The OpenVX Standard API: Computer Vision for the Masses

Kiriti Nagesh Gowda
OpenVX Chair | The Khronos Group
Sr. Staff Engineer | AMD

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Agenda

- OpenVX - Open, Royalty-free Standard for Computer Vision
- OpenVX 1.3.1 - An Overview
- Conformance
- Vendor Applications - Case Study
- Open-Source Cross-Platform Application - Case Study
- OpenVX - Future Work
- Summary

OpenVX - Open, Royalty-free Standard for Computer Vision

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Open, Royalty-free Standard for Computer Vision

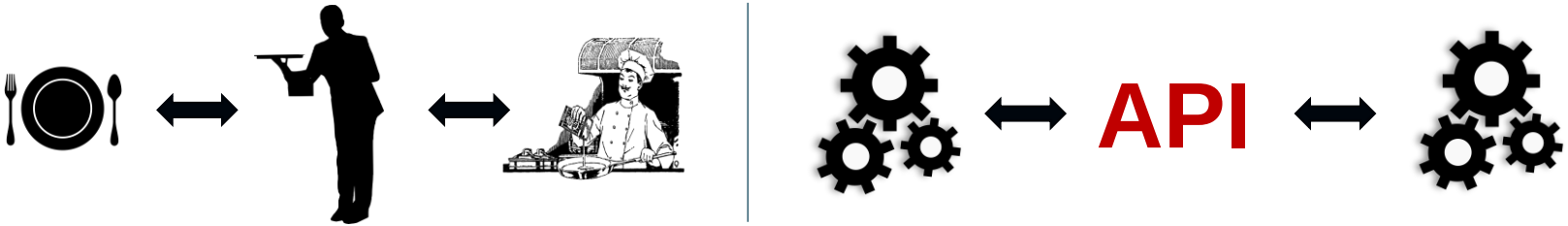
OpenVX™ is an open, royalty-free API standard for a cross-platform acceleration of computer vision applications

High-level graph-based abstraction for portable, efficient vision processing

Open, Royalty-free Standard for Computer Vision

What is an API?

Application Programming Interface



Why APIs are important

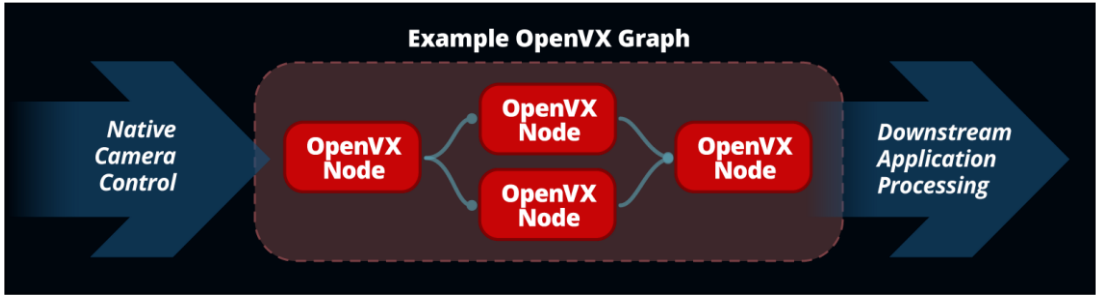
- Building Blocks
- Speeds up development
- Portability
- Innovation

OpenVX enables portable, performance, and power-optimized computer vision processing, especially important in embedded and real-time use cases

