestroyGpuTimerHandle
(fastGpuTimerHandle_t handle)
```

Destroys Timer handle.

Parameters:

handle[in] – pointer to Timer handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.23 *Mux functions*

5.23.1 *fastMuxCreate*

fastStatus_t fastMuxCreate
(fastMuxHandle_t *handle,
fastDeviceSurfaceBufferHandle_t* srcBuffers,
unsigned numberOfInputs,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates Mux and returns associated handle.

Parameters:

handle[out]	–	pointer to created Mux handle;
srcBuffers[in]	–	array of linked buffer from previous component;
numberOfInputs[in]	–	element count in srcBuffers;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Allocates necessary buffers in GPU memory. In case GPU does not have enough free memory returns FAST_INSUFFICIENT_DEVICE_MEMORY.

All input buffers have to be same size and type, else function returns FAST_INVALID_FORMAT.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_FORMAT.

5.23.2 *fastMuxSelect*

fastStatus_t fastMuxSelect
(fastMuxHandle_t handle,
unsigned srcBufferIndex)

Selects specified input and passes it to the output.

Parameters:

handle[in] – Mux handle;

srcBufferIndex[in] – index of selected input.

Notes:

Index is zero-based numbering. It has to be less than numberOfInputs in Create function, else function returns FAST_INVALID_SIZE.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INVALID_SIZE.

5.23.3 *fastMuxDestroy*

```
fastStatus_t fastMuxDestroy
(fastMuxHandle_t handle)
```

Destroys Mux.

Parameters:

handle[in] – Mux handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.24 *SDI import and export*

5.24.1 *fastSDIImportFromHostCreate/fastSDIImportFromDeviceCreate*

```
fastStatus_t fastSDIImportFromHostCreate (
  fastSDIImportFromHostHandle_t *handle,
  fastSDIFormat_t sdiFmt,
  unsigned maxWidth,
```



```
    unsigned maxHeight,
    fastDeviceSurfaceBufferHandle_t *dstBuffer)

  fastStatus_t fastSDIImportFromDeviceCreate (
    fastSDIImportFromDeviceHandle_t *handle,
    fastSDIFormat_t sdiFmt,
    unsigned maxWidth,
    unsigned maxHeight,
    fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates SDI Import component and returns associated handle.

Parameters:

handle[out]	–	pointer to created SDI Import handle;
sdiFmt[in]	–	SDI format;
maxWidth[in]	–	maximum width of image in pixels;
maxHeight[in]	–	maximum height of image in pixels;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Allocates necessary buffers in GPU memory. In case GPU does not have enough free memory returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format, then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_FORMAT,
- FAST_UNSUPPORTED_SURFACE.

5.24.2 *fastSDIExportToHostCreate/fastSDIExportToDeviceCreate*

```
  fastStatus_t fastSDIExportToHostCreate (
    fastSDIExportToHostHandle_t *handle,
```



```
    fastSDIFormat_t sdiFmt,
    void *staticParameters,
    unsigned maxWidth,
    unsigned maxHeight,
    fastDeviceSurfaceBufferHandle_t srcBuffer)

  fastStatus_t fastSDIExportToDeviceCreate (
    fastSDIExportToDeviceHandle_t *handle,
    fastSDIFormat_t sdiFmt,
    void *staticParameters,
    unsigned maxWidth,
    unsigned maxHeight,
    fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Creates SDI Export component and returns associated handle.

Parameters:

handle[out]	–	pointer to created SDI Import handle;
sdiFmt[in]	–	index of selected input;
staticParameters[in]	–	pointer to structure with additional parameters. List of supported structures: fastSDIRGBAExport_t, fastSDIYCbCrExport_t;
maxWidth[in]	–	maximum width of image in pixels;
maxHeight[in]	–	maximum height of image in pixels;
srcBuffer[in]	–	linked buffer from previous component.

Notes:

Allocates necessary buffers in GPU memory. In case GPU does not have enough free memory returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If srcBuffer format is incompatible with selected sdiFmt, then function returns FAST_INVALID_FORMAT.

Srtucture fastSDIRGBAExport_t defines padding for alpha channel of RGBA pixel.

```
  typedef struct{
    fastRGBAAlphaPadding_t padding;
  fastSDIRGBAExport_t}
```


where

- padding – defines padding for alpha channel: zero or FF.

Srtucture fastSDIYCbCrExport_t overrides source bits depth.

```
typedef struct{
   unsigned overrideSourceBitsPerChannel;
} fastSDIYCbCrExport_t
```

where

- overrideSourceBitsPerChannel – new bits depth.

Used in case of data bits depth is not according surface format. For example, in 12 bits format stored 10 bits data.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_FORMAT.

5.24.3 *fastSDIImportFromHostGetAllocatedGpuMemorySize*

```
fastStatus_t fastSDIImportFromHostGetAllocatedGpuMemorySize
(fastSDIImportFromHostHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory size for SDI Import component.

Parameters:

handle[in]	–	SDI Import component handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for SDI Import component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.24.4 *fastSDIImportFromDeviceGetAllocatedGpuMemorySize*

```
fastStatus_t fastSDIImportFromDeviceGetAllocatedGpuMemorySize (
  fastSDIImportFromDeviceHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory size for SDI Import component.

Parameters:

handle[in]	–	SDI Import component handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for SDI Import component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.24.5 *fastSDIExportToHostGetAllocatedGpuMemorySize*

```
fastStatus_t fastSDIExportToHostGetAllocatedGpuMemorySize (
  fastSDIExportToHostHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory size for SDI Export component.

