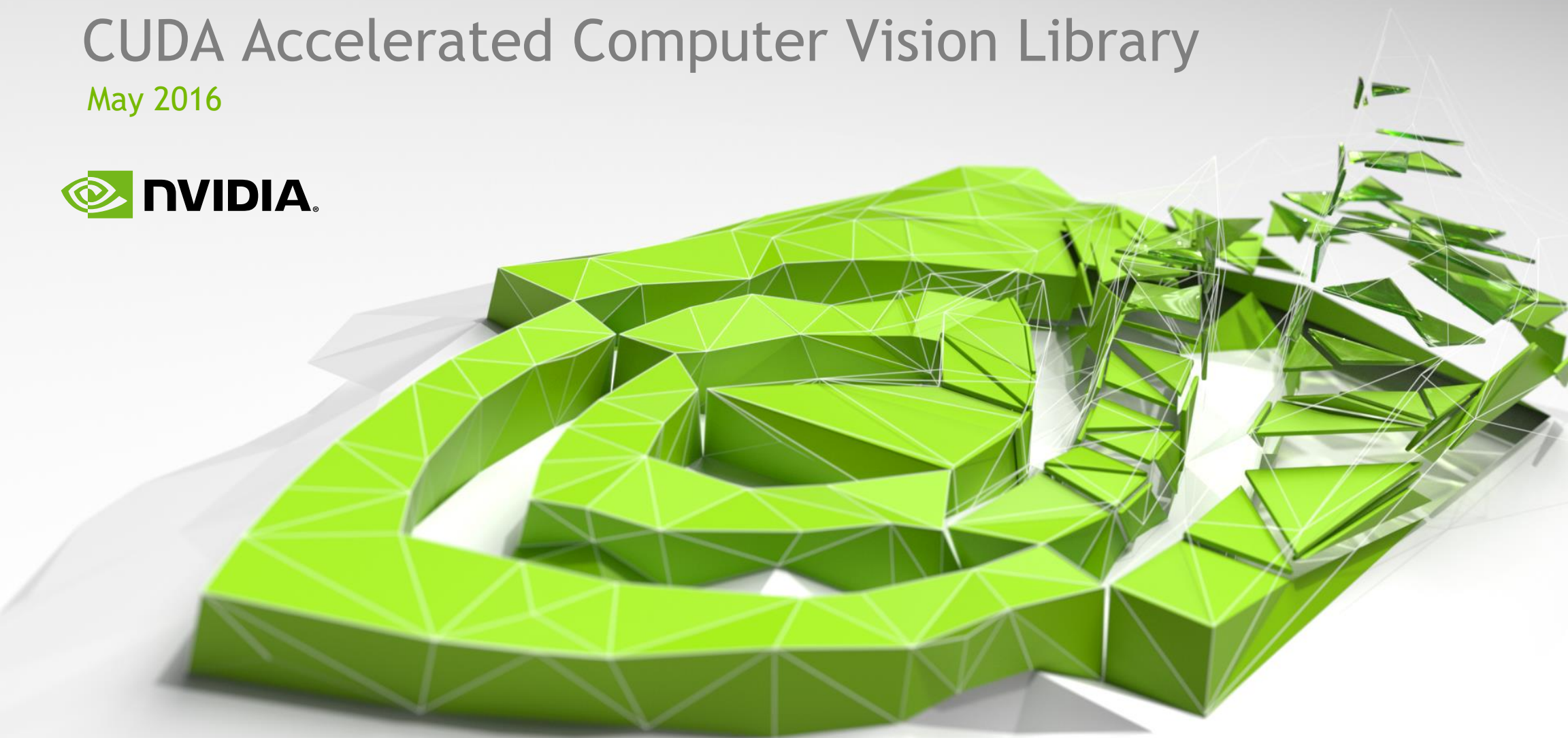


VisionWorks™

CUDA Accelerated Computer Vision Library

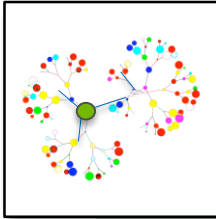
May 2016



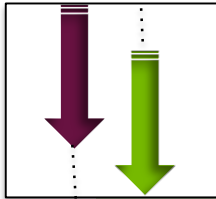
VisionWorks™ at a Glance



CUDA accelerated library
(OpenVX primitives + NVIDIA extensions + Plus Algorithms)



Flexible framework for seamlessly adding user-defined primitives.
Interoperability with OpenCV



