Introduction to Embedded Vision

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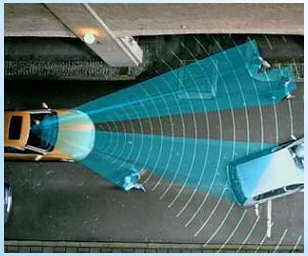
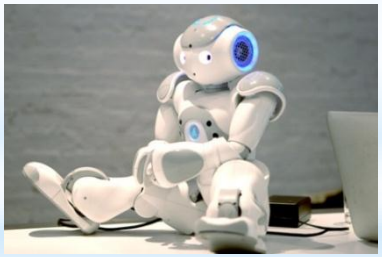
The Era of Embedded Vision

- We are entering the era of machines that see and understand
- We call this "embedded vision"
- The concept isn't new; its rapid, widespread proliferation is new
  - Industrial, automotive, medical, defense, retail, gaming, consumer electronics, security, education, …





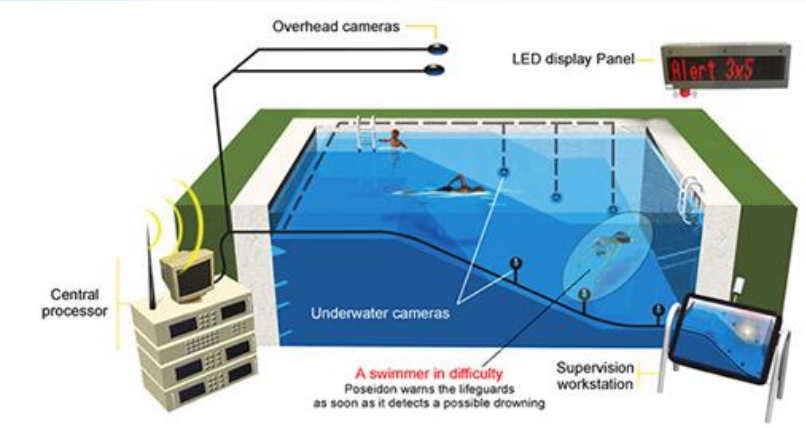
Embedded Vision Is Delivering Compelling Value in a Rapidly Growing Range of Applications

- Embedded vision upgrades what machines know about the physical world, and how they interact with it…
- … enabling dramatic improvements in existing products—and creation of new types of products
- In virtually every industry, embedded vision has the capacity to:
  - **Boost efficiency:** Improving throughput and quality
  - **Enhance safety:** Detecting danger and preventing accidents
  - **Simplify usability:** Making the "user interface" disappear
  - **Fuel innovation:** Enabling us to do things that were impossible

What Can You Do With Embedded Vision?

Prevent Drowning

- ~400,000 drowning deaths occur worldwide each year
- In the U.S., drowning is the 2nd-leading cause of accidental child death
- 19% of child drowning deaths occur with certified lifeguards present
- A person drowning is unable to call for help
- The Poseidon system from MG International monitors swimmers and alerts lifeguards to swimmers in distress



Images courtesy of and © MG INTERNATIONAL - POSEIDON

Reduce Car Crashes

- ~1.2 million people are killed in vehicle accidents annually
- ~65 million new vehicles are produced annually
- Vision-based safety systems aim to reduce accidents by:
  - Warning when closing too fast on vehicle ahead
  - Warning of a pedestrian or cyclist in path of vehicle
  - Warning of unintentional lane departure
  - Automatically dimming high-beams
  - Alerting driver when drowsiness impacts attention
- Most systems today are passive: alert the driver
  - Active systems are becoming mainstream
- Some systems augment vision with radar
- Key challenge: accuracy across diverse situations (weather, glare, groups of people, …)