Open, Royalty-free Standard for Computer Vision

Open, Royalty-free Standard for Computer Vision

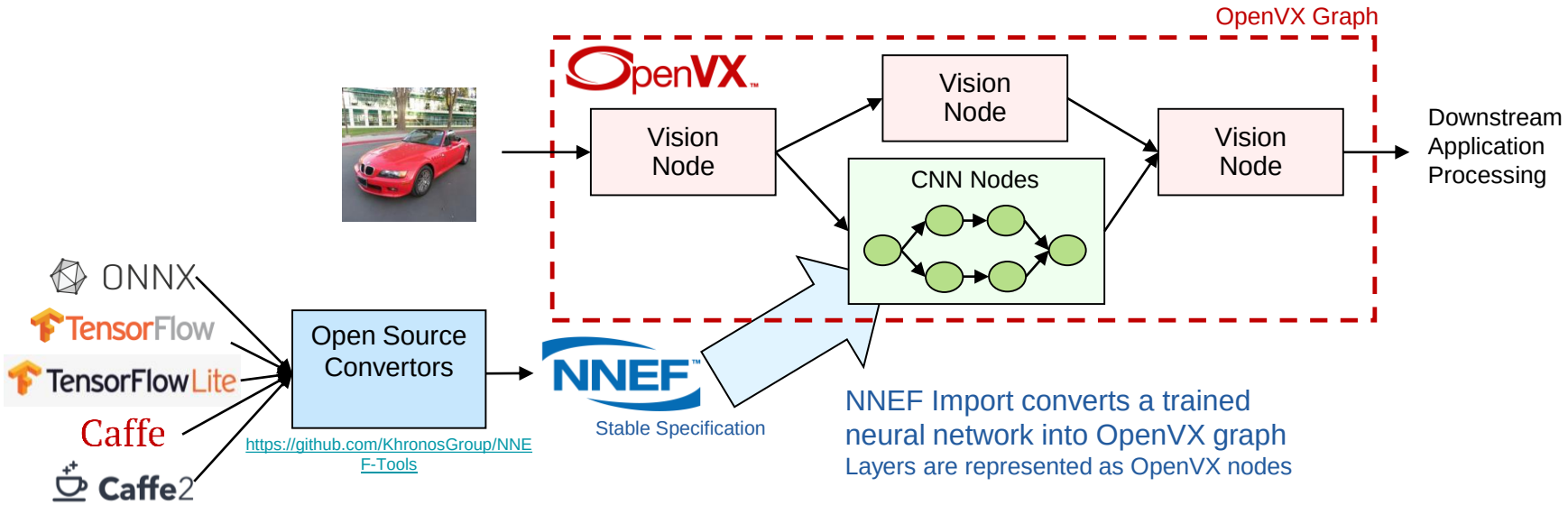
OpenVX™ Graph Framework



- Fuse nodes when possible to achieve better overall performance
- Auto graph-level memory optimizations to achieve a low memory footprint
- Deployed on a wide range of computer hardware, including small embedded CPUs, ASICs, APUs, discrete GPUs, and heterogeneous servers

Open, Royalty-free Standard for Computer Vision

OS Support: Linux, Windows, Android, iOS, Raspbian, Embedded OS, no OS



OpenVX 1.3.1 - An Overview

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OpenVX 1.3.1 - An Overview

The defined OpenVX 1.3.1 feature sets include:

- **Graph Infrastructure** - baseline for other feature sets
- **Vision** - core vision functionality
- **Enhanced Vision** - functions introduced in OpenVX 1.2
- **Neural Network Inferencing** - including tensor objects
- **NNEF Kernel Import** - including tensor objects
- **Binary Images** – one bit image processing
- **Safety Critical** - reduced features to enable easier safety certification

OpenVX 1.3.1 - Highlights

- Three Conformance Feature Sets:
  - **Vision** - OpenVX 1.1 equivalent vision functions
  - **Neural Network** - OpenVX 1.2 equivalent neural-network functions, plus the neural network extension, and the tensor object
  - **NNEF Import** - kernel import plus the tensor object
- Two Optional Feature Sets:
  - **U1** - binary image support
  - **Enhanced Vision** - vision functions introduced in OpenVX 1.2
- One Organizational Feature Set:
  - **Base Feature Set** - basic graph infrastructure
- One Informational Feature Set:
  - **Deployment Feature Set** - for safety critical usage

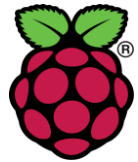
OpenVX - Conformance

OpenVX - Conformance

- OpenVX Work Group provides comprehensive conformance test suite
- Implementations must pass exhaustive conformance test suite to be conformant
- Hardware vendors provide optimized Conformant Implementation of OpenVX drivers
  - Architected to get the best performance from their silicon architecture
  - Ready for developers to use

OpenVX - Conformance

Conformant Implementations of OpenVX from the following vendors



OpenVX - Newest Contributing Member

Khronos Group Welcomes Robert Bosch GmbH as Contributor Member to OpenVX Working Group