Thread-safe API



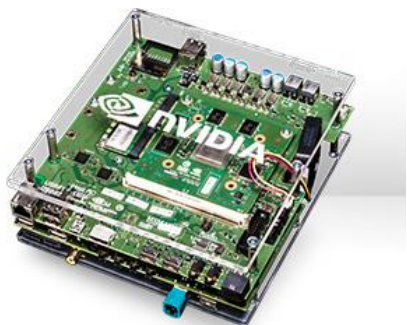
Documentation, tutorials, sample software pipelines that teach use of primitives and framework

VisionWorks™ Supported Platforms

Automotive



Drive PX



JETSON TK1 Pro → Drive PX2

Embedded



JETSON TX1



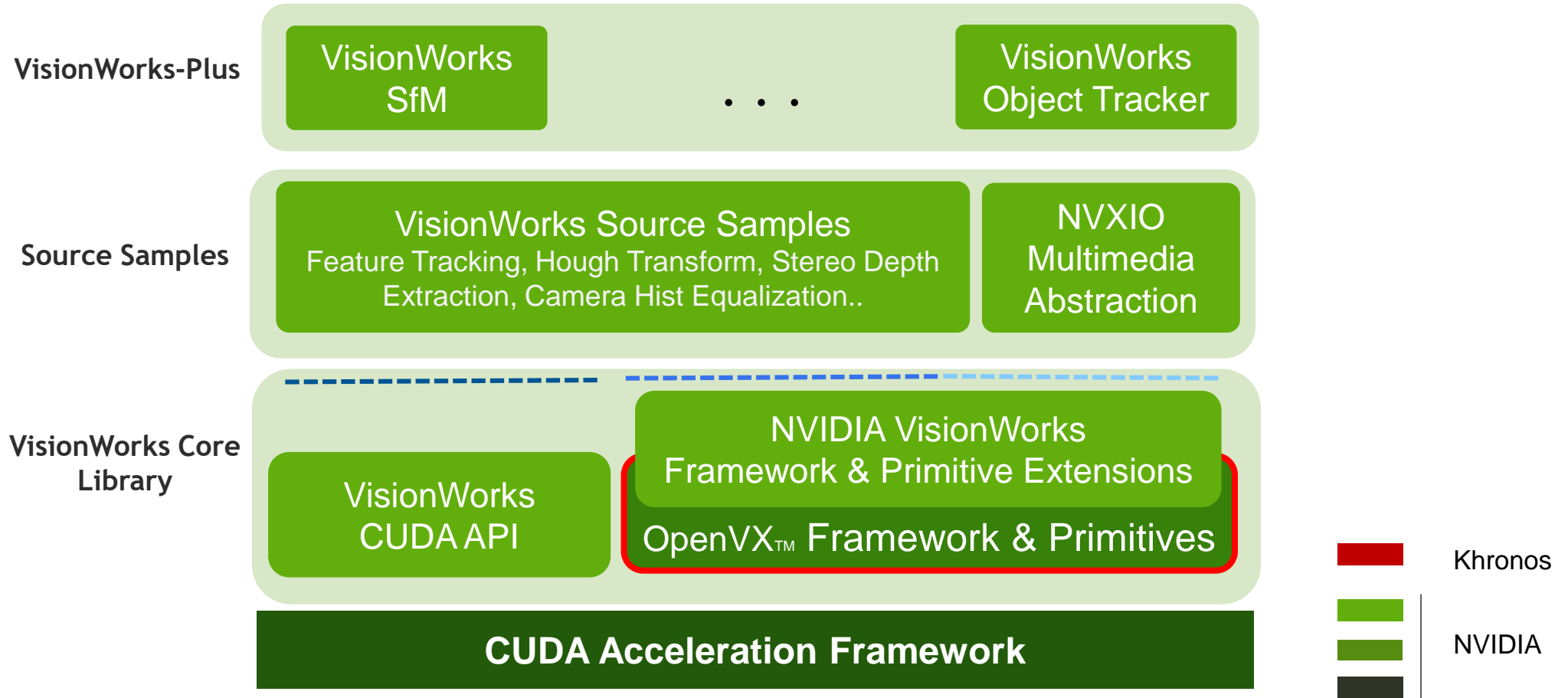
JETSON TK1

Desktop



Ubuntu Linux 14.04,
Windows 8

VisionWorks™ Toolkit Software Stack



VisionWorks™ Primitives

All OpenVX
Primitives



NVIDIA
Extensions

IMAGE ARITHMETIC

Absolute Difference
Accumulate Image
Accumulate Squared
Accumulate Weighted
Add/ Subtract/ Multiply +
Channel Combine
Channel Extract
Color Convert +
CopyImage
Convert Depth
Magnitude
MultiplyByScalar
Not / Or / And / Xor
Phase
Table Lookup
Threshold