Mobileye C2-270,
$920 including installation

Make Systems Dramatically Easier to Use

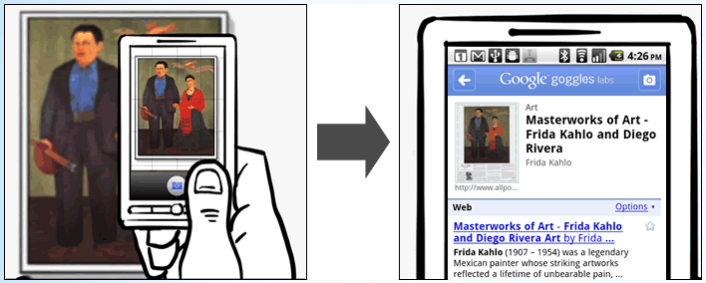
Microsoft Kinect,
$110 including game title

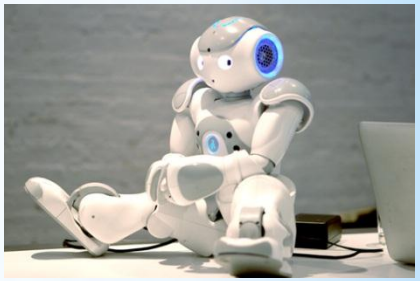
- Video games are a ~$60 billion/year business
- Vision-based control of video games enables new types of games and new types of users
- The Microsoft Kinect is the fastest-selling non-wireless consumer electronics product ever: eight million units sold in first two months
- Price: $130 (includes a game title); bill of materials cost: ~$60
- Kinect is not just a game controller:
  - Can be used to control audio/video systems and web browsers
  - Is being used as a low-cost vision development platform
- Key challenge: must be extremely easy to use and very inexpensive

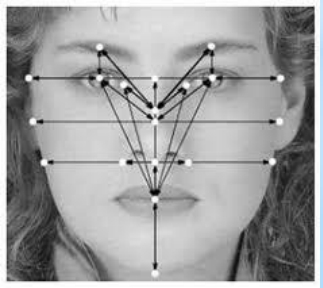
Image courtesy of and © Useit.com

vs.

What Can You Imagine?