- BOSCH working with the OpenVX Group to add multiple extensions to OpenVX

OpenVX - Vendor Applications: A Case Study

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OpenVX - Vendor Applications Case Study

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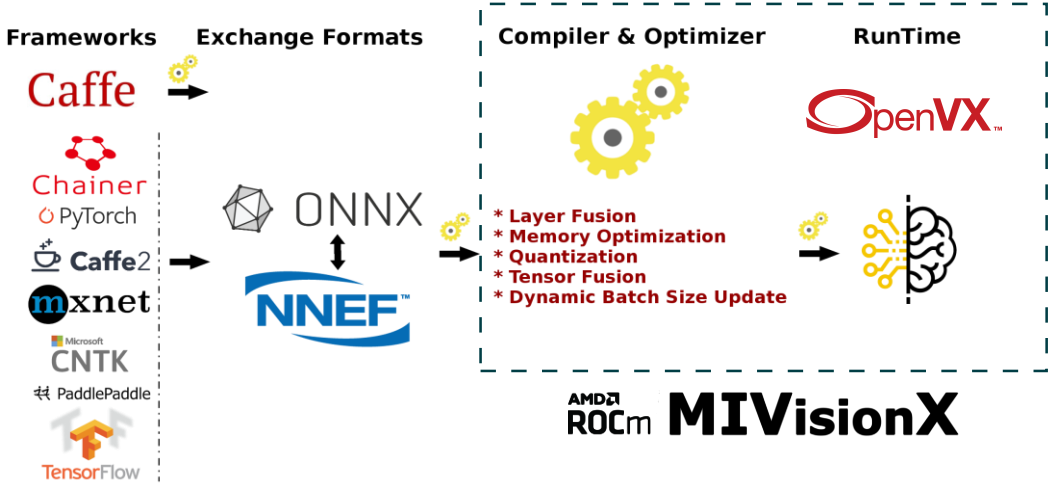
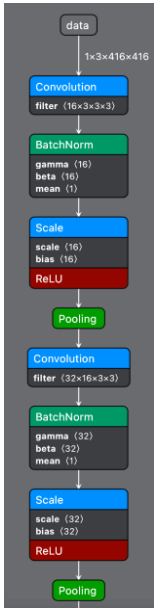
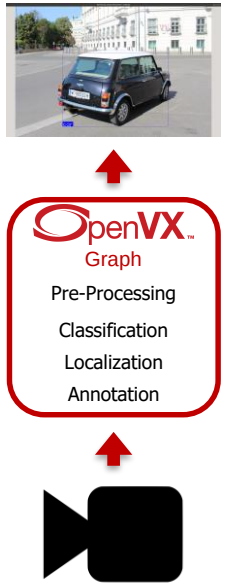
Application: Object detection with neural networks





AMD ROCm MIVisionX



OpenVX - Vendor Applications Case Study

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Application: Reliable motion detection

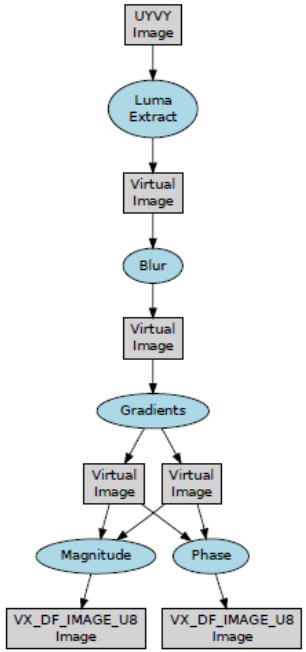
- Uses OpenVX API internally for accelerating algorithm on custom HW blocks
- Compute heavy algorithm for reliable motion detection

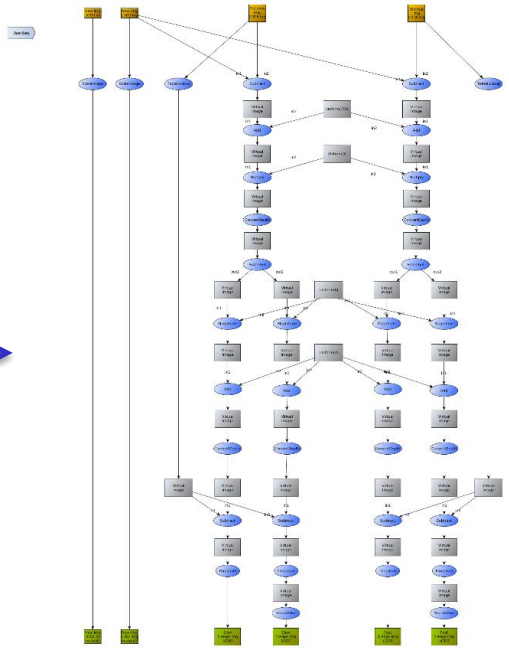
Before OpenVX:

- Hand optimized custom assembler by algorithm developers

After OpenVX:

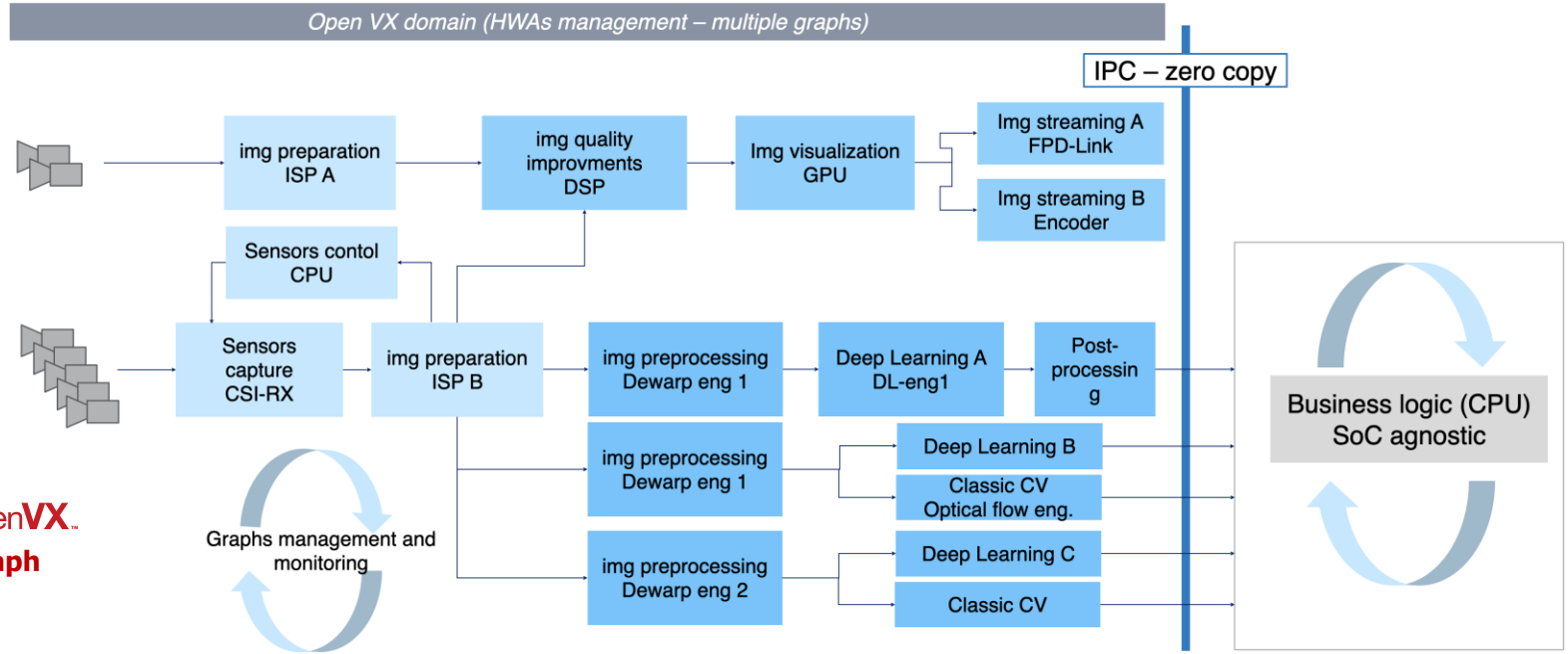
- Algorithm developers "draw" algorithms as graphs
- Driver developers implement the needed graph API





