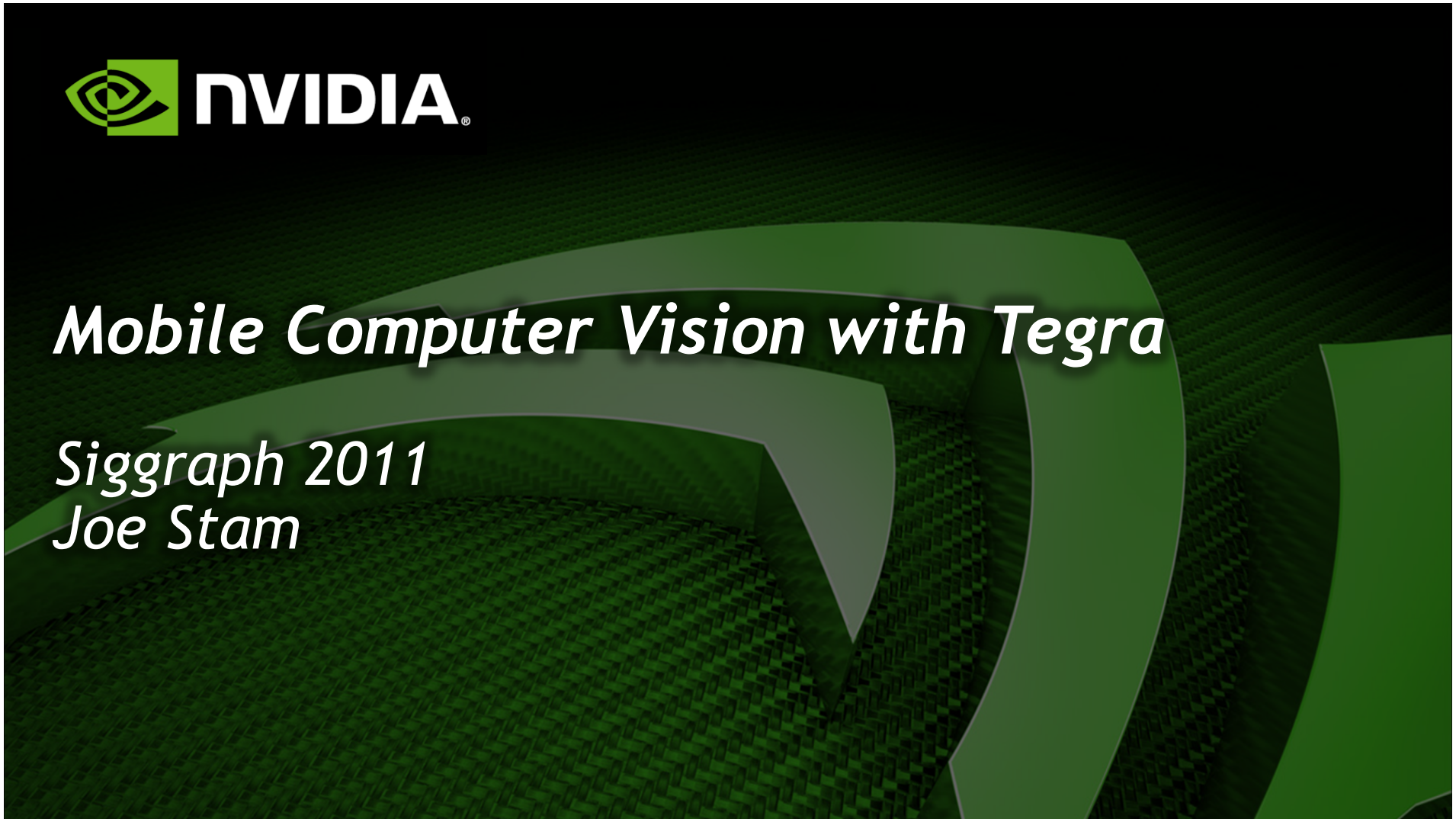
NVIDIA
Mobile Computer Vision with Tegra
Siggraph 2011
Joe Stam

NVIDIA Mobile Computer Vision

- Focus on Mobile Vision Applications
- Optimize core algorithms for Tegra hardware
- Enable Developers

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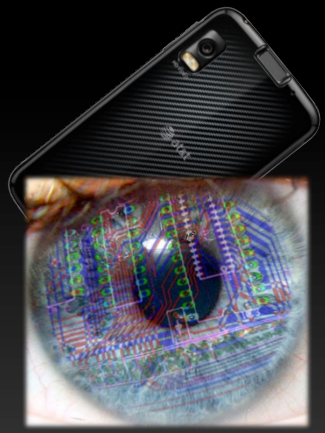
Graphics

Render Images From Scenes

Inverse Problems

Massively Parallel

Computer Vision



Understand Scenes From Images

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Perception

- *Where is the device?*
- *What's nearby?*
- *Who's nearby?*
- *What is the user doing?*

Interaction

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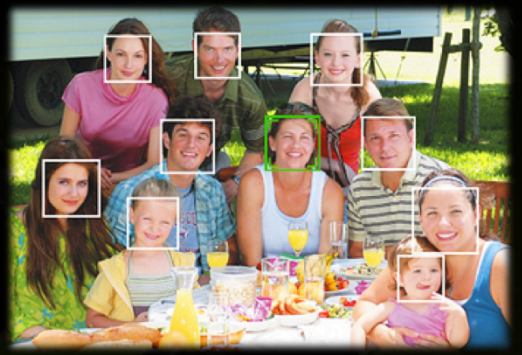
Computer Vision = Smart Photography