Parameters:

handle[in]	–	SDI Export component handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for SDI Export component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.24.6 *fastSDIExportToDeviceGetAllocatedGpuMemorySize*

```
fastStatus_t fastSDIExportToDeviceGetAllocatedGpuMemorySize (
  fastSDIExportToDeviceHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory size for SDI Export component.

Parameters:

handle[in]	–	SDI Export component handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for SDI Export component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.24.7 *fastSDIImportFromHostCopy/fastSDIImportFromDeviceCopy*

```
fastStatus_t fastSDIImportFromHostCopy (
  fastSDIImportFromHostHandle_t handle,
  void* h_src,
  unsigned width,
  unsigned height)

fastStatus_t fastSDIImportFromDeviceCopy (
  fastSDIImportFromDeviceHandle_t handle,
  void* d_src,
  unsigned width,
  unsigned height)
```

Loads SDI formatted image to the pipeline.

Parameters:

handle[in] – SDI Import component handle;

h_src[in] – SDI formatted image located on host;

d_src[in] – SDI formatted image located on device;

width[in] – image width in pixels;

height[in] – image height in pixels.

Notes:

Buffer h_src has to be allocated by fastMalloc. Buffer allocated by original malloc also can be used, but copy speed will degrade.

Buffer d_src has to be allocated in Device memory by cudaMalloc. If size of d_dst is not enough, then function will fail with segmentation fault.

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.24.8 *fastSDIImportFromHostCopyPacked/fastSDIImportFromDeviceCopyPacked*

```
fastStatus_t fastSDIImportFromHostCopyPacked (
  fastSDIImportFromHostHandle_t handle,
  void* h_src,
  unsigned pitch,    unsigned width,
  unsigned height)

fastStatus_t fastSDIImportFromDeviceCopyPacked (
  fastSDIImportFromDeviceHandle_t handle,
  void* d_src,
  unsigned pitch,    unsigned width,
  unsigned height)
```


Loads packed SDI image to the pipeline. Supported formats are 422_8_CbYCrY, 422_8_CrYCbY, 422_10_CbYCrY_PACKED.

Parameters:

handle[in] – SDI Import component handle;

h_src[in] – SDI formatted image located on host;

d_src[in] – SDI formatted image located on device;

pitch[in] – image row pitch in bytes;

width[in] – image width in pixels;

height[in] – image height in pixels.

Notes:

Buffer h_src has to be allocated by fastMalloc. Buffer allocated by original malloc also can be used, but copy speed will degrade.

Buffer d_src has to be allocated in Device memory by cudaMalloc. If size of d_dst is not enough, then function will fail with segmentation fault.

If image size is greater than maximum value on creation, then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.24.9 *fastSDIExportToHostCopy/fastSDIExportToDeviceCopy*

```
fastStatus_t fastSDIExportToHostCopy (
  fastSDIExportToHostHandlet handle,
void* h_dst,
  unsigned *width,
  unsigned *height)
```



```
fastStatus_t fastSDIExportToDeviceCopy (
  fastSDIExportToDeviceHandle_t handle,
  void* d_dst,
  unsigned *width,
  unsigned *height)
```

Exports SDI formatted image from pipeline to host memory.

Parameters:

handle[in] – SDI Export component handle;

h_dst[out] – host buffer for exported SDI formatted image;

d_dst[out] – device buffer for exported SDI formatted image;

width[out] – image width in pixels;

height[out] – image height in pixels.

Notes:

Buffer size in Bytes can be calculated by GetSDIBufferSize function from HelperSDI.hpp (part of SDIConverterSample application).

Buffer h_dst has to be allocated by fastMalloc. Buffer allocated by original malloc also can be used, but copy speed will degrade.

Buffer d_dst has to be allocated in Device memory by cudaMalloc. If size of d_dst is not enough, then function will fail with segmentation fault.

User has to estimate width and height of export image and allocate buffer according to these values. Function returns real width and height.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.24.10 *fastSDIImportToHostCopy3/fastSDIImportToDeviceCopy3*

```
fastStatus_t fastSDIImportFromHostCopy3 (
  fastSDIImportFromHostHandle_t handle,
```



```
    fastChannelDescription_t *srcY,
    fastChannelDescription_t *srcU,
    fastChannelDescription_t *srcV)

fastStatus_t fastSDIImportFromDeviceCopy3 (
    fastSDIImportFromDeviceHandle_t handle,
    fastChannelDescription_t *srcY,
    fastChannelDescription_t *srcU,
    fastChannelDescription_t *srcV)
```

Loads YCbCr planar or mixed image from three separate buffers to the pipeline. All supported formats are listed in Table 8.

Parameters:

handle[in] – SDI Import component handle;

srcY[in] – Y plane of image;

srcU[in] – Cb plane or mixed Cb/Cr image;

srcV[in] – Cr plane of image or null for mixed image.

Notes:

Srtucture fastChannelDescription_t defines size of plane.

```
typedef struct{
    unsigned char *data;
    unsigned width;
    unsigned pitch;
    unsigned height;
} fastChannelDescriptiont
```

where

- data – plane buffer. It has to be allocated by fastMalloc for host version and cudaMalloc for device version;
- width – plane width;
- height – plane height;
- pitch – size of image raw in byte. Value alligned by 4.

If even one image plane has incorrect size , then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_INVALID_SIZE.

5.24.11 *fastSDIExportToHostCopy3/fastSDIExportToDeviceCopy3*

```
fastStatus_t fastSDIExportToHostCopy3 (
  fastSDIExportToHostHandle_t handle,
  fastChannelDescription_t *dstY,
  fastChannelDescription_t *dstU,
  fastChannelDescription_t *dstV)

fastStatus_t fastSDIExportToDeviceCopy3 (
  fastSDIExportToDeviceHandle_t handle,
  fastChannelDescription_t *dstY,
  fastChannelDescription_t *dstU,
  fastChannelDescription_t *dstV)
```

Loads YCbCr planar or mixed image from three separate buffers to the pipeline. All supported formats are listed in Table 8

Parameters:

handle[in] – SDI Export component handle;

srcY[in] – Y plane of image;

srcU[in] – Cb plane or mixed Cb/Cr image;

srcV[in] – Cr plane of image or null for mixed image.

Notes:

If even one image plane has incorrect size , then error status FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_INVALID_SIZE.

5.24.12 *fastSDIImportFromHostDestroy/fastSDIImportFromDeviceDestroy*

```
fastStatus_t fastSDIImportFromHostDestroy (
  fastSDIImportFromHostHandle_t handle)

fastStatus_t fastSDIImportFromDeviceDestroy (
  fastSDIImportFromDeviceHandle_t handle)
```

Destroys SDI Import component.

Parameters:

handle[in] – SDI Import component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.24.13 *fastSDIExportToHostDestroy/fastSDIExportToDeviceDestroy*

```
fastStatus_t fastSDIExportToHostDestroy (
  fastSDIExportToHostHandle_t handle)

fastStatus_t fastSDIExportToDeviceDestroy (
  fastSDIExportToDeviceHandle_t handle)
```

Destroys SDI Export component.

Parameters:

handle[in] – SDI Export component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.25 *RAW import*

5.25.1 *fastRawImportFromHostCreate/fastRawImportFromDeviceCreate*

```
fastStatus_t fastRawImportFromHostCreate (
  fastRawUnpackerHandle_t *handle,
  fastRawFormat_t rawFmt,
  fastSurfaceFormat_t surfaceFmt,
  unsigned maxWidth,
  unsigned maxHeight,
  fastDeviceSurfaceBufferHandle_t *dstBuffer)

fastStatus_t fastRawImportFromDeviceCreate (
  fastRawUnpackerHandle_t *handle,
  fastRawFormat_t rawFmt,
  fastSurfaceFormat_t surfaceFmt,
  unsigned maxWidth,
  unsigned maxHeight,
  fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates RAW Import component and returns associated handle.