OpenVX - Vendor Applications Case Study

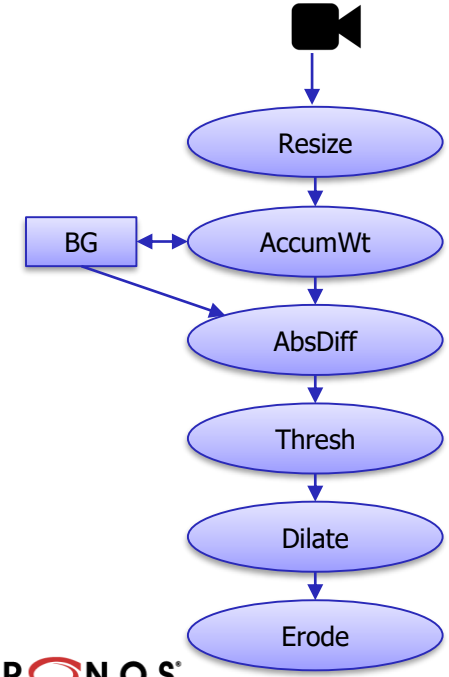
BOSCH

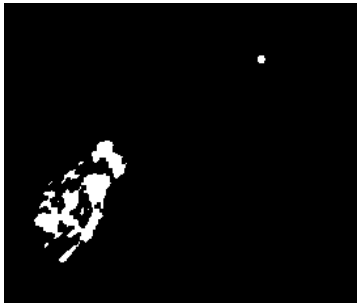


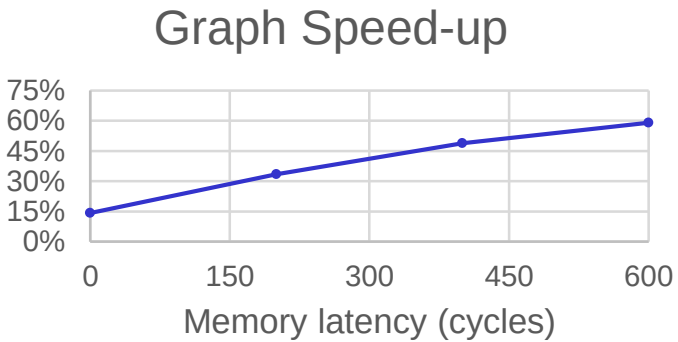
OpenVX - Vendor Applications Case Study

cadence

Application: Background subtraction for video security







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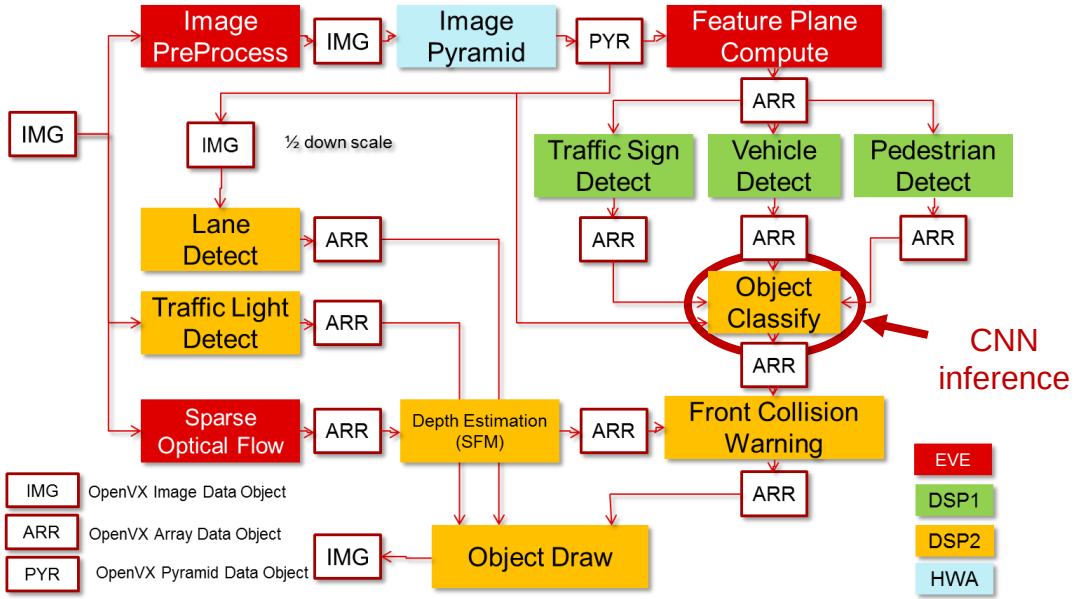
OpenVX - Vendor Applications Case Study

