embedded VISION ALLIANCE

Development and Deployment of Embedded Vision in Industry: An Update

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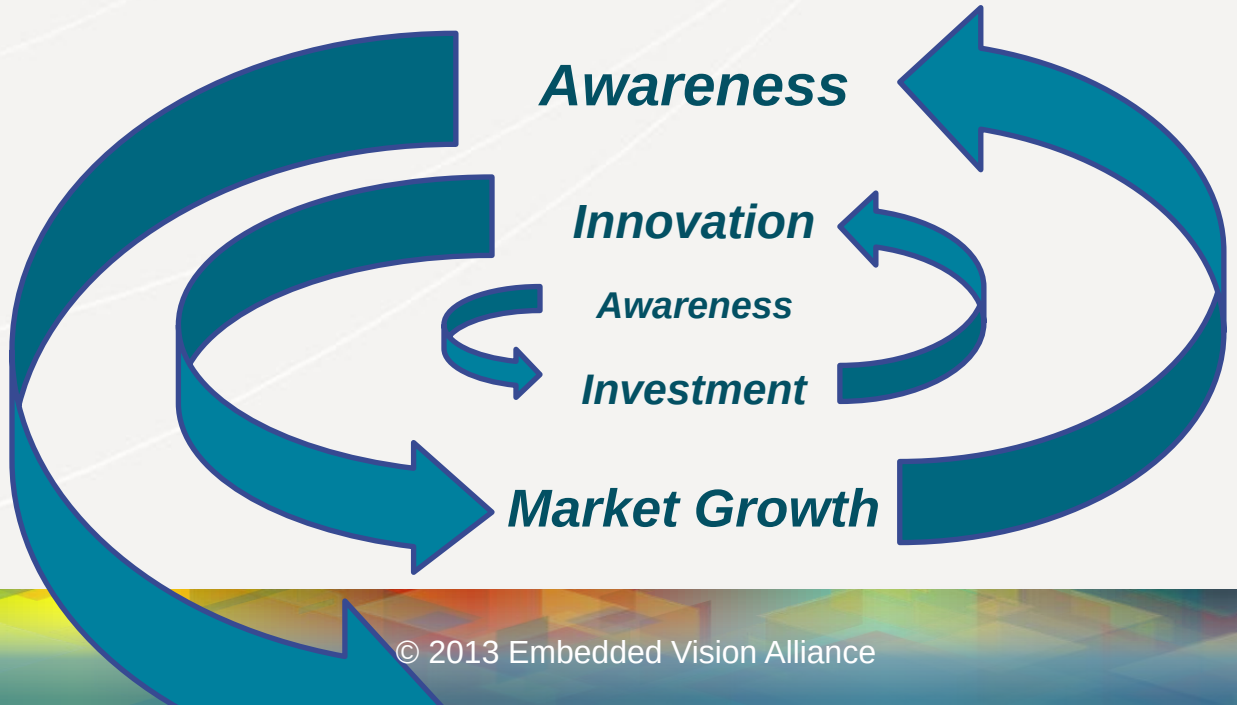
The Big Picture

"Computer vision" is crossing the chasm from expensive niche technology to become "embedded vision," a ubiquitous technology

- Successful deployments in diverse markets: healthcare, automotive, entertainment, education, industrial, retail, consumer, security, …
- Using varied system architectures: embedded systems, smartphones and tablets, PCs, the cloud



Outline

- The big picture
- “Savior” apps
- Advances in enabling technology
- Smartphones and tablets lead the way
- Public awareness
- Industry awareness
- Regulation
- Supplier ecosystem challenges
- Impact on scientific and engineering applications

"Savior" Apps

Beyond established niches in factory automation, military, and security, new vision markets are attaining commercial significance:

- **Automotive Safety**: forward collision avoidance, lane keeping, etc.
  - IMS Research predicts annual revenue growth of 6-9% for vision processors in under-the-hood automotive applications, reaching $187 million worldwide by 2016
- **Gaming**
  - Over 24 million Microsoft Kinect units sold (> $1 billion revenue)
  - The next-generation Xbox One console requires the new Kinect
- **Augmented Reality** (especially on mobile devices)
  - Several mobile AR apps have exceeded 1 million downloads
  - SmarTech Publishing forecasts that augmented-reality-related retail and promotional activities will generate $300 million by 2017