Get the right shot, automatically

Face Detection



Scene Classification

Stabilization

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Computer Vision = New Applications

Augmented Reality

Augmented Reality Ghost Hunter (Argh)

Wordlens

Google Goggles

Gesture interfaces

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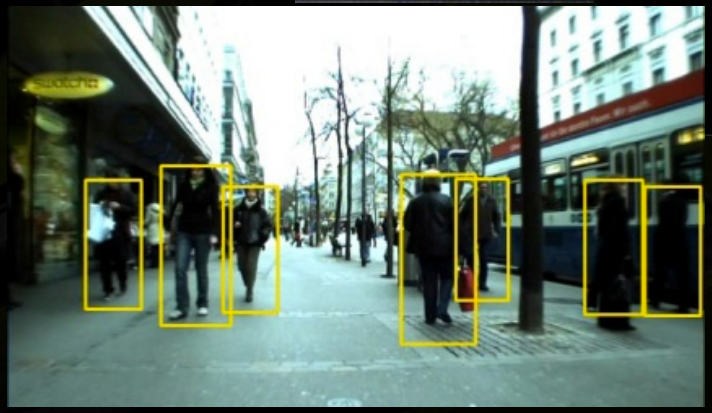
Computer Vision = Vehicle Safety



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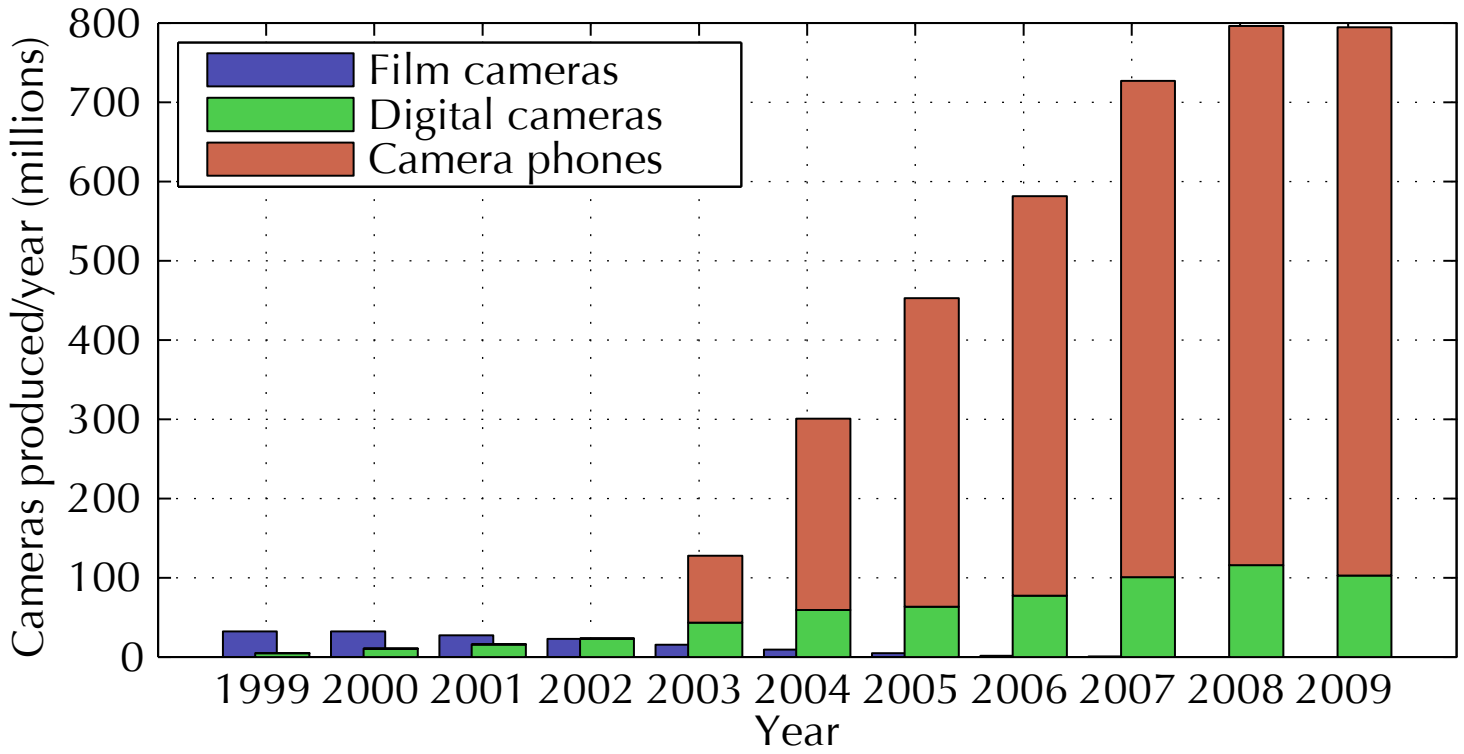
Traditional cameras vs. camera phones



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Trends in camera phone sales

- Sales keep growing
  - 2003 — 85 million — 16% of the phones
  - 2010 — 805 million — 65% of the phones
  - 2014 — 1.3 billion — 85% of the phones
- Average resolution grows too
  - 2008 — 1 MP
  - 2009 — 2 MP
    - 2010 5+MP: ~ 13%, >100 million
  - 2014 — 5 MP
    - 2014 5+MP: ~ 42%, >550 million