Texas Instruments

Application: Front camera ADAS

OpenVX Graph



An OpenVX Cross-Platform Application: A Case Study

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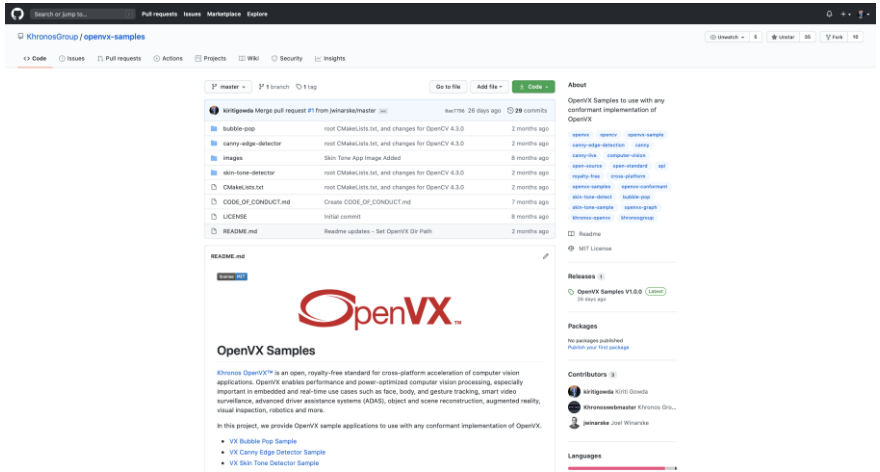
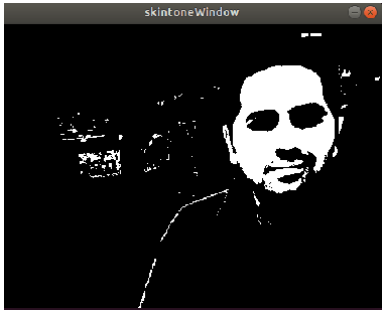
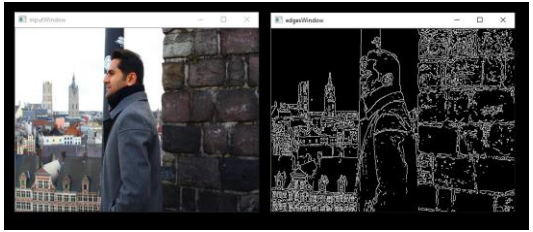
OpenVX Cross-Platform Application: A Case Study

Open-Source OpenVX Samples

Open-Source OpenVX sample applications, to use with **any conformant implementation** of OpenVX available on GitHub



