Khronos Connects Software to Silicon

ROYALTY-FREE, OPEN STANDARD APIs for advanced hardware acceleration

- Graphics, video, audio, compute, visual and sensor processing

Low level silicon to software interface needed on every platform

Defines the forward looking roadmap for the silicon community

Shipping on billions of devices across multiple operating systems

Rigorous conformance tests for cross-vendor consistency

Khronos is OPEN for any company to join and participate

Acceleration APIs BY the Industry FOR the Industry
Interesting Mobile Use Cases use CAMERA
OpenVX

- **Vision Hardware Acceleration Layer**
  - Enables hardware vendors to implement accelerated imaging and vision algorithms
  - For use by high-level libraries or apps

- **Focus on enabling real-time vision**
  - On mobile and embedded systems

- **Diversity of efficient implementations**
  - From programmable processors, through GPUs to dedicated hardware pipelines

Dedicated hardware can help make vision processing performant and low-power enough for pervasive ‘always-on’ use
OpenVX Execution Flow

- **OpenVX Graph for efficient execution**
  - Each Node can be implemented in software or accelerated hardware
  - Data transfer between nodes may be optimized

- **EGL can provide data and event interop with other APIs – with streaming**
  - BUT use of other Khronos APIs are not mandated

- **VXU Utility Library provides efficient access to single nodes**
  - Open source implementation – easy way to start using OpenVX
## OpenVX and OpenCV are Complementary

<table>
<thead>
<tr>
<th>Governance</th>
<th>OpenCV</th>
<th>OpenVX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>Open Source Community Driven No formal specification</td>
<td>Formal specification and full conformance tests Implemented by hardware vendors</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td></td>
<td>Very wide 1000s of functions of imaging and vision Multiple camera APIs/interfaces</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Memory-based architecture Each operation reads and writes memory Sub-optimal power / performance</td>
<td>Graph-based execution Optimized nodes and data transfer Highly efficient</td>
</tr>
<tr>
<td>Conformance</td>
<td>No Conformance testing Every vendor implements different subset</td>
<td>Full conformance test suite / process Reliable acceleration platform</td>
</tr>
<tr>
<td>Use Case</td>
<td>Rapid prototyping</td>
<td>Production deployment</td>
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OpenVX Participants and Timeline

- Aiming for specification before end of 2013
- Itseez is working group chair
- QC/TI are specification editors
Breaking News!

Need Camera Control API to feed processing for advanced use cases

Khronos is initiating new working group to develop native camera control API

Image, Vision and Rendering APIs
Advanced Camera API Use Cases

- **High-dynamic range (HDR) and computational flash photography**
  - High-speed burst with individual frame control over exposure and flash

- **Rolling shutter elimination**
  - High-precision synchronization with motion sensor data

- **HDR Panorama, photo-spheres**
  - Continuous frame capture with constant exposure and white balance

- **Subject isolation and depth detection**
  - High-speed burst with individual frame control over focus

- **Augmented Reality**
  - 60Hz, low-latency capture with motion sensor synchronization
  - Multiple Region of Interest (ROI) capture
  - Multiple sensors for scene scaling
  - Detailed feedback on camera operation per frame
Existing APIs as Starting Point

• FCAM – Open source project
  - Capture of stream of camera images with precision control
    - A pipeline that converts requests into image stream
    - All parameters packed into the requests - no invisible state
    - Programmer has full control over sensor settings for each frame in stream
  - Control over focus and flash
    - No hidden daemon running
  - Control ISP
    - Can access supplemental statistics from ISP if available

• Android New Camera HAL (2013)
  - Uses some of these concepts
Example use of Khronos APIs in AR

Positional Sensors

Camera Control API

Camera

Camera Control API Provides Sample/Frame Time Stamps

Positional and GPS Sensor Data

Synchronization and sensor fusion

Computer Vision/Tracking & Computational Photography

Tracked features

EGLStream Image stream to GPU

3D Rendering and Video Composition On GPU

Audio Rendering

Application on CPUs and GPUs

OpenGLES

OpenVX

OpenCL

OpenSL

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Leveraging Proven Native APIs into HTML5

- Leverage native API investments into the Web
  - Faster API development and deployment
  - Familiar foundation reduces developer learning curve

- Khronos and W3C expanding liaison
  - Multiple potential joint projects

Native APIs shipping or working group underway
JavaScript API shipping or work underway
Possible future JavaScript APIs

WebCL
WebGL
WebSL Easy to use JavaScript Audio
Canvas
WebVX
WebCAM
Camera Control API
Device and Sensor APIs
Device Orientation Working Groups
WebAudio (JavaScript API)
OpenGL ES
OpenGL
OpenVX
StreamInput

Easy to use
JavaScript
Audio

Vision Processing
Camera control

HTML
JavaScript
Native

Under Discussion
Summary

• Khronos is developing APIs for advanced camera control and vision processing to enable apps to tap into silicon acceleration

• Sensor and vision processing now just as important as graphics and compute acceleration

• Cooperation between hardware and software communities needed to deliver compelling mobile vision processing in a fixed power budget

• If this is relevant to your business – please consider joining Khronos to participate in the development of these important standards

• www.khronos.org