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™ Primitives

### 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
- Dilatation 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

**All OpenVX Primitives**

**NVIDIA Extensions**

+ type/mode extension by NVIDIA

- NVIDIA extension primitives
VisionWorks™ Primitives

• 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')
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.
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 enables developer with low-level access. Developer manages:

- Data allocations and transfer
- Scheduling and pipelining

Diagram:

Camera/image/video input data → YUV frame → Gray frame → nvxcuColor Convert → nvxcuChannel Extract → nvxcuGaussian Pyramid → nvxcuOpticalFlowPyrLK → nvxcuHarris Track → Rendering/Output

Array of keypoints

RGB frame (CUDA buffer)
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.

Weekly VisionWorks downloads for various platforms
Resources & Useful Links

http://www.embedded-vision.com/
https://www.khronos.org/openvx/
https://developer.nvidia.com/embedded/visionworks