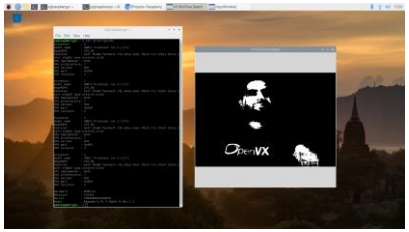




OpenVX Cross-Platform Application: A Case Study

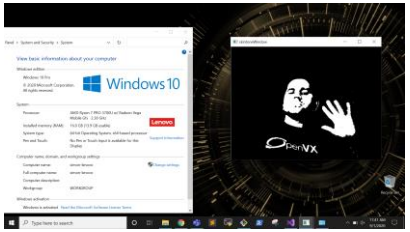
SkinTone Detector Sample

On Raspberry Pi 4 Model B Rev 1.2

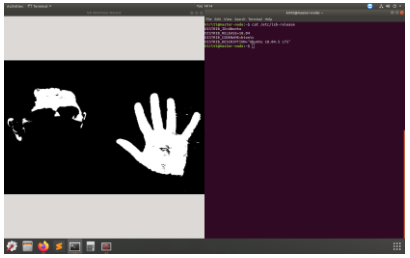


* using open-source OpenVX Raspberry Pi Implementation for OpenVX Libraries

On X86 Processor Windows



On X86 Processor Linux

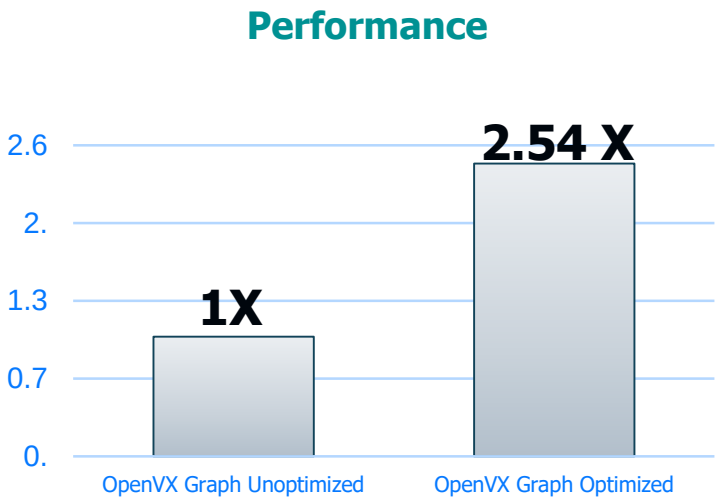


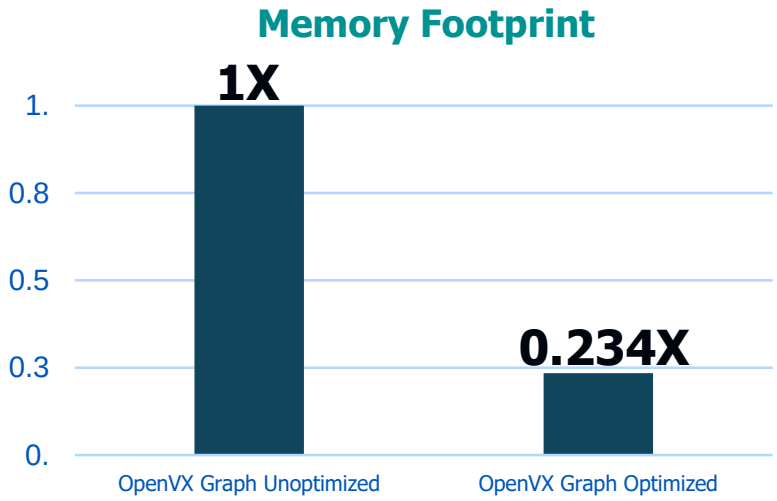
On MacOS

* using AMDs open-sourced MIVisionX for OpenVX Libraries

OpenVX Cross-Platform Application: A Case Study

SkinTone Detector Sample





* using AMDs open-sourced MIVisionX for OpenVX Libraries

OpenVX - Future Work

OpenVX Camera Capture Extension

- OpenVX relies on external libraries for input
  - may not be supported across required operating systems
  - may be too large for embedded systems
  - have different functionality gaps
- OpenVX can use a simple camera capture API library that works everywhere
  - Linux, Windows, Android, iOS, Raspbian, Embedded OS, no OS
  - initialize()/reinitialize(), capture(), release(), getAttributes(): size, format, etc.
- Once the image is captured, OpenVX will wrap it (not copy it) into an vx_image object

OpenVX Camera Capture Extension

OpenVX - Summary

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Summary

- OpenVX is unique in being the only vision API shipped as an optimized driver
- OpenVX delivers performance comparable to hand-optimized, non-portable code
- Acceleration on a wide range of vision hardware architectures
- OpenVX provides a high-level graph-based abstraction
  - Enables graph-level optimizations
  - Can be implemented on almost any hardware or processor
- Portable, Efficient Vision Processing!

Acknowledgement

Thanks To

- **Mike Schmit – Director of Software Engineering, AMD**
- **Neil Trevett – President, The Khronos Group**
- **AMD's MIVisionX Team**
- **OpenVX Working Group**
- **Embedded Vision Summit 2023 Organizers**