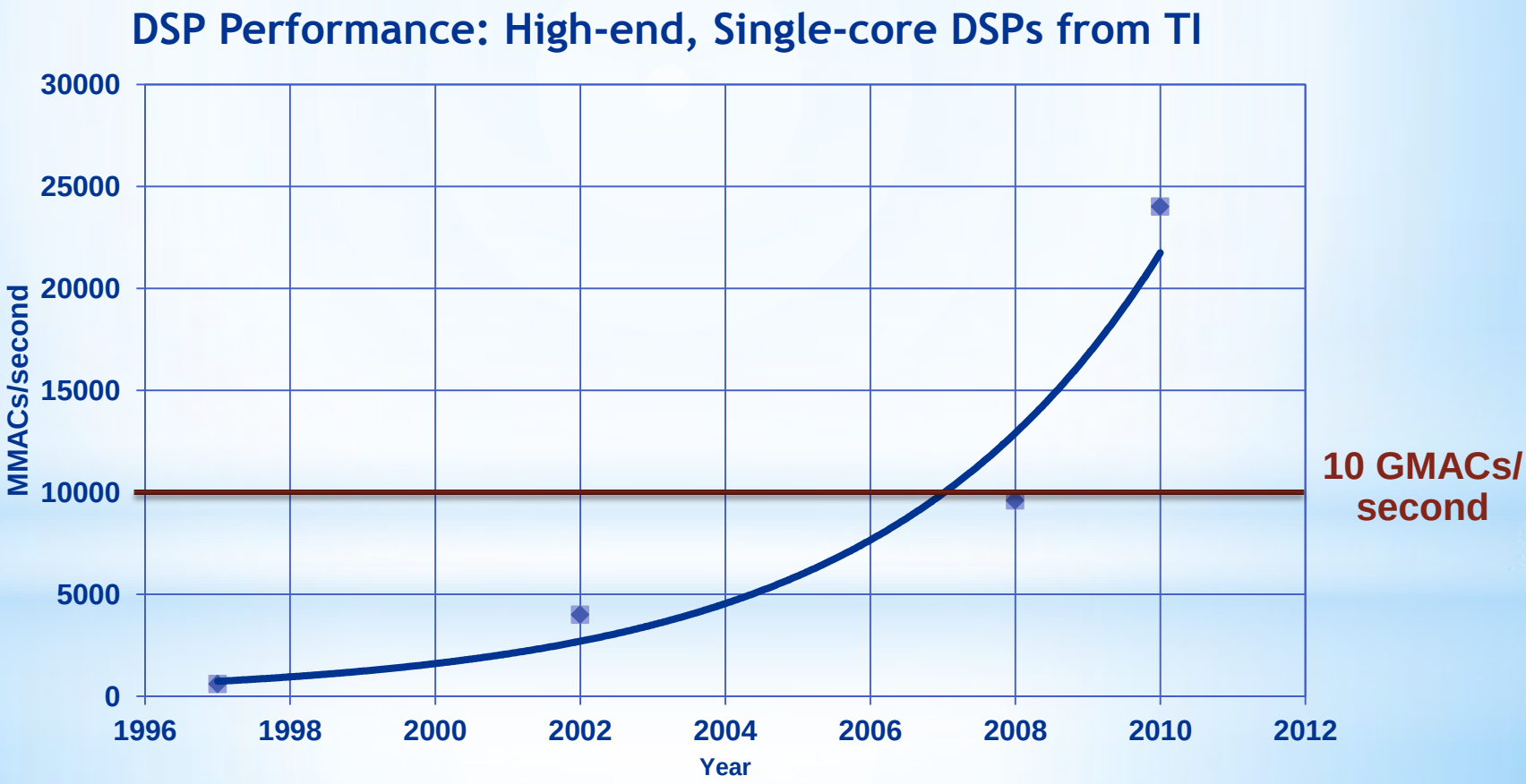
Embedded Vision is Brought to You By…

- The emerging proliferation of embedded vision is enabled by:
  - Hardware:
    - Processors
    - Sensors
  - Software:
    - Algorithms, libraries, APIs
  - Tools and techniques
  - Knowledge: Awareness, skills, information

The Processing Challenge

- Embedded vision applications typically require:
  - Very high performance
  - Programmability
  - Low cost
  - Energy efficiency
- Achieving all of these together is difficult
  - Vision algorithms are diverse and dynamic, so fixed-function compute engines are less attractive

Enabling Embedded Vision: Processor Performance



Source: BDTI Analysis

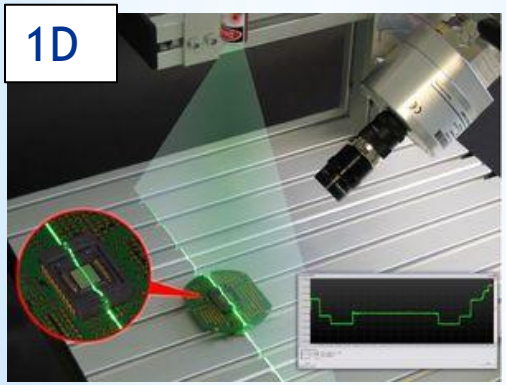
Processor Types for Embedded Vision

While any processor can in theory be used for embedded vision, the most promising types today are:

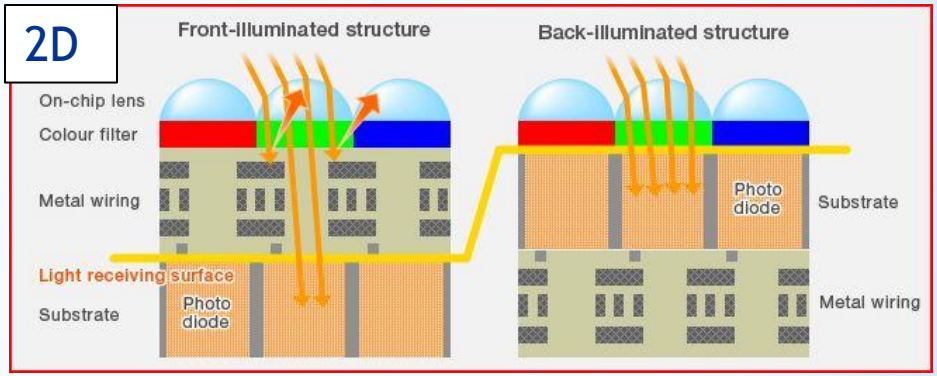
- High-performance embedded CPU
- Application-specific standard product (ASSP) + CPU
- Graphics processing unit (GPU) + CPU
- DSP processor + accelerators + CPU
- Mobile "application processor"
- Field programmable gate array (FPGA) + CPU

Sensors Are Advancing Rapidly

1D



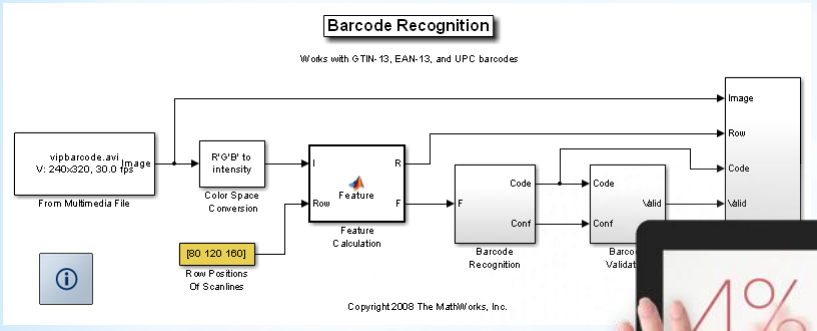
2D

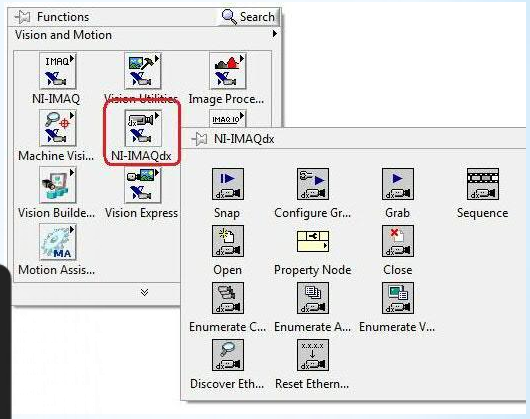


3D

4D

Algorithms, Libraries, APIs





Tools and Techniques

Sophisticated tools are available for vision algorithm development on PCs and PC-like embedded systems

But there are relatively few resources for embedded vision development

Needed:

- Frameworks
- Higher levels of abstraction, with efficient implementation
- Support for field experiments
- Portability among processor types

Needed: Knowledge, Skills, Information

- Embedded vision requires is a whole-system approach
- In most industries, engineers have little experience with vision
- It's difficult to find practical information
- Typical vision applications require lots of processing performance, with limited power, cost and size
  - Need parallelism, which complicates implementation
  - Need optimization, which requires specialized skills

Free Resources from the Embedded Vision Alliance

- The Embedded Vision Alliance web site, at www.Embedded-Vision.com covers embedded vision applications and technology, including interviews and demonstrations
- The Embedded Vision Academy, a free service of the Alliance, offers free in-depth tutorial articles, video "chalk talks," code examples and discussion forums: www.EmbeddedVisionAcademy.com
- The Embedded Vision Insights newsletter provides updates on new materials available on the Alliance website. Sign up at www.Embedded-Vision.com/user/register
- Embedded vision technology and services companies interested in becoming sponsoring members of the Alliance may contact info@Embedded-Vision.com

Embedded Vision Insights
The Latest Developments on Designing Machines that See

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