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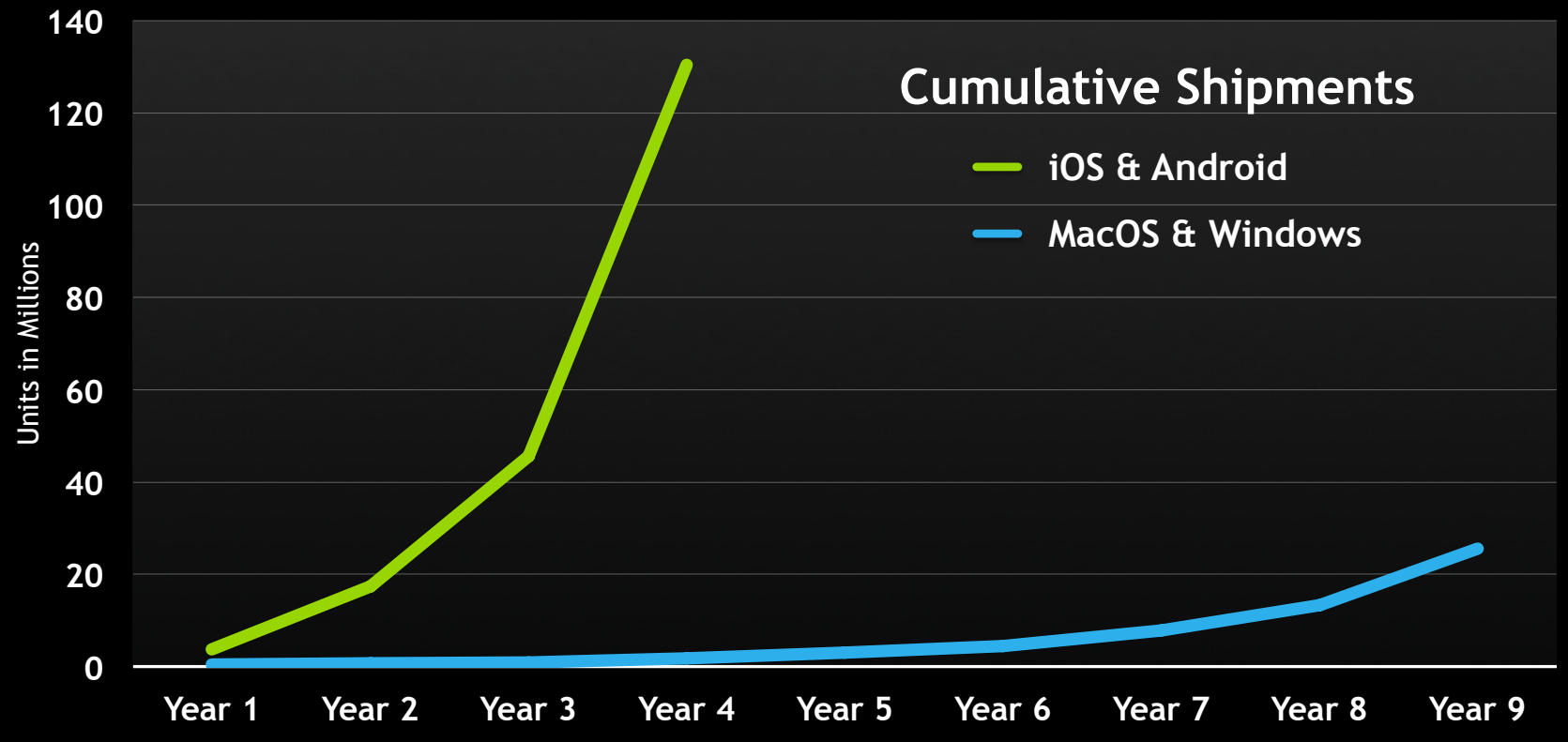
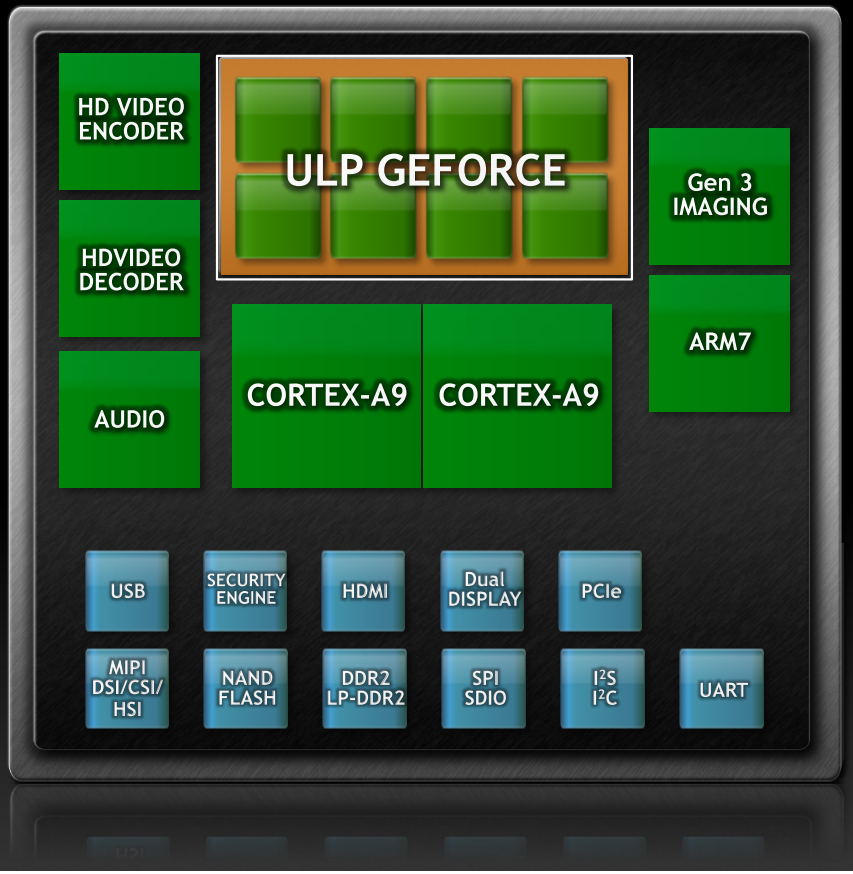
Mobile Computing on a Tear