Parameters:

handle[out] – pointer to created RAW Import handle;

rawFmt[in] – RAW format;

surfaceFmt[in] – Target surface format;

maxWidth[in] – maximum width of image in pixels;

maxHeight[in] – maximum height of image in pixels;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Allocates necessary buffers in GPU memory. In case GPU does not have enough free memory returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format, then the function will return FAST_UNSUPPORTED_SURFACE.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_FORMAT,
- FAST_UNSUPPORTED_SURFACE.

5.25.2 *fastRAWImportFromHostGetAllocatedGpuMemorySize*

```
fastStatus_t fastRawImportFromHostGetAllocatedGpuMemorySize (
  fastRawImportFromHostHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory size for RAW Import component.

Parameters:

handle[in] – RAW Import component handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for RAW Import component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.25.3 *fastRAWImportFromDeviceGetAllocatedGpuMemorySize*

```
fastStatus_t fastRAWImportFromDeviceGetAllocatedGpuMemorySize (
  fastRawImportFromDeviceHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory size for RAW Import component.

Parameters:

handle[in]	–	RAW Import component handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for RAW Import component.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.25.4 *fastRawImportFromHostDecode/fastRawImportFromDeviceDecode*

```
fastStatus_t fastRawImportFromHostDecode (
  fastRawUnpackerHandle_t handle,
  void* src,
  unsigned srcPitch,
  unsigned *width,
  unsigned *height)

fastStatus_t fastRawImportFromDeviceDecode (
  fastRawUnpackerHandle_t handle,
  void* src,
  unsigned srcPitch,
  unsigned *width,
  unsigned *height)
```


Loads Raw image to the pipeline.

Parameters:

handle[in] – Raw component handle;

src[out] – host/device buffer with imported Raw image;

srcPitch[in] – pitch in byte of imported Raw image;

width[out] – image width in pixels;

height[out] – image height in pixels.

Notes:

Buffer src for ImportFromHost has to be allocated by fastMalloc. Buffer allocated by original malloc also can be used, but copy speed will degrade.

Buffer src for ImportFromDevice has to be allocated in Device memory by cudaMalloc. If size of src is not enough, then function will fail with segmentation fault.

User has to estimate width and height of export image and allocate buffer according to these values. Function returns real width and height.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR.

5.25.5 *fastRawImportFromHostDestroy/fastRawImportFromDeviceDestroy*

```
fastStatus_t fastRawImportFromHostDestroy (
  fastRawImportFromHostHandle_t handle)

fastStatus_t fastRawImportFromDeviceDestroy(
  fastRawImportFromDeviceHandle_t handle)
```

Destroys Raw Import component.

Parameters:

handle[in] – Raw Import component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.26 *Surface converter*

5.26.1 *fastSurfaceConverterCreate*

```
fastStatus_t fastSurfaceConverterCreate (
  fastSurfaceConverterHandle_t *handle,
  fastSurfaceConverter_t surfaceConverterType,
  void *staticSurfaceConverterParameters,
  unsigned maxWidth,
  unsigned maxHeight,
  fastDeviceSurfaceBufferHandle_t srcBuffer,
  fastDeviceSurfaceBufferHandle_t *dstBuffer)
```

Creates Surface Converter and returns associated handle.

Parameters:

handle[out]	–	pointer to created Surface Converter handle;
surfaceConverterType[in]	–	surface converter type;
staticFilterParameters[in]	–	static parameters for image filter;
maxWidth[in]	–	maximum image width in pixels;
maxHeight[in]	–	maximum image height in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastSurfaceConverterCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastSurfaceConverterCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return

FAST_UNSUPPORTED_SURFACE.

List of supported structures for staticFilterParameters:

- fastBitDepthConverter_t,
- fastSelectChannel_t,
- fastRgbToGrayscale_t,
- fastBayerPatternParam_t.

Structure fastBitDepthConverter_t is a static parameter for FAST_BIT_DEPTH filter.

```
typedef struct{
  unsigned overrideSourceBitsPerChannel;
  bool isOverrideSourceBitsPerChannel;
  unsigned targetBitsPerChannel;
} fastBitDepthConverter_t
```

where

- overrideSourceBitsPerChannel – overrided bit depth of source surface;
- isOverrideSourceBitsPerChannel – activate source bit depth overriding;
- targetBitsPerChannel – bit depth of destination surface.

Structure fastSelectChannel_t is a static parameter for FAST_SELECT_CHANNEL filter.

```
typedef struct{
  fastChannelType_t channel;
} fastSelectChannel_t
```

where

- channel – selected RGB channel.