FLOW & DEPTH

Median Flow
Optical Flow (LK) +
Semi-Global Matching

Stereo Block Matching
IME Create Motion Field
IME Refine Motion Field
IME Partition Motion Field

GEOMETRIC TRANSFORMS

Affine Warp +
Warp Perspective +
Flip Image
Remap
Scale Image +

FILTERS

BoxFilter
Convolution
Dilation Filter
Erosion Filter
Gaussian Filter
Gaussian Pyramid
Laplacian3x3

Median Filter
Scharr3x3
Sobel 3x3

FEATURES

Canny Edge Detector
FAST Corners +
FAST Track
Harris Corners +
Harris Track
Hough Circles
Hough Lines

ANALYSIS

Histogram
Histogram Equalization
Integral Image
Mean Std Deviation
Min Max Locations

+ type/mode extension by NVIDIA

■ NVIDIA extension primitives

VisionWorks™ Primitives

All OpenVX
Primitives



NVIDIA
Extensions

- VisionWorks primitives are CUDA optimized
(except MedianFlow & FindHomography extensions)
- 85% of VisionWorks OpenVX API is also accelerated with NEON.
Table of NEON optimized primitives are listed in VisionWorks Toolkit Ref.
(Go to "VisionWorks API" -> "NVIDIA Extensions API" -> "Vision Primitives API")
- Primitive acceleration with VisionWorks
 - Up to 92x speedup compared to OpenCV CPU kernels on Drive PX (Ave 8x)
 - Up to 13x speedup compared to OpenCV CUDA kernels on Drive PX (Ave 2x)

*(Measured on Drive PX, OS='V4L' Linux Kernel='3.18.21-tegra-g06aec38'
CPU Rate='1632 MHz' GPU Rate='844 MHz' EMC Rate='1600 MHz')*



NVIDIA[®] VISIONWORKS[™]

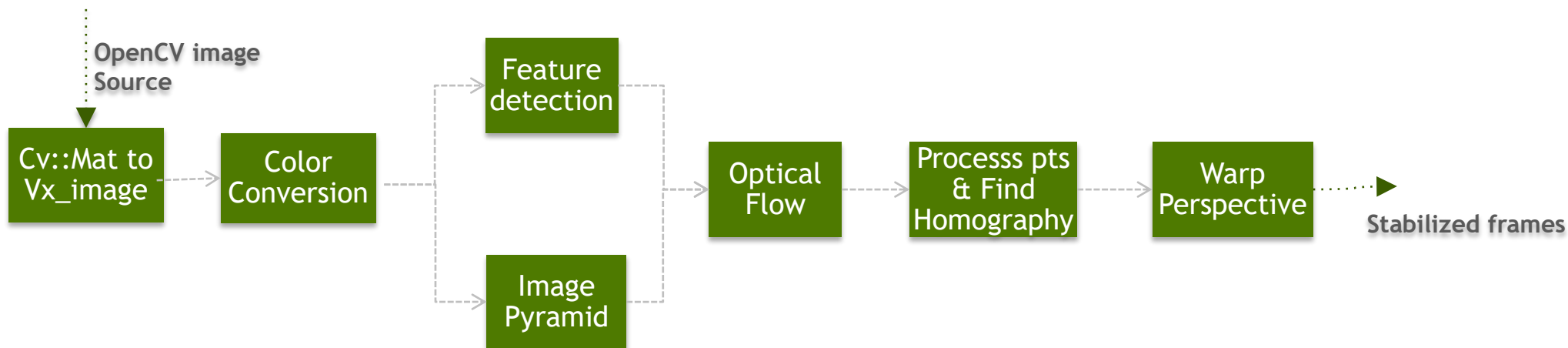
Programming with VisionWorks Library

VisionWorks OpenVX™ Immediate Mode

Video STABILIZATION SAMPLE

OpenVX Immediate mode API (prefixed as vxu) enables developers to easily port their applications.