Source: Gartner, Apple, NVIDIA

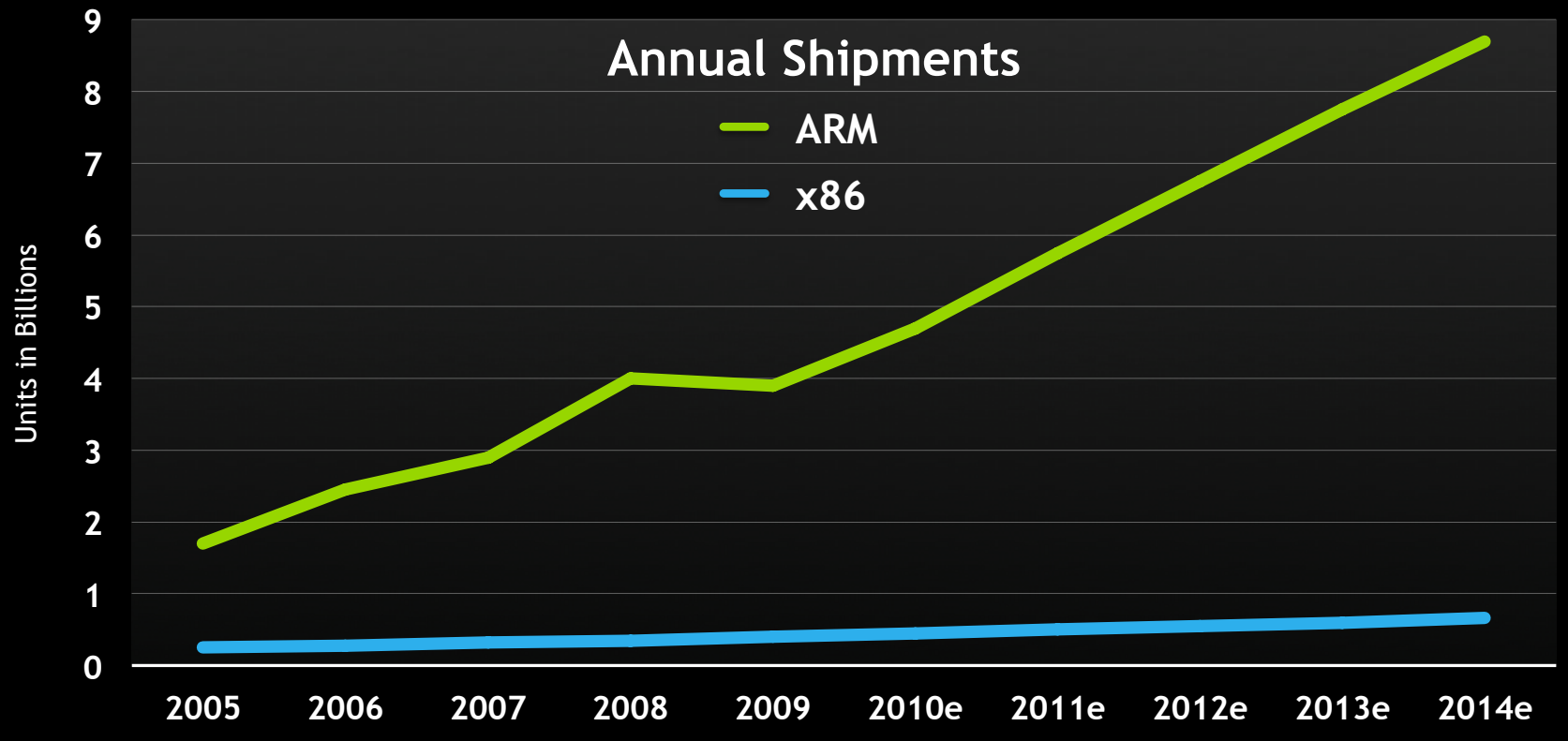
TEGRA
The Mobile Super Chip

Tegra 2 – Heterogeneous Multi-core



CPU	Dual Cortex-A9, up to 1GHz
GRAPHICS	8 Core ULP GeForce
VIDEO	1080P H.264
MEMORY	LPDDR2 – 600, DDR2 - 667
IMAGING	Ultra High Performance Image Processor
AUDIO	HW Audio
STORAGE	eMMC, NAND, USB

ARM is Pervasive and Open



Source: ARM, Mercury Research, NVIDIA

PROJECT KAL-EL

- World's first mobile quad-core CPU
- New 12-Core NVIDIA GPU
  with support for 3D stereo
- Extreme HD – 2560x1600
- 5X Tegra 2

TEGRA ROADMAP

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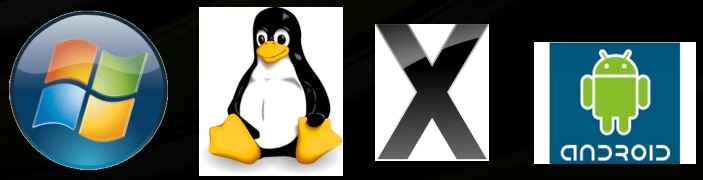
Software Solutions for
Mobile Computer Vision

OpenCV

Thousands of Developers, Cross Platform API

- Open standard for Compute Vision
- Analogous to OpenGL for Graphics
- 12 years old, professionally developed
- Optimized for x86 SSE, CUDA GPU
- Over 3 Million Downloads!
- > 500 Algorithms



Common API for Server, Workstation, Desktop and now Mobile Platforms!