Structure fastRgbToGrayscale_t is a static parameter for FAST_RGB_TO_GRAYSCALE filter.

```
typedef struct{
  float coefficientR;
  float coefficientG;
  float coefficientB;
} fastRgbToGrayscale_t
```


where

- coefficientR – weight for R channel;
- coefficientG – weight for G channel;
- coefficientB – weight for B channel.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.26.2 *fastSurfaceConverterGetAllocatedGpuMemorySize*

```
fastStatus_t fastSurfaceConverterGetAllocatedGpuMemorySize (
  fastSurfaceConverterHandle_t handle,
  unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for Surface Converter component.

Parameters:

handle[in]	–	Surface Converter handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Surface Converter component.

Statuses:

- FAST_OK.

5.26.3 *fastSurfaceConverterChangeSrcBuffer*

```
fastStatus_t fastSurfaceConverterChangeSrcBuffer (
  fastSurfaceConverterHandle_t handle,
  fastDeviceSurfaceBufferHandle_t srcBuffer)
```


Sets new source buffer.

Parameters:

handle[in] – Surface Converter handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.26.4 *fastSurfaceConverterTransform*

```
fastStatus_t fastSurfaceConverterTransform (
  fastSurfaceConverterHandle_t handle,
  void *surfaceConverterParameters,
  unsigned width,
  unsigned height)
```

Performs current Surface Converter transformation.

Parameters:

handle[in] – Surface Converter handle;

surfaceConverterParameters[in] – parameters for current image;

width[in] – image width in pixels;

height[in] – image height in pixels.

Notes:

If image size is greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Pointer filterParameters can point on the following structures:

- fastBitDepthConverter_t,

- fastSelectChannel_t,
- fastRgbToGrayscale_t.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.26.5 *fastSurfaceConverterDestroy*

fastStatus_t fastSurfaceConverterDestroy (
fastSurfaceConverterHandle_t handle)

Destroys Surface Converter component handle.

Parameters:

handle[in] – Surface Converter component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR.

5.27 *Histogram functions*

5.27.1 *fastHistogramCreate*

fastStatus_t fastHistogramsCreate
(fastHistogramsHandle_t *handle,
fastHistogramType_t histogramType,
void *staticParameters,
unsigned int bins,
unsigned int maxWidth,
unsigned int maxHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer)

Creates Histogram and returns associated handle.

Parameters:

handle[out]	–	pointer to created Histogram component;
histogramType[in]	–	histogram type;
staticParameters[in]	–	pointer to static parameters;
bins[in]	–	number of bins in histogram. Number is power of two;
maxWidth[in]	–	maximum input image width in pixels;
maxHeight[in]	–	maximum input image height in pixels;
srcBuffer[in]	–	linked buffer from previous component.

Notes:

Function fastHistogramCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastHistogramCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

There is no static parameter for FAST_HISTOGRAM_COMMON type. Static parameter has to be null.

Structure fastHistogramBayer_t is static parameter for FAST_HISTOGRAM_BAYER and FAST_HISTOGRAM_BAYE_G1G2 types.


```
typedef struct{
  fastBayerPattern_t bayerPattern;
} fastHistogramBayer_t
```

where bayerPattern is pattern for bayer filtered image.

Structure fastHistogramParade_t is static parameter for FAST_HISTOGRAM_PARADE type.

```
typedef struct{
  unsigned int stride;
} fastHistogramParade_t
```

where stride is step to next image column used for parade calculation.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.27.2 *fastHistogramGetAllocatedGpuMemorySize*

```
fastStatus_t fastHistogramGetAllocatedGpuMemorySize
(fastHistogramHandle_t handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for Histogram component.

Parameters:

handle[in]	–	Histogram handle;
requestedGpuSizeInBytes[out]	–	memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for Histogram component.

Statuses:

- FAST_OK.

5.27.3 *fastHistogramChangeSrcBuffer*

fastStatus_t fastHistogramChangeSrcBuffer
(fastHistogramHandle_t handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)

Sets new source buffer.

Parameters:

handle[in] – Histogram handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.27.4 *fastHistogramCalculate*

fastStatus_t fastHistogramCalculate
(fastHistogramHandle_t handle,
void *histogramParameters,
unsigned int roiLeftTopX,
unsigned int roiLeftTopY,
unsigned int roiWidth,
unsigned int roiHeight,
unsigned int *h_histogram)

Calculates histogram in ROI for current image.

Parameters:

handle[in] – Histogram handle;

histogramParameters[in] – pointer to dynamic parameter;

roiLeftTopX[in] – column of top left corner of ROI;

roiLeftTopY[in] – row of top left corner of ROI;

roiWidth[in] – width of ROI;

roiHeight[in] – height of ROI;

h_histogram[out] – CPU buffer for calculated histogram.

Notes:

If

$$\mathsf{roiLeftTopX} + \mathsf{roiWidth}$$

greater than image width or

$$\mathsf{roiLeftTopY} + \mathsf{roiHeight}$$

greater than image height error status FAST_INVALID_SIZE will be returned.

Values roiLeftTopX, roiLeftTopY have to be even in case of bayer histogram.

There is no dynamic parameter for FAST_HISTOGRAM_COMMON type. Structure fastHistogramBayer_t is dynamic parameter for FAST_HISTOGRAM_BAYER and FAST_HISTOGRAM_BAYER_G1G2 types. Structure fastHistogramParade_t is dynamic parameter for FAST_HISTOGRAM_PARADE type.

Buffer h_histogram has to be allocated with fastMalloc. Buffer, which is allocated by original malloc also can be used, but copy speed will degrade. If size of h_histogram is not enough, then the function will fail with segmentation fault.

Number of elements in h_histogram is multiplication of bin count on number of histogram. Elements of histogram are int values. Number of histograms depends on histogram type, surface format and image width (for some types). Number of histograms can be calculated by GetHistogramCount function in HistogramSample.

Function FastHistogramCalculate copies h_histogram buffer asynchronously. So when function finished, the buffer is not ready. It is necessary to use cudaEvent to wait until copy has been finished. See HistogramSample.

Format h_histogram depends on histogram type. For FAST_HISTOGRAM_COMMON, FAST_HISTOGRAM_BAYER, FAST_HISTOGRAM_BAYER_G1G2 types h_histogram is an array of histograms where each histogram is dense array of values. Histogram order in h_histogram for color image is R, G, B. Histogram order in h_histogram for Bayer

filtered image is the same. Histogram order in h_histogram for Bayer filtered image for FAST_HISTOGRAM_BAYER_G1G2 is R, G1, B, G2. Where G1 is green pixel in the first line of pattern, G2 is green pixel in the second line of pattern. For more details see SaveHistogramToFile in HistogramSample.

For FAST_HISTOGRAM_PARADE h_histogram is array of parades. Parade order is R, G, B. Parade contains the first bin for each column then second bin for each column and so on. For more details see SaveParadeToFile in HistogramSample.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.27.5 *fastHistogramDestroy*

```
fastStatus_t fastHistogramDestroy
(fastHistogramHandle_t handle)
```

Destroys Histogram component.