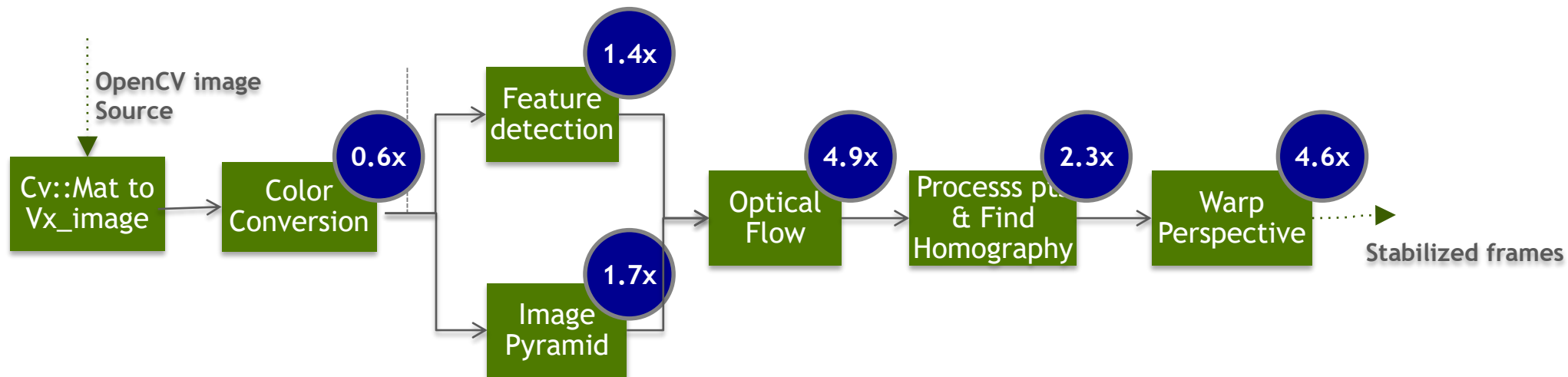
Ported Video Stabilization algorithm in OpenCV-CUDA to VisionWorks Immediate Mode.



VisionWorks OpenVX™ Immediate Mode

Video STABILIZATION SAMPLE

Performance boost: Video stabilization application is accelerated by 2.6x
(including the overhead for Mat to vx_image conversions)

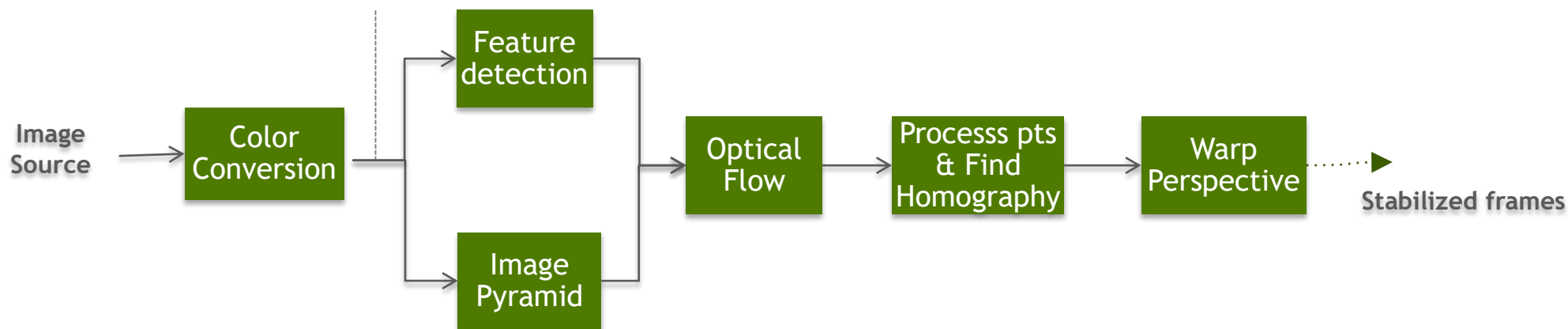


VisionWorks OpenVX™ Graph MODE

Video STABILIZATION SAMPLE

OpenVX Graph API (prefixed with vx) enables advanced optimizations

- Buffer reuse
- Efficient use of streaming and CUDA textures
- Automatic scheduling across processing units based on various factors (safety, perf,..)
- Tiling and pipelining vision functions at sub-frame level