Mercedes Benz 2013 A Class

http://www.youtube.com/watch?v=WGgSyA8HXyY

A Seminal Embedded Vision Product: Kinect

The Microsoft Kinect has brought vision to 20 million living rooms.

www.youtube.com/watch?v=DyLWGKiNLRY

IKEA Catalog with Augmented Reality

What would it look like if… ?

www.youtube.com/watch?v=dwt-mgxq_ao

Other Very Promising Vision Application Areas

Established Markets:

- **Manufacturing**: inspection, motion control (already a $3 billion industry)
- **Military:** security, surveillance, target tracking

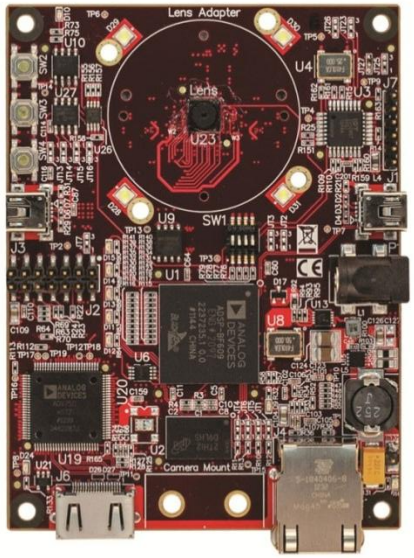
Emerging Markets:

- **Retail**: visual search, augmented reality kiosks, interactive digital signs
- **Health care:** surgical robots, home health monitoring
- **Consumer electronics**: natural user interfaces, personal robots
- **Transportation and other infrastructure**: safety, security, congestion

Advances in Enabling Technology

To enable ubiquitous embedded vision, enabling technologies must be robust, inexpensive, small, energy efficient—and easy to use

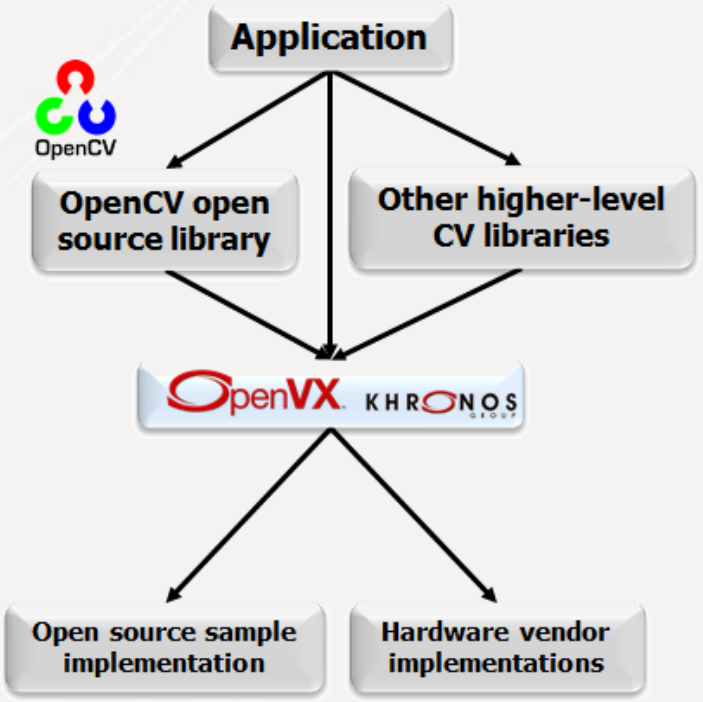
- Vision-specific **processors**: e.g., CogniVue, CEVA, Tensilica, TI, STMicro, Renesas, Toshiba, Imagination Technologies
- Vision-specific embedded **development kits**: e.g., Analog Devices/Avnet, Xilinx, Raspberry Pi
- Low-cost **3D sensors**: e.g., SoftKinetic, PrimeSense, PMDTech, Leap Motion
- Vision-specific **software libraries, frameworks**, tools, etc.: e.g., OpenCV, Vuforia, FastCV, LabVIEW Vision, Perceptual Computing SDK
- Vision-oriented **standards**: e.g., Khronos OpenVX



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



Smartphones and Tablets Lead the Way

In smartphones and tablets, vision enables natural user interfaces, computational photography, augmented reality and other novel functions

Mobile processor suppliers are investing to enable vision

- E.g., Qualcomm Vuforia and FastCV, NVIDIA TDP and OpenCV
- Enabling offload of vision processing to GPU, DSP, etc.

itunes.apple.com

nocamels.com

edudemic.com

Who Cares About Mobile Computer Vision?