Parameters:

handle[in] – Histogram component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.28 *NppFilter functions*

5.28.1 *fastNppFilterCreate*

fastStatus_t fastNppFilterCreate
(fastNppFilterHandle_t *handle,
fastNPPImageFilterType_t filterType,
void *staticFilterParameters,
unsigned maxWidth,
unsigned maxHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates NppFilter and returns associated handle.

Parameters:

handle[out]	–	pointer to created NppFilter component;
filterType[in]	–	filter type;
staticFilterParameters[in]	–	pointer to static parameter;
maxWidth[in]	–	maximum input image width in pixels;
maxHeight[in]	–	maximum input image height in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastNppFilterCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastNppFilterCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

There are three filters: NPP_GAUSSIAN_SHARPEN, NPP_UNSHARP_MASK_SOFT, NPP_UNSHARP_MASK_HARD.

Filter NPP_GAUSSIAN_SHARPEN supports next surfaces: I8, RGB8, I16, RGB16.

Filters NPP_UNSHARP_MASK_* support next surfaces: RGB8, RGB12, RGB16.

Structure fastNPPGaussianFilter_t is static parameter for NPP_GAUSSIAN_SHARPEN

filter type.

```
typedef struct{
   double radius;
   double sigma;
} fastNPPGaussianFilter_t
```

where radius is a radius of gaussian kernel, sigma is parameter for kernel value.

In general radius of kernel should be

$$3 \times \mathsf{sigma}$$

but for performance optimization radius can be less than

$$3 \times \mathsf{sigma}.$$

Liner size of kernel can be estimated like

$$2 \times \mathsf{radius} + 1.$$

Filters NPP_UNSHARP_MASK_SOFT and NPP_UNSHARP_MASK_HARD have the same function

$$\mathsf{out} = \mathsf{val} + \mathsf{amount} \times (\mathsf{val} - \mathsf{blur}) \times \mathsf{envelop}(\mathsf{val}),$$

where

- val is original image value,
- blur is a pixel of blurred image,
- amount controls how much contrast is added at the edges.
- Envelop function allow to make amount parameter depended on pixel brightness.

Also there is additional parameter threshold. The threshold controls the minimum brightness change that will be sharpened. If

$$(\mathsf{val} - \mathsf{blur})$$

less threshold then amount will be set to zero.

Filter NPP_UNSHARP_MASK_SOFT ignores threshold parameter.

Structure fastNPPUnsharpMaskFilter_t is static parameter for NPP_UNSHARP_MASK_SOFT and NPP_UNSHARP_MASK_HARD filter types.


```
typedef struct{
  float amount;
  float sigma;
  float envelopMedian; /*(0;1)*/
  float envelopSigma; /*(0;), 0.5 - mean median of value interval*/
  int envelopRank; /*2,4,6,8,12*/
  float envelopCoef; /*(;0)*/
  float threshold; /*(0;1)*/
} fastNPPUnsharpMaskFilter_t
```

where

- amount is filter function parameter,
- sigma defines blur kernel size and value.

There is no radius as a parameter for the filter. Radius is always equal to

$$3 \times \text{sigma}.$$

Threshold is relative to pixel range. Description envelop function and its parameters you can find in the chapter about NPP component.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.28.2 *fastNppFilterGetAllocatedGpuMemorySize*

```
fastStatus_t fastNppFilterGetAllocatedGpuMemorySize
(fastNppFilterHandle_t *handle,
unsigned *requestedGpuSizeInBytes)
```

Returns requested GPU memory for NppFilter component.

Parameters:

handle[in] – NppFilter handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for NppFilter component.

Statuses:

- FAST_OK.

5.28.3 *fastNppFilterChangeSrcBuffer*

```
fastStatus_t fastNppFilterChangeSrcBuffer
(fastNppFilterHandle_t *handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in] – NppFilter handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.28.4 *fastNppFilterFiltersTransform*

```
fastStatus_t fastNppFilterTransform
(fastNppFilterHandle_t handle,
unsigned width,
unsigned height,
void *filterParameters)
```


Performs current NppFilter transformation.

Parameters:

handle[in] – ImageFilter component handle;

width[in] – image width in pixels;

height[in] – image height in pixels;

filterParameters[in] – filter parameters for current image.

Notes:

If image size is greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Pointer filterParameters can point on the following structures:

- fastNPPGaussianFilter_t,
- fastNPPUnsharpMaskFilter_t.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.28.5 *fastNppFilterDestroy*

fastStatus_t fastNppFilterDestroy
(fastNppFilterHandle_t handle)

Destroys NppFilter component.

Parameters:

handle[in] – NppFilter component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.29 *NppGeometry functions*

5.29.1 *fastNppGeometryCreate*

fastStatus_t fastNppGeometryCreate
(fastNppGeometryHandle_t *handle,
fastNppGeometryTransformationType_t transformationType,
fastNPPImageInterpolation_t interpolationMode,
void *filterParameters,
unsigned maxDstWidth,
unsigned maxDstHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates NppGeometry and returns associated handle.

Parameters:

handle[out]	–	pointer to created NppGeometry component;
transformationType[in]	–	transformation type;
interpolationMode[in]	–	interpolation mode;
filterParameters[in]	–	pointer to static parameter;
maxWidth[in]	–	maximum input image width in pixels;
maxHeight[in]	–	maximum input image height in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastNppGeometryCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastNppGeometryCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

There are two transformations:

- FAST_NPP_GEOMETRY_REMAP,
- FAST_NPP_GEOMETRY_REMAP3.

Transformation FAST_NPP_GEOMETRY_REMAP3 allows individual transformation for each RGB channels.

Filter FAST_NPP_GEOMETRY_REMAP supports next surfaces: I12, RGB12, I16, RGB16.

Filter FAST_NPP_GEOMETRY_REMAP3 supports next surfaces: RGB12, RGB16.

Structure fastNPPRemap_t is static parameter for FAST_NPP_GEOMETRY_REMAP filter type.

```
typedef struct{
  fastNPPRemapMap_t *map;
  fastNPPRemapBackground_t *background;
} fastNPPRemap_t
```

Structure fastNPPRemap3_t is static parameter for FAST_NPP_GEOMETRY_REMAP3 filter type.