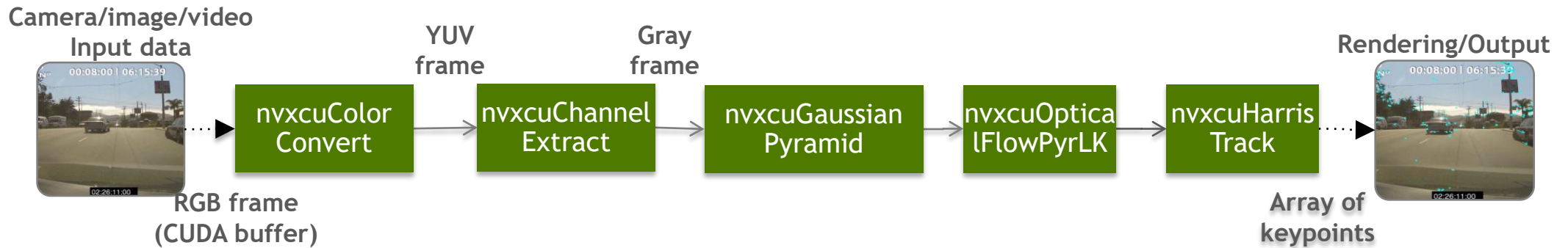


VisionWorks CUDA API

FEATURE TRACKING SAMPLE

VisionWorks CUDA API enables developer with low-level access. Developer manages

- Data allocations and transfer
- Scheduling and pipelining



VisionWorks™ API Selection

VisionWorks OpenVX™ Immediate Mode

Quick port from other
libraries



One can reassign CPU
and GPU tasks based on
perf.

VisionWorks OpenVX™ Graph Mode

Let the graph manager to
hide overheads, optimize
and manage data



One can reassign CPU and
GPU tasks based on perf.

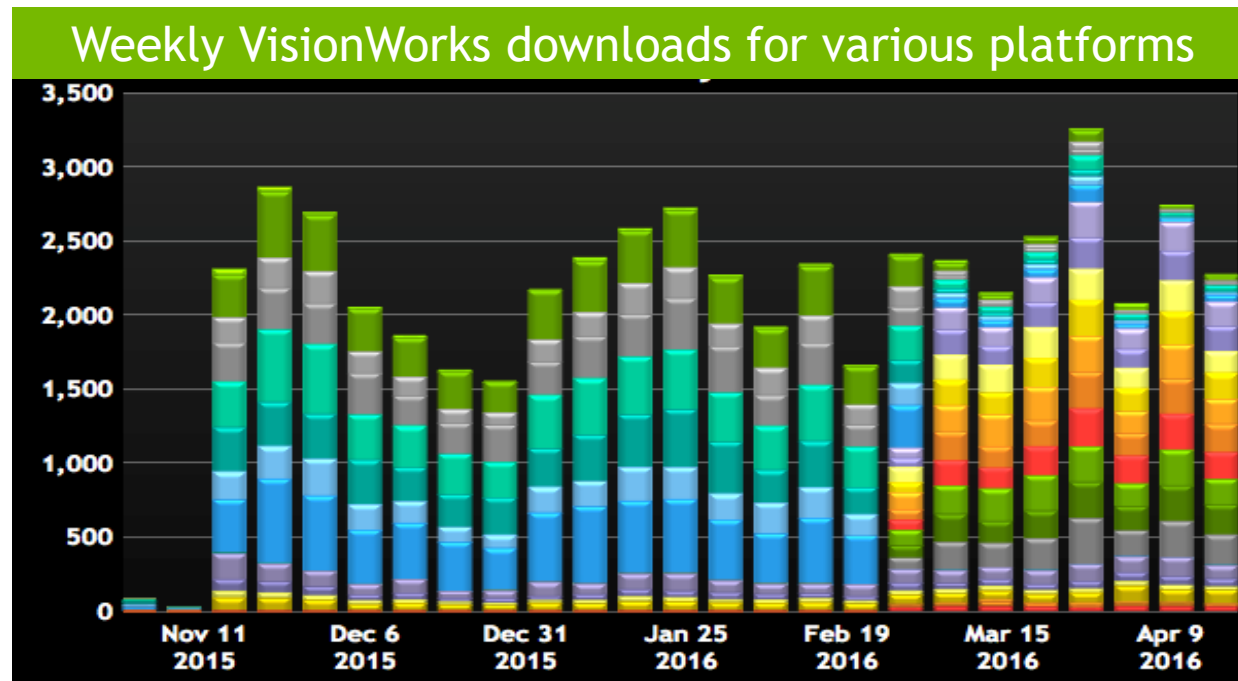
VisionWorks CUDA API

Low level CUDA API
access for advanced
CUDA developers

VisionWorks™ Conclusion



- First Khronos OpenVX™ 1.0 compliant library (Jan 2015)
- Optimization and visualization
- 45K downloads since release in Nov 2015.



Resources & Useful Links



<http://www.embedded-vision.com/>

<https://www.khronos.org/openvx/>

<https://developer.nvidia.com/embedded/visionworks>

VisionWorks Webinars - <https://developer.nvidia.com/embedded/learn/tutorials>