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OpenCV Functionality Overview

Image processing

General Image Processing

Segmentation

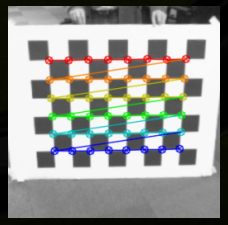
Machine Learning, Detection

Image Pyramids

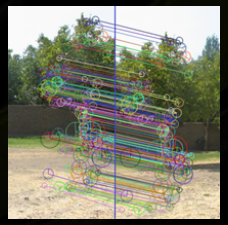
Transforms

Fitting

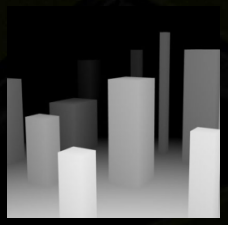
Video, Stereo, and 3D



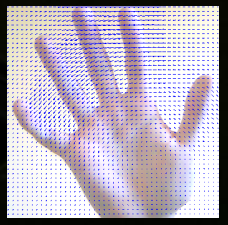
Camera Calibration



Features

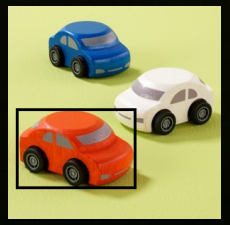


Depth Maps



Optical Flow

Inpainting



Tracking

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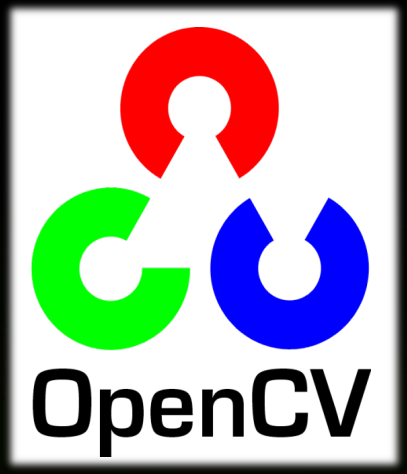
OpenCV for CUDA

- Open Source
- Supported by NVIDIA
- Beta with OpenCV 2.2
- Release with OpenCV 2.3



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Current OpenCV Cuda Functionality

- Initialization, Information, Data allocation & movement
- Per-element operations (add, subtract, logical)
- Color Conversion
- Geometrical transforms (rotate, warp, scale, remap)
- Mean-Shift transforms (filtering, segmentation)
- Corner Detectors
- Reductions with/without mask (norm, sqrSum, integral)
- Template Matching
- Filter Engine (convolutions, blur, morphology)
- Histograms
- Stereo Correspondence
- Histogram of Gradient (HOG) descriptors (pedestrian detection)
- Haar features, face detection
- Feature detection for object recognition (Speeded Up Robust Features, SURF)
- Other Image transforms (flip, LUT, split, phase, dFFT Canny)
- Panorama stitching
- Point Cloud Library support (in progress)

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Android

- **Fastest Growing OS Ever**
- **39% of mobile market**
  (vs. iOS 28%)*

*Source: http://blog.nielsen.com/nielsenwire/online_mobile/in-u-s-smartphone-market-android-is-top-operating-system-apple-is-top-manufacturer/

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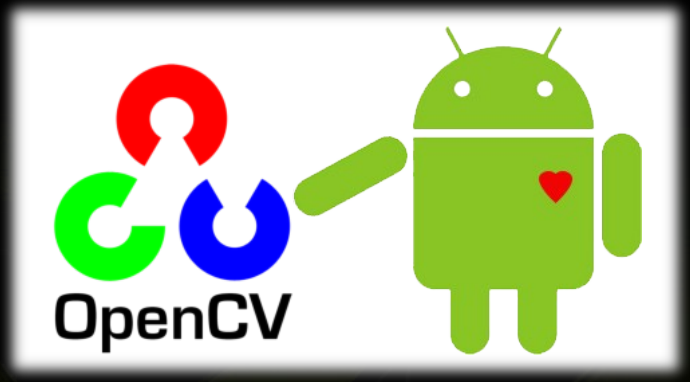
OpenCV for Android



- **OpenCV 2.3.1 for Android:**
  - **Native Android Camera Support**
  - **Multithreading**
  - **Java API**
  - **Tegra HW Optimizations (soon)**

Wiki with the latest information:

http://opencv.willowgarage.com/wiki/Android

Support/discussion group:

https://groups.google.com/group/android-opencv

Released Today!

