Introduction to OpenCV for Tegra

Shalini Gupta, Nvidia
Computer Vision = Mobile differentiator

Applications
- Smart photography
- Augmented reality, gesture recognition, visual search
- Vehicle safety
OpenCV

- OpenCV = Open source Computer Vision library
- >2500 functions
- Started by Intel in 1999
- Professionally managed by Itseez
- >47K users worldwide
- >6M downloads
Portability

- Available for Windows, Linux, Mac, Android, iOS
- Optimized for x86 SSE, CUDA GPU, and Tegra
- Has C/C++, Java and Python interfaces
- Common API for server, workstation, desktop and now mobile platforms
License

- Release under a **BSD license**
- Free for academic and commercial use

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Functionality overview

Image processing

- General Image Processing
- Segmentation
- Machine Learning, Detection
- Image Pyramids
- Transforms
- Fitting

Video, Stereo, and 3D

- Camera Calibration
- Features
- Depth Maps
- Optical Flow
- Inpainting
- Tracking
OpenCV for Tegra

- Extension of OpenCV for Android
- Same API
- Optimized (1.6 - 32x) with
  - NEON SIMD
  - GLSL
  - Tegra HW optimizations

Performance and Power!!
Speedups (Tegra 4)

![Bar Chart]

- FAST detector: 2.6x
- Optical Flow: 32x
- Median Blur: 1.6x
- Gaussian Blur: 1.9x
- Canny: 6.9x
- pyrDown: 3.4x
- Morphology: 9.5x
- Color Conversion: 10.5x
- Sobel: 5.2x
- Resize: 2.7x

Legend:
- Tegra CPU
- Tegra NEON
Speedups (Tegra 4)

<table>
<thead>
<tr>
<th>Function</th>
<th>Tegra CPU Speedup</th>
<th>Tegra GPU Speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td>WarpAffine</td>
<td>8.2x</td>
<td></td>
</tr>
<tr>
<td>WarpPerspective</td>
<td>12.5x</td>
<td></td>
</tr>
<tr>
<td>WarpPerspectiveNear</td>
<td>14.7x</td>
<td></td>
</tr>
<tr>
<td>medianBlur</td>
<td></td>
<td>7.1x</td>
</tr>
<tr>
<td>blur3x3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter2d</td>
<td></td>
<td>10.3x</td>
</tr>
</tbody>
</table>
Tegra Android Development Pack (S3489)

- Register at NVIDIA’s Developer Zone website and apply for Tegra Registered Developer Program
- Software tools to develop for Android on Tegra
- For Windows, Linux, Mac
- Contains OpenCV for Tegra SDK
OpenCV for Tegra SDK in TADP

- OpenCV for Tegra SDK
- Reference manual with Tegra Optimized functions
Pre-configured Eclipse OpenCV Examples

Native Examples

http://docs.nvidia.com/tegra/data/How_to_Use_OpenCV_for_Tegra.html
Distribution - OpenCV Manager

Dynamic linking (recommended)
- Same app on multiple platforms - use unique platform-, operating system-, and version-specific library
- Small app footprint - no library in app
- No need to recompile app with new library as OpenCV 2.4.x is backward binary compatible

OpenCV Manager
- Android service for runtime asynchronous initialization of OpenCV in apps
- Downloaded from Google Play/user prompted to install from TADP package
- Should be used explicitly in Android app (see Eclipse examples)
Pre-configured Eclipse OpenCV Examples

http://docs.nvidia.com/tegra/data/How_to_Use_OpenCV_for_Tegra.html
OpenCV Manager Installation on Device

Automatic install from Google Play

Manually install via `adb install`
OpenCV for Tegra - Usage Models

Java and Native

Applications
- Home
- Contacts
- Phone
- ...

Application Framework
- Activity Manager
- Telephony Manager
- Network Manager
- Notification Manager

Libraries
- Surface Manager
- OpenGL ES
- NDK
- OpenCV
- ... SQL
- SSL
- libc

Android Runtime
- Core Libraries
- Dalvik Virtual Machine

JNI Calls

Java API

CV App

JNI wrappers

Java import
OpenCV for Tegra - Java

API: http://docs.opencv.org/java/

```java
package org.opencv.samples.tutorial2;

import org.opencv.android.BaseLoaderCallback;
import org.opencv.android.CameraBridgeViewBase.CvCameraViewFrame;
import org.opencv.android.
import org.opencv.android.
import org.opencv.android.
import org.opencv.android.
import org.opencv.android.
import org.opencv.android.
import org.opencv.core.
import org.opencv.core.
import org.opencv.impro.

public Mat onCameraFrame(CvCameraViewFrame inputFrame) {
    final int viewMode = mViewMode;
    switch (viewMode) {
        case VIEW_MODE_GRAY:
            // input frame has gray scale format
            Imgproc.cvtColor(inputFrame.gray(), mRgba, Imgproc.COLOR_GRAY2RGBA, 4);
            break;
        case VIEW_MODE_RGBA:
            // input frame has RGBA format
            // process frame
            break;
    }
}
```
OpenCV for Tegra - Native

API: http://docs.opencv.org/modules/refman.html
OpenCV for Tegra - Native

Static/Dynamic Linking

```makefile
LOCAL_PATH := $(call my-dir)
include $(CLEAR_VARS)

OPENCV_INSTALL_MODULES:=0
OPENCV_LIB_TYPE:=SHARED

LOCAL_SRC_FILES := DetectionBasedTracker_jni.cpp
LOCAL_C_INCLUDES += $(LOCAL_PATH)
LOCAL_LDLIBS += -llog -ldl

LOCAL_MODULE := detection_based_tracker
include $(BUILD_SHARED_LIBRARY)
```
Tegra Optimizations Check

Open the OpenCV Manager App

About
OpenCV library is used by other applications for image enhancement, panorama stitching, object detection, recognition and tracking and so on. OpenCV Manager provides the best version of the OpenCV for your hardware. See opencv.org for details.
OpenCV Manager version: 2.6

Device information
Hardware: Tegra 3
OS version: REL (4.1.1), API 16

Installed packages
Built-in OpenCV library (active, optimized)
Library version: 2.4.4.0 rev 2
Target hardware: Tegra 3

adb logcat:
E/OpenCV_for_Tegra(28465): Tegra platform detected, optimizations are switched ON
## OpenCV for Tegra Demo App

From Google play
OR
NVPACK/OpenCV-2.4.4-Tegra-sdk/apk/OpenCV_for_Tegra_Demo.apk

<table>
<thead>
<tr>
<th>Mode</th>
<th>Speedup (Tegra 4)</th>
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<tbody>
<tr>
<td>Median Blur</td>
<td>23.7</td>
</tr>
<tr>
<td>Gaussian Blur</td>
<td>7.8</td>
</tr>
<tr>
<td>Sketch</td>
<td>6.9</td>
</tr>
<tr>
<td>Morpho Gradient</td>
<td>3.9</td>
</tr>
<tr>
<td>Watermark</td>
<td>3.1</td>
</tr>
<tr>
<td>Sobel</td>
<td>2.0</td>
</tr>
<tr>
<td>Optical Flow</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Information Links

- OpenCV: [http://opencv.org/](http://opencv.org/)
- OpenCV for Android: [http://opencv.org/android](http://opencv.org/android)
- How to use OpenCV for Tegra: [http://docs.nvidia.com/tegra/data/How_to_Use_OpenCV_for_Tegra.html](http://docs.nvidia.com/tegra/data/How_to_Use_OpenCV_for_Tegra.html)
Questions?