- Advertisers, retailers and publishers, because it enables enhanced customer engagement
- Consumers and app developers, because it provides ease of use, impressive new capabilities, and fun
- OEMs, processor vendors, and network operators, because they must differentiate increasingly commoditized products
- Embedded systems developers, who are increasingly borrowing mobile technology (as they have borrowed PC technology in the past)

www.digitaltrends.com

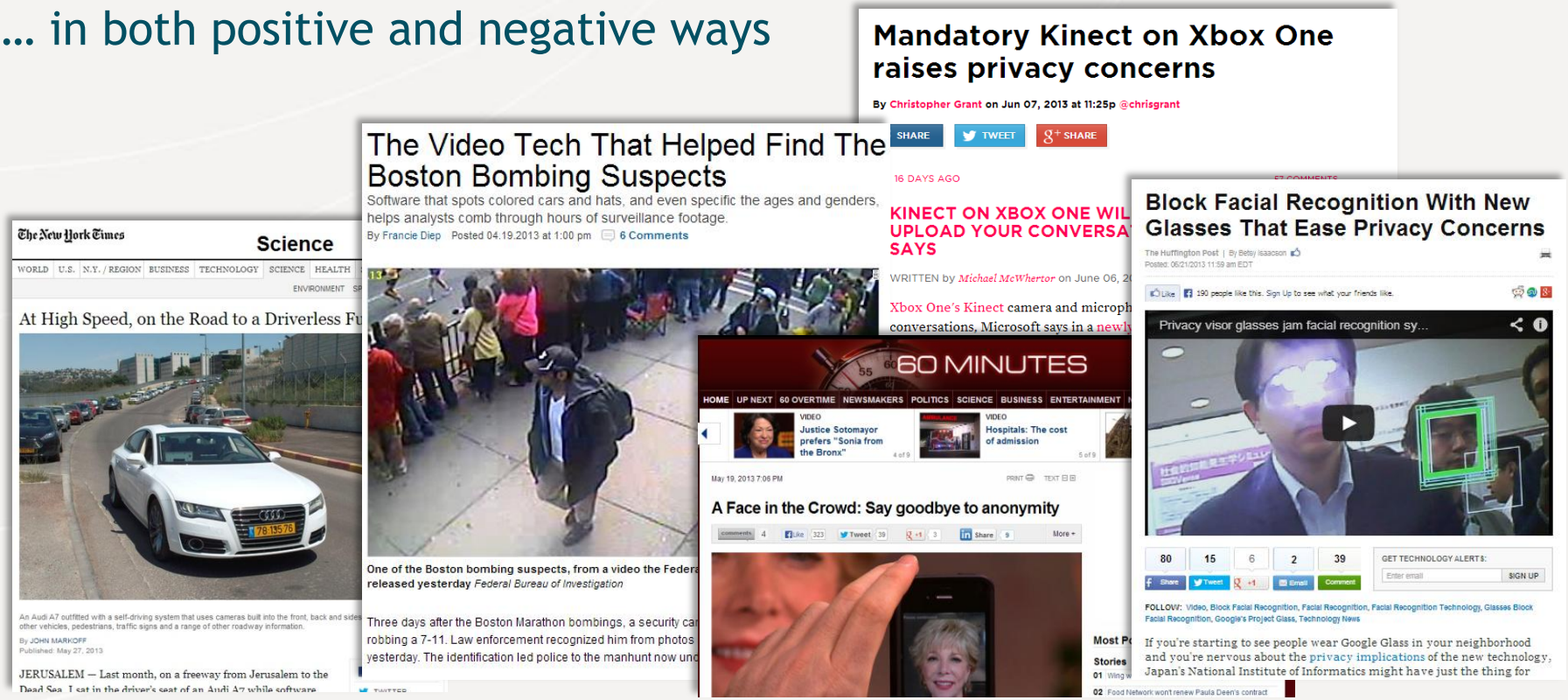
www.wantchinatimes.com

www.fingerfood.5thfinger.com

Public Awareness

Thanks to the success of the Kinect, vision-based mobile apps, and automotive safety systems, consumers are increasingly aware of embedded vision technology…