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OpenCV on Tegra

Optimized for ARM, Tegra & Android

Bringing the most popular Computer Vision Library to the worlds most popular Processor Architecture on the Fastest Growing OS

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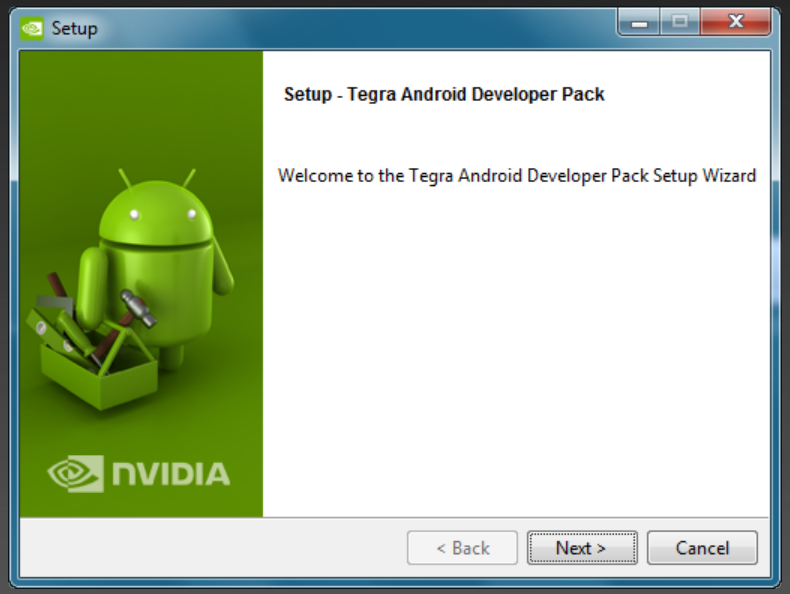
Tegra Android™ Development Pack

“All-in-one” installer for Android NDK development under Eclipse

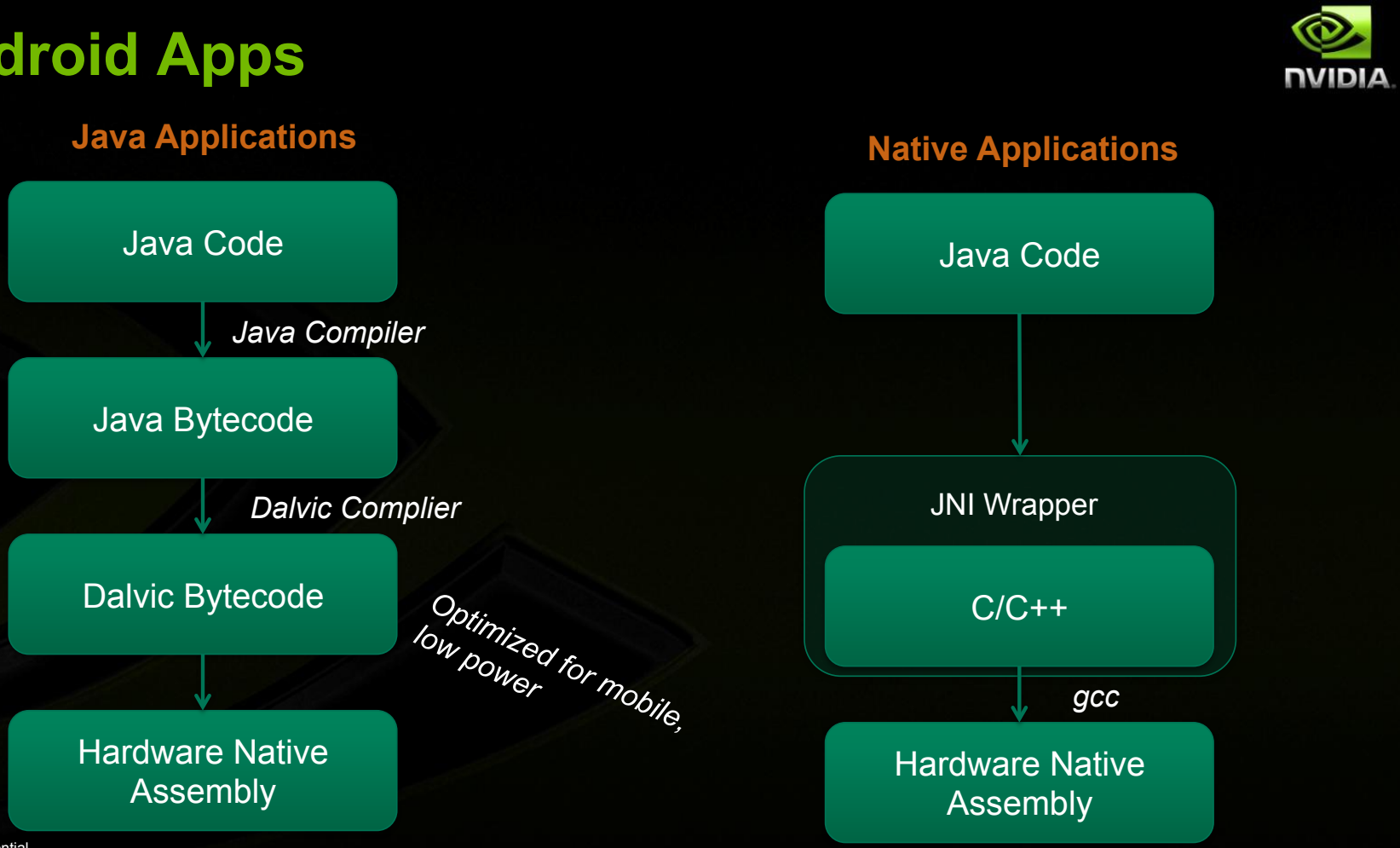


Includes:

- Tegra OS Images (Gingerbread / HoneyComb)
- Android SDK
- Android NDK
- Java Development Kit
- Cygwin
- Apache Ant
- PerfHUD ES
- OProfile
- Eclipse (including ADT and CDT plug-ins)
- Nvidia Debug Manager for Android (NVDM)
- Tegra SDK Samples
- Flash Andoid OS Images to the Tegra DevKit
- Import + compile Tegra SDK Samples in Eclipse

http://developer.nvidia.com/tadp

Android Apps



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OpenCV supports Java and Native

- Most Android apps written in Java (SDK)
- Use Native Applications (NDK) for high performance or hardware optimization (e.g. Neon)

Simply using OpenCV functions: JAVA
Writing your own computer vision algorithms: NATIVE
Advanced camera control (FCAM): NATIVE

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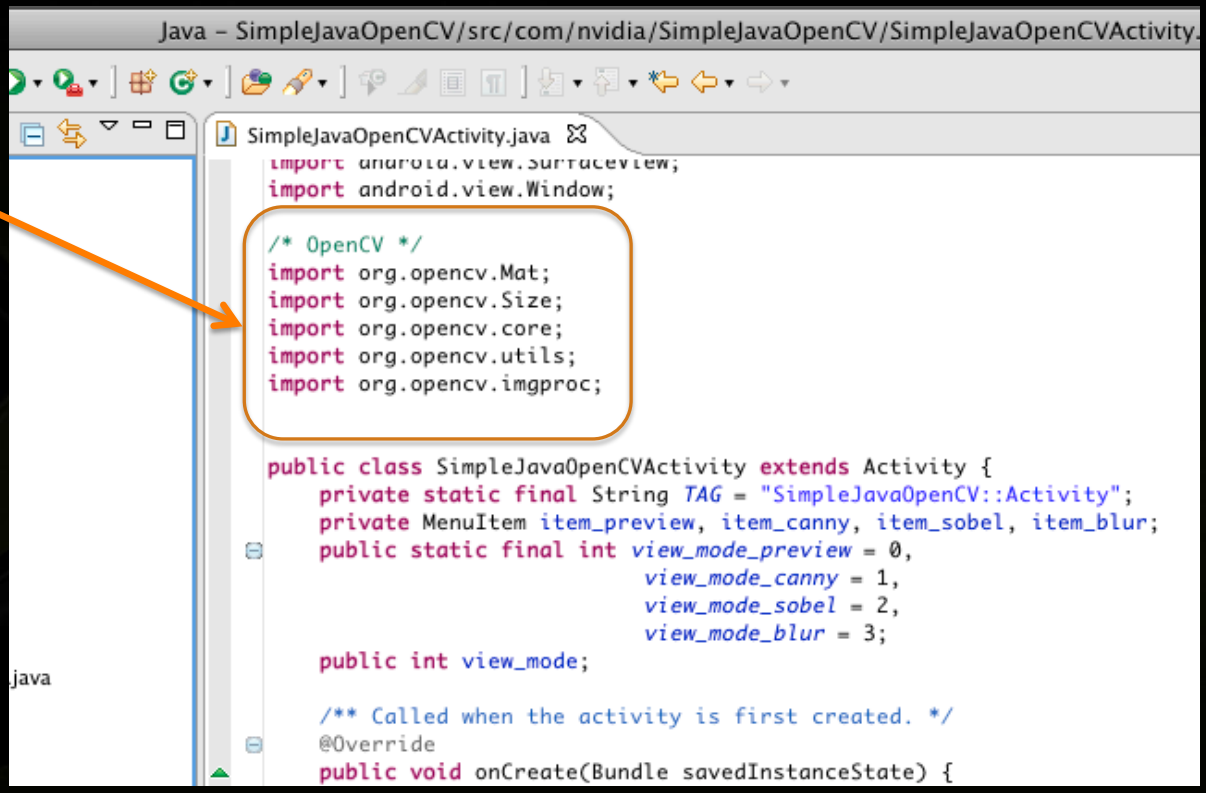
OpenCV Java API Example

- Import the needed OpenCV modules into your Java source files



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OpenCV Java API

- **Java OpenCV code is just like C++ OpenCV code!**

Create an OpenCV Mat from Android Camera data

Use common OpenCV functions

Make and Android Bitmap From and OpenCV Mat

```
Canvas canvas = holder.lockCanvas();

Mat yuv  = new Mat(h+h/2, w, Mat.CvType.CV_8UC1);
yuv.put(0, 0, data);
Mat rgba = new Mat(h, w, Mat.CvType.CV_8UC4);

SimpleJavaOpenCVActivity a = (SimpleJavaOpenCVActivity)getContext();
int view_mode = a.view_mode;
if(view_mode == SimpleJavaOpenCVActivity.view_mode_preview) {
    imgproc.cvtColor(yuv, rgba, imgproc.CV_YUV420i2RGB, 4);
} else if(view_mode == SimpleJavaOpenCVActivity.view_mode_canny) {
    Mat gray  = yuv.submat(0, h, 0, w);
    Mat edges = new Mat(h, w, Mat.CvType.CV_8UC1);
    imgproc.canny(gray, edges, 80, 100);
    imgproc.cvtColor(edges, rgba, imgproc.CV_GRAY2BGRA, 4);
} else if(view_mode == SimpleJavaOpenCVActivity.view_mode_sobel) {
    Mat gray  = yuv.submat(0, h, 0, w);
    imgproc.sobel(gray, gray, core.CV_8U, 1, 1);
    imgproc.cvtColor(gray, rgba, imgproc.CV_GRAY2BGRA, 4);
} else if(view_mode == SimpleJavaOpenCVActivity.view_mode_blur) {
    imgproc.cvtColor(yuv, rgba, imgproc.CV_YUV420i2RGB, 4);
    imgproc.blur(rgba, rgba, new Size(15, 15));
}

Bitmap bmp = Bitmap.createBitmap(w, h, Bitmap.Config.ARGB_8888);
utils.MatToBitmap(rgba, bmp);

canvas.drawBitmap(bmp, (canvas.getWidth()-w)/2, (canvas.getHeight()-h)/2, null);
```