```
typedef struct{
  fastNPPRemapMap_t *map[3];
  fastNPPRemapBackground_t *background;
} fastNPPRemap3_t
```

where

- map field stores information about transformation,
- background stores RGB value for background.

Structure fastNPPRemap3_t has individual transformation for each RGB channels, respectively.

Remap transformation is the process of taking pixels from one place in the image and

locating them in another position in a new image. To accomplish the mapping process, it might be necessary to do some interpolation for non-integer pixel locations, since there will not always be a one-to-one-pixel correspondence between source and destination images.

Structure fastNPPRemapMap_t stores information about transformation.

```
typedef struct{
  float *mapX;
  float *mapY;
  unsigned dstWidth;
  unsigned dstHeight;
} fastNPPRemapMap_t
```

where dstWidth, dstHeight are new image width and height respectively. Arrays mapX, mapY have size as a source image. Value in the array is position of pixel in new image. Array mapX stores new X position (column) , Array mapY stores new Y position (row).

During transformation some new pixel will be defined by old pixel. This pixel will be filled by background color.

Structure fastNPPRemapBackground_t defines color for background.

```
typedef struct{
  unsigned R;
  unsigned G;
  unsigned B;
  bool isEnabled;
} fastNPPRemapBackground_t
```

If background is enabled then destination image before transformation will be filled by background. If background is disabled then non initialized pixels can contain noise or pixel of previous images.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INVALID_VALUE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_UNSUPPORTED_SURFACE.

5.29.2 *fastNppGeometryGetAllocatedGpuMemorySize*

fastStatus_t fastNppGeometryGetAllocatedGpuMemorySize
(fastNppGeometryHandle_t *handle,
unsigned *requestedGpuSizeInBytes)

Returns requested GPU memory for NppGeometry component.

Parameters:

handle[in] – NppGeometry handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for NppGeometry component.

Statuses:

- FAST_OK.

5.29.3 *fastNppGeometryChangeSrcBuffer*

fastStatus_t fastNppGeometryChangeSrcBuffer
(fastNppGeometryHandle_t *handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)

Sets new source buffer

Parameters:

handle[in] – NppGeometry handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.29.4 *fastNppGeometryTransform*

fastStatus_t fastNppGeometryTransform
(fastNppGeometryHandle_t handle,
void *filterParameters,
unsigned width,
unsigned height)

Performs current NppGeometry transformation.

Parameters:

handle[in] – ImageFilter component handle;

filterParameters[in] – filter parameters for current image;

width[in] – NppGeometry width in pixels;

height[in] – image height in pixels.

Notes:

If image size is greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Pointer filterParameters can point on the following structures:

- fastNPPRemap_t,
- fastNPPRemap3_t.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.29.5 *fastNppGeometryDestroy*

fastStatus_t fastNppGeometryDestroy

(fastNppGeometryHandle_t handle)

Destroys NppGeometry component.

Parameters:

handle[in] – NppGeometry component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.30 *NppResize functions*

5.30.1 *fastNppResizeCreate*

fastStatus_t fastNppResizeCreate
(fastNppResizeHandle_t *handle,
unsigned resizedWidth,
unsigned resizedHeight,
fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates NppResize and returns associated handle.

Parameters:

handle[out]	–	pointer to created Resizer component;
resizedWidth[in]	–	maximum destination (cropped) image width in pixels;
resizedHeight[in]	–	maximum destination (cropped) image height in pixels;
srcBuffer[in]	–	linked buffer from previous component;
dstBuffer[out]	–	pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastNppResizeCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastNppResizeCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Component supports next surfaces: RGB8, RGB12, RGB16.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.30.2 *fastNppResizeGetAllocatedGpuMemorySize*

fastStatus_t fastNppResizeGetAllocatedGpuMemorySize
(fastNppResizeHandle_t *handle,
unsigned *requestedGpuSizeInBytes)

Returns requested GPU memory for NppResize component.

Parameters:

handle[in] – NppResize handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for NppResize component.

Statuses:

- FAST_OK.

5.30.3 *fastNppResizeChangeSrcBuffer*

fastStatus_t fastNppResizeChangeSrcBuffer
(fastNppResizeHandle_t *handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)

Sets new source buffer.

Parameters:

handle[in] – NppResize handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.30.4 *fastNppResizeTransform*

fastStatus_t fastNppResizeTransform
(fastNppResizeHandle_t handle,
fastNPPImageInterpolation_t resizeType,
unsigned width,
unsigned height,
unsigned resizedWidth,
unsigned *resizedHeight,
double shiftX,
double shiftY)

Performs current NppResize transformation.

Parameters:

handle[in]	–	NppResizer handle;
resizeType[in]	–	type of resize interpolation;
width[in]	–	input image width in pixels;
height[in]	–	input image height in pixels;
resizedWidth[in]	–	width of resized image in pixels;
resizedHeight[out]	–	height of resized image in pixels;
shiftX[in]	–	shift between source and destination grids by x coordinate. Currently ignored, should be 0,0;
shiftY[in]	–	shift between source and destination grids by y coordinate. Currently ignored, should be 0,0.

Notes:

If size of input image or size of resized image are greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Height of resized image is calculated by the function and then customer application gets it in resizedHeight.

Statuses:

- FAST_OK,

- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.30.5 *fastNppResizeTransformStretch*

fastStatus_t fastNppResizeTransformStretch
(fastNppResizeHandle_t handle,
fastNPPImageInterpolation_t resizeType,
unsigned width,
unsigned height,
unsigned resizedWidth,
unsigned resizedHeight,
double shiftX,
double shiftY)

Performs current NppGeometry transformation.

Parameters:

handle[in] – NppResizer handle;

resizeType[in] – type of resize interpolation;

width[in] – input image width in pixels;

height[in] – input image height in pixels;

resizedWidth[in] – width of resized image in pixels;

resizedHeight[in] – height of resized image in pixels;

shiftX[in] – shift between source and destination grids by x coordinate. Currently ignored, should be 0,0;

shiftY[in] – shift between source and destination grids by y coordinate. Currently ignored, should be 0,0.

Notes:

If size of input image or size of resized image are greater than maximum value on creation error status FAST_INVALID_SIZE will be returned.

Function allows upscale one dimension and downscale other dimension.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.30.6 *fastNppResizeDestroy*