… in both positive and negative ways



Regulation

As awareness of vision technology grows, so does interest in regulating it, particularly with respect to privacy and safety

With little current regulation and low barriers to entry, there's a risk that privacy abuses will spur a backlash

Industry is showing little leadership in this realm


Facebook facial recognition software violates privacy laws, says Germany

Social network must stop programme and delete data already collected on users – or face fines up to €300,000, says official

Pidd in Berlin

ardian, Wednesday 3 August 2011 10.08 EDT

np to comments (34)

ook is threatened with legal action in Germa

re, which critics say violates privacy and da

ol runs all photos uploaded to the social net

mme and identifies the user's friends on ea

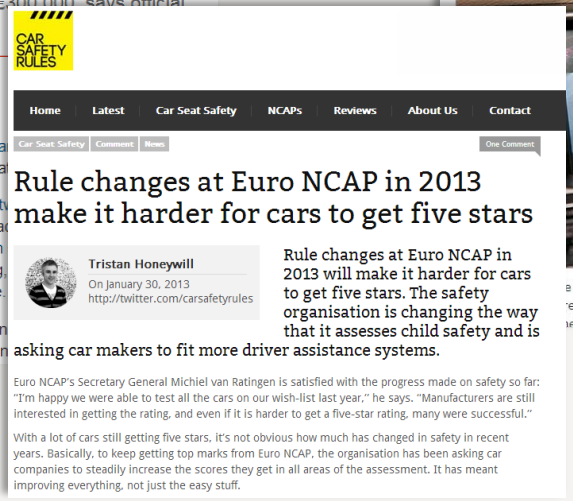
when it was rolled out in June to more than

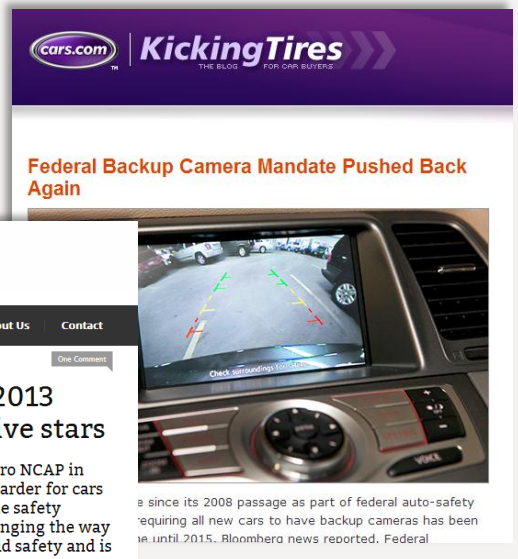
users can opt out of the automatic tagging,

ore (indefinitely) all photos added to the site.