Resource Slide

OpenVX Resources - Khronos

Sample Implementation:

https://github.com/KhronosGroup/OpenVX-sample-impl

Sample Applications:

https://github.com/KhronosGroup/openvx-samples

Tutorial Material:

https://github.com/rgiduthuri/openvx_tutorial

Conformant Implementations

https://www.khronos.org/conformance/adopters/conformant-products/openvx

Khronos OpenVX API Registry

https://www.khronos.org/registry/OpenVX/

OpenVX for Raspberry Pi

https://www.raspberrypi.org/blog/openvx-api-for-raspberry-pi/

AMD ROCm MIVisionX - OpenVX

https://gpuopen-professionalcompute-libraries.github.io/MIVisionX/

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BACKUP SLIDES

OpenVX - Open-Source Tools

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OpenVX - Open-Source Tools

Scripting Tool - RunVX

- RunVX is a command-line tool to execute OpenVX graphs
- It encapsulates most of the routine OpenVX calls, thus speeding up development and enabling rapid prototyping.
- As input, RunVX takes a GDF (Graph Description Format) file, a simple and intuitive syntax to describe the various data, nodes, and dependencies.
- The tool has other useful features, such as, file read/write, data compares, image and keypoint data visualization, etc.

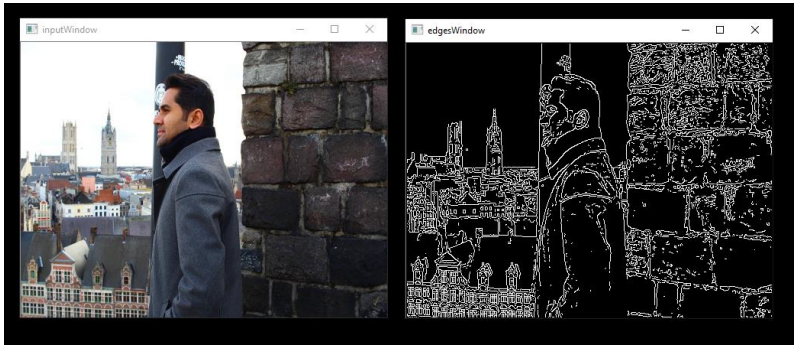
Open-Sourced on GitHub - https://github.com/GPUOpen-ProfessionalCompute-Libraries/MIVisionX

```
# create input and output images
data input  = image:480,360,RGB2
data output = image:480,360,U008

# specify input source for input image and request for displaying input and output images
read input  ../images/face.jpg
view input  inputWindow
view output edgesWindow

# compute luma image channel from input RGB image
data yuv  = image-virtual:0,0,IYUV
data luma = image-virtual:0,0,U008
node org.khronos.openvx.color_convert input yuv
node org.khronos.openvx.channel_extract yuv !CHANNEL_Y luma

# compute edges in luma image using Canny edge detector
data hyst = threshold:RANGE,U008,U008:INIT,80,100
data gradient_size = scalar:INT32,3
node org.khronos.openvx.canny_edge_detector luma hyst gradient_size !NORM_L1 output
```



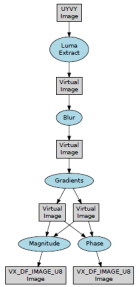
OpenVX - Open-Source Tools

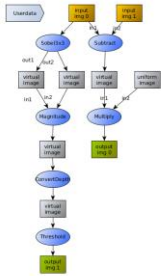
AXIS COMMUNICATIONS

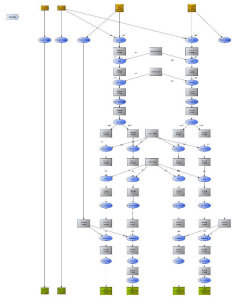
Graph Tool - openvx-graph-parser

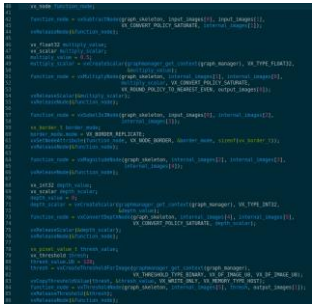
Tool for OpenVX C code generation from graphical calculation graph definitions. Includes a Python based parser which takes graphs defined in graphml format and generates valid OpenVX C code.

Open-Sourced on GitHub - https://github.com/AxisCommunications/openvx-graph-parser









OpenVX - Open-Source Tools

Python Binding - PyVX

pycbindgen is a python based frontend tool for generating python module for a given C library. It uses pycaparser and CFFI python modules underneath.

OpenVX functionality in Python

Will be **Open-Sourced on GitHub** - https://github.com/KhronosGroup