Implementing Embedded Vision: Designing Systems That See and Understand Their Environments

When to Use FPGAs to Accelerate Embedded Vision Applications

March 21th, 2013

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