amburg's data protection official has written

running the facial recognition programme on





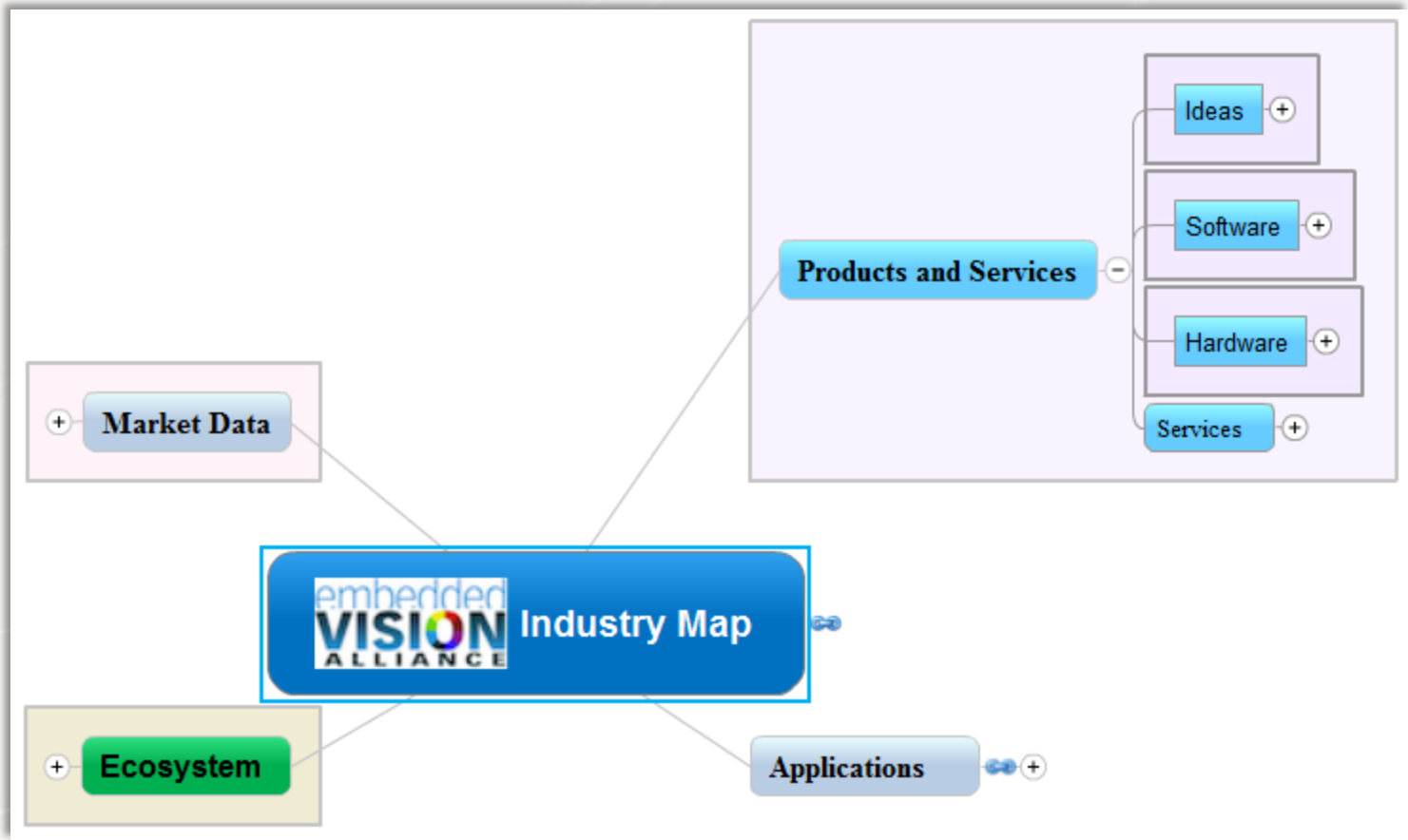
Industry Awareness

Awareness of the expanded applicability of embedded vision is growing rapidly in industry, outside of traditional niche applications

- Semiconductor suppliers are investing heavily to raise awareness
  - E.g., Intel's "Perceptual Computing" initiative
- Low-cost resources such as the Kinect, embedded development kits, and SDKs make it easier to get started
- The Embedded Vision Alliance has engaged with over 10,000 product creators through its web site, webinars, conferences, etc.
  - Offering resources such as the Quick-Start OpenCV Kit

Industry Ecosystem

The supplier ecosystem is growing, but is fragmented and confusing



How Do Broader Embedded Vision Trends Affect Scientific and Engineering Applications?

- Huge investment surge in enabling technology ➔ accelerated innovation
  - Scientific and engineering applications are adopting technology from other markets, creating disruption
- Increased awareness of vision technology ➔ new opportunities
  - For vision suppliers
  - For vision engineers ➔ increased competition for talent
- Smaller, less expensive, lower-power vision systems ➔ new markets
  - Including more vision deployed in the field (not only in the factory)

Embedded Vision Summits are embedded-vision-focused technical educational events for engineers in industry

- High-quality, practically-oriented technical talks
- Inspiring keynote presentations
- Exciting demos of the latest apps and technologies
- Extensive networking opportunities

600 professionals have attended Summits so far, and have given the events an average rating of 8.5/10

Next Summit: Boston, October 2-3, 3013

Summits are being planned for China, Japan, Germany, Israel, and Silicon Valley

For more information, go to www.EmbeddedVisionSummit.com

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

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Conclusions

- Embedded vision has arrived
- Automotive safety, gaming and consumer augmented reality are key growth applications
- Smartphones and tablets are key
- Consumer awareness is growing, sparking interest but also concerns
  - Privacy concerns and regulation are real risks
- Industry awareness of the expanded applicability of embedded vision is growing rapidly
- Low-cost resources make it easier to get started
- Supplier ecosystem is growing, but fragmented and confusing
- Most vision technology innovation is now aimed at non-traditional markets
  - Creating opportunity and disruption for traditional applications

Thank You!

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