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Thank You to

For continuous support and innovation in OpenCV

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The Embedded Vision Alliance

VISION: Computer vision — machines that see and understand their environments — can bring compelling capabilities to many applications

EMBEDDED VISION: Embedded vision brings computer vision into the mainstream, by incorporating it into a wide variety of electronic products cost-effectively

EMBEDDED VISION ALLIANCE: The Embedded Vision Alliance is an industry partnership seeking to transform the electronics industry by inspiring and empowering engineers to design systems that see and understand

The Alliance's first initiative is ***www.Embedded-Vision.com*** — the engineer's go-to resource for embedded vision technology information and know-how

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Visit *www.Embedded-Vision.com*

Visit *www.Embedded-Vision.com* — the engineer's go-to resource for embedded vision technology information and know-how

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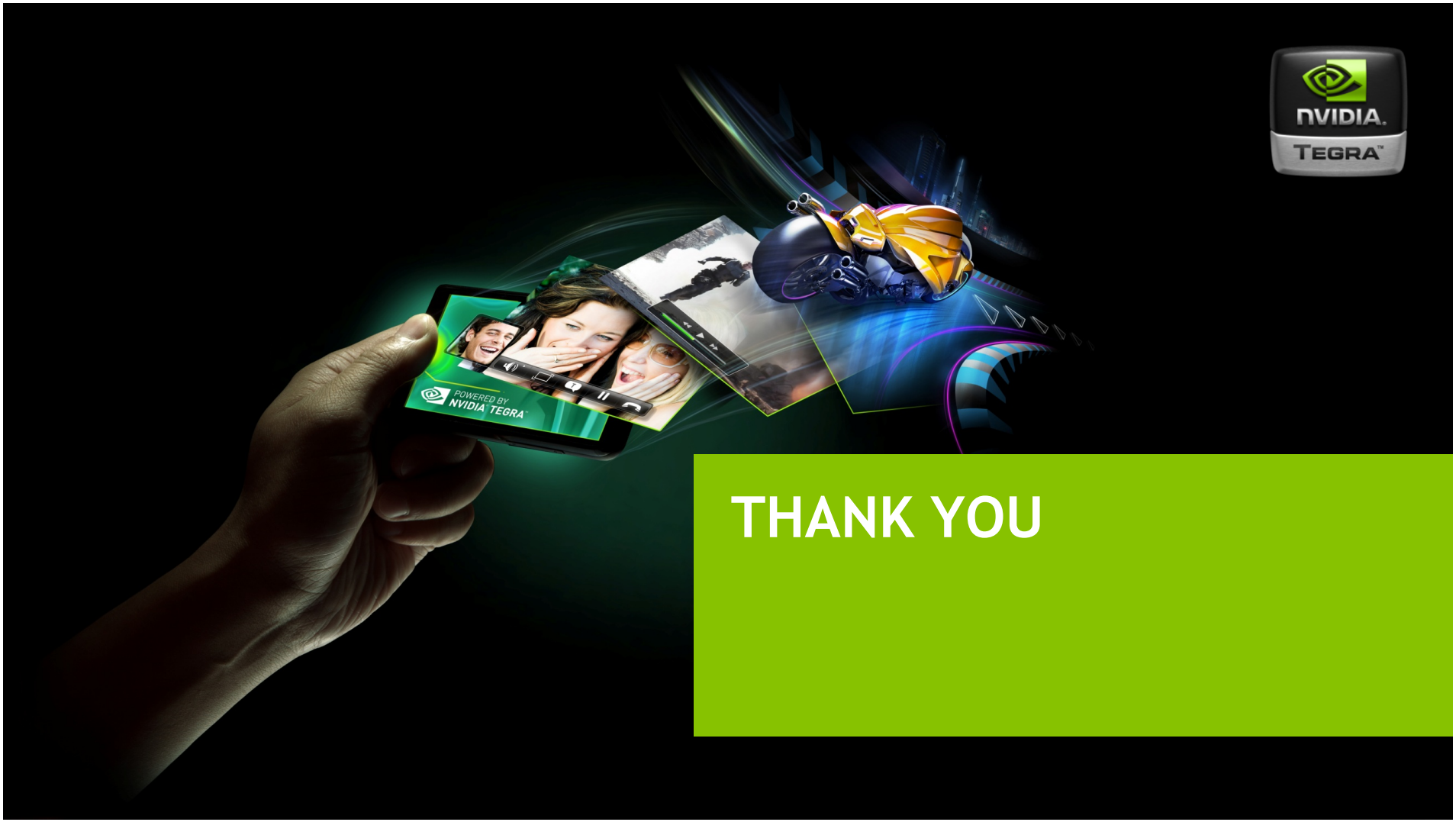
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