```
fastStatus_t fastNppResizeDestroy
(fastNppResizeHandle_t handle)
```

Destroys NppResize component.

Parameters:

handle[in] – NppResize component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

5.31 *NppRotate functions*

5.31.1 *fastNppRotateCreate*

```
fastStatus_t fastNppRotateCreate
(fastNppRotateHandle_t *handle,
fastNPPImageInterpolation_t interpolationMode,
```


fastDeviceSurfaceBufferHandle_t srcBuffer,
fastDeviceSurfaceBufferHandle_t *dstBuffer)

Creates NppRotate and returns associated handle.

Parameters:

handle[out] – pointer to created NppRotate component;

interpolationMode[in] – type of rotate interpolation;

srcBuffer[in] – linked buffer from previous component;

dstBuffer[out] – pointer for linked buffer for the next component (output buffer of current component).

Notes:

Function fastNppRotateCreate allocates all necessary buffers in GPU memory. So in case GPU does not have enough free memory, then fastNppRotateCreate returns FAST_INSUFFICIENT_DEVICE_MEMORY.

If component does not support current surface format then the function will return FAST_UNSUPPORTED_SURFACE.

Component supports next surfaces: I8,RGB8, I12, RGB12, I16, RGB16.

Statuses:

- FAST_OK,
- FAST_INSUFFICIENT_DEVICE_MEMORY,
- FAST_INTERNAL_ERROR,
- FAST_INVALID_SIZE,
- FAST_UNSUPPORTED_SURFACE.

5.31.2 *fastNppRotateGetAllocatedGpuMemorySize*

fastStatus_t fastNppRotateGetAllocatedGpuMemorySize
(fastNppRotateHandle_t *handle,
unsigned *requestedGpuSizeInBytes)

Returns requested GPU memory for NppRotate component.

Parameters:

handle[in] – NppRotate handle;

requestedGpuSizeInBytes[out] – memory size in Bytes.

Notes:

Function returns requested memory size in Bytes for NppRotate component.

Statuses:

- FAST_OK.

5.31.3 *fastNppRotateChangeSrcBuffer*

```
fastStatus_t fastNppRotateChangeSrcBuffer
(fastNppRotateHandle_t *handle,
fastDeviceSurfaceBufferHandle_t srcBuffer)
```

Sets new source buffer.

Parameters:

handle[in] – NppRotate handle;

srcBuffer[in] – new source buffer.

Notes:

MaxWidth and MaxHeight of new buffer should be equal to appropriate values of current buffer otherwise FAST_INVALID_SIZE will be returned.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE.

5.31.4 *fastNppRotateGetRotateQuad*

```
fastStatus_t fastNppRotateGetRotateQuad
(fastNppRotateHandle_t handle,
unsigned width,
unsigned height,
double rotateAngle,
double shiftX,
```


double shiftY,
NppQuadCorners_t *quadCorners)

Returns coordinates of rectangle that envelop rotated image.

Parameters:

handle[in] – NppRotate handle;

width[in] – input image width in pixels;

height[in] – input image height in pixels;

rotateAngle[in] – rotation angle in degrees;

shiftX[in] – shift by X for upper left corner of image;

shiftY[in] – shift by Y for upper left corner of image;

quadCorners[out] – pointer to result coordinates. Coordinate can be negative.

Notes:

The function is wrapper for nppiGetRotateQuad function. It allows to calculate real size of rotated image. It is not so obvious because image size depend on rotation angle.

Statuses:

- FAST_OK,
- FAST_INVALID_SIZE,
- FAST_INTERNAL_ERROR.

5.31.5 *fastNppRotateTransform*

fastStatus_t fastNppRotateTransform
(fastNppRotateHandle_t handle,
unsigned width,
unsigned height,
unsigned dstRoiX,
unsigned dstRoiY,
double rotateAngle,
double shiftX,
double shiftY)

Performs current NppRotate transformation.

Parameters:

handle[in] – NppRotate handle;

width[in] – input image width in pixels;

height[in] – input image height in pixels;

dstRoiX[in] – width of rotated image in pixels;

dstRoiX[out] – height of rotated image in pixels;

rotateAngle[in] – rotation angle in degrees;

shiftX[in] – shift by X for upper left corner of image;

shiftY[in] – shift by Y for upper left corner of image.

Notes:

The function is wrapper for nppiRotate* function. Parameters dstRoiX, dstRoiY, shiftX, shiftY calculated on result of fastNppRotateGetRotateQuad function. See sample of rotation in NppSample.

Statuses:

- FAST_OK,
- FAST_INVALID_VALUE,
- FAST_INVALID_HANDLE,
- FAST_INTERNAL_ERROR,
- FAST_UNKNOWN_ERROR,
- FAST_EXECUTION_FAILURE,
- FAST_INVALID_SIZE.

5.31.6 *fastNppRotateDestroy*

fastStatus_t fastNppRotateDestroy
(fastNppRotateHandle_t handle)

Destroys NppRotate component.

Parameters:

handle[in] – NppRotate component handle.

Notes:

Procedure frees all device memory.

Statuses:

- FAST_OK,
- FAST_INVALID_HANDLE.

6 Source Code for Sample Applications

The source codes for sample applications and for all other demo software are located in the samples directory of the SDK. Microsoft Visual Studio (2015) solution and Linux makefiles are included with the source code. Qt solution is coming soon.

6.1 *Other Sample Applications*

Command-line sample applications are provided with the current SDK. The executables for all sample applications are in the SDK /bin directory. Each sample can be executed without any parameters to display a message which briefly describes all available parameters. To build the above applications, one have to utilize the following files:

- all h-files are in the SDK inc directory,
- all lib-files are in the SDK lib directory.

6.2 *Examples of command line for DebayerSample application*

Debayering with DebayerSample application:

```
DebayerSample.exe -i kodim19.pgm -o kodim19.ppm -type DFPD -pattern RGGB
-info
```

The application takes `kodim19.pgm` image from the current directory and runs debayer with DFPD algorithm and pattern RGGB to create an image `kodim19.ppm`. Parameter `-info` means that we will get detailed info about timing and performance.

```
.\x64\Release\DebayerSample.exe -if .\..\Images\*.pgm
-o .\x64\Release\*.ppm -type DFPD -pattern RGGB -maxWidth 4096
-maxHeight 4096 -info
```

The application takes all PGM images from the folder

```
.\..\Images\
```

and does debayering with DFPD algorithm and pattern RGGB to create corresponding images with PPM extension. Maximum width and height of all images can't exceed 4096 in that particular case. Real maximum height and width depend on GPU memory size.

6.3 *Examples of command line for JpegSample application*

Decoding with JpegSample application:

```
JpegSample.exe -i input.jpg -o output.ppm -info
```

The application takes `input.jpg` image from the current directory and decodes it to file `output.ppm`. Parameter `-info` means that application will output detailed info about timing and performance.

```
.\x64\Release\JpegSample.exe -if .\..\Images\*.jpg -o .\x64\Release\*.ppm
-maxWidth 4096 -maxHeight 4096 -info
```

The application takes all JPEG images from the folder

```
.\..\Images\
```

and decodes them into corresponding images with PPM extension. Maximum width and height of all images in that particular case can't exceed 4096. Real maximum height and width depend on GPU memory size.

Encoding with JpegSample application:

```
JpegSample.exe -i input.ppm -o output.jpg -q 90 -s 444 -info
```

The application takes `input.ppm` image from the current directory and encodes it to file `output.jpg` with JPEG quality 90%, subsampling $4:4:4$ and optimum restart interval is computed automatically. Parameter `-info` means that application will output detailed info about timing and performance.

6.4 *Example of command line for DebayerJpegSample application*

That application makes Demosaicing and JPEG compression in one pipeline:

```
DebayerJpegSample.exe -i input.pgm -o output.jpg -type DFPD -pattern RGGB
-q 90 -s 420 -info
```

The application takes `input.pgm` image from the current directory and converts it to `output.jpg`. Parameter `-info` means that application will output detailed info about timing and performance.

6.5 *Examples of command line for SDIConverterSample application*

That application takes an input image from the current directory and runs SDI transforms from RGB to YCbCr or from YCbCr to RGB. Parameter `-info` means that we will get detailed info about timing and performance.

Command line for SDIConverterSample:

```
SDIConverterSample.exe -i <input image> -o <output image> -format <format>
-width <width> -height <height> -d <device ID> -info
```

Command line for import:

```
SDIConverterSample.exe -i <input image> -o <output image>
-format CbYCr422_709 -width 1920 -height 1080 -d <device ID> -info
```

Command line for export:

```
SDIConverterSample.exe -export -i <input image> -o <output image>
-format CbYCr422_709 -width 1920 -height 1080 -d <device ID> -info
```

6.6 *Example of command line for PhotoHostingSample application*

That application does image processing with the following pipeline: JPEG decoding, cropping, resizing, sharpening, JPEG encoding

```
PhotoHostingSample.exe -i input.jpg
-o output.crop.1023.jpg -outputWidth 1023 -crop 1900x1000+12+10 -q 90
-s 444 -info
```

The application takes `input.jpg` image from the current directory, crops it with offsets 12 and 10 with final resolution 1900x1000, then does resize to final width 1023 and converts it to `output.crop.1023.jpg`. Parameter `-info` means that application will output detailed info about timing and performance.

This is an example for batch image processing:

```
.\x64\Release\PhotoHostingSample.exe -if .\..\Images\*.jpg
-o .\x64\Release\*.512.jpg -outputWidth 511 -maxWidth 4096 -maxHeight 4096
```



```
-q 90 -s 444 -info
```

6.7 *Troubleshooting*

Debug version of SDK which allows generation of a trace/debug log is also available. It can be helpful for problem detection and identification. The debug DLL file name is the same as the non-debug version, but with the addition of the letter "d" at the end of filename prior to the file extension.

We welcome and encourage your questions and comments concerning our products use from evaluation through deployment of your application.

Contact us at info@fastcompression.com

6.8 *Disclaimer of Warranty*

In addition to the provisions of the Standard License Agreement (SLA) of FASTVIDEO the following apply:

Although FASTVIDEO has taken care to ensure the accuracy of the information contained herein it accepts no responsibility for the consequences of any use thereof and also reserves the right to change the specification without prior notice.

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7 Application Notes

All functions of the software work with NVIDIA Maxwell and late GPU architectures with the latest drivers installed. We don't support GPUs with cc < 5.0 from NVIDIA. The software can't work neither with Intel nor AMD/ATI GPUs.

The software can't work with Windows 2000 and XP. Command line applications are compiled for Windows-7/8/10, 64-bit.

Before testing SDK components or sample applications, please check that CUDA runtime libraries and GPU drivers are installed.

CUDA JPEG codec can work with JPEG images only according to specification of the Baseline part of JPEG Standard. CUDA JPEG encoder can work with 12-bit image format as well. Arithmetic coding, lossless JPEG (JPEG_LS), progressive JPEG and other extended features are beyond codec's capabilities.

CUDA JPEG codec could be exceptionally fast at JPEG decoding only in the case when input images have built-in Restart Markers. These markers ensure fully parallel implementation of JPEG decoding on GPU. If compressed input image doesn't have Restart Markers, the codec can perform Huffman decoding stage of JPEG Baseline algorithm on CPU and then carry on with GPU. This solution is still much faster than full JPEG decompression on CPU. If you do image compression with CUDA JPEG codec, the software automatically adds Restart Markers into compressed bitstream and you will not have any problems with performance at the decompression stage.

To get maximum performance, GPU needs as much data as possible. For small images (resolution less than 300×300) one can get moderate performance results even with very powerful GPU.

There is an upper limit for resolution for big images due to size of available GPU RAM. Please test your images on demo sample application to be sure that your GPU can work with images with desired resolution. There is also a lower limit for image resolution which is quite small.

Please note that in the case when you are utilizing discrete GPU at laptop, be sure that your laptop is directly connected to external power supply. Without external power, GPU performance will degrade.

If you implement your own software with FASTVIDEO SDK, please check that your application is running just one instance of `fastvideo_sdk.dll` per GPU, though it's possible (with less performance) to run several instances as well. The most efficient way is to run just one instance per GPU, because the software is highly optimized and GPU

occupancy is very high, so at each moment just one image could be processed on particular GPU. It could be a good idea to organize input and output queues which are working with the same instance of `fastvideo_sdk.dll` to ensure maximum performance.

To get better performance we also recommend to utilize big images and multiple CUDA Streams to ensure overlapping between data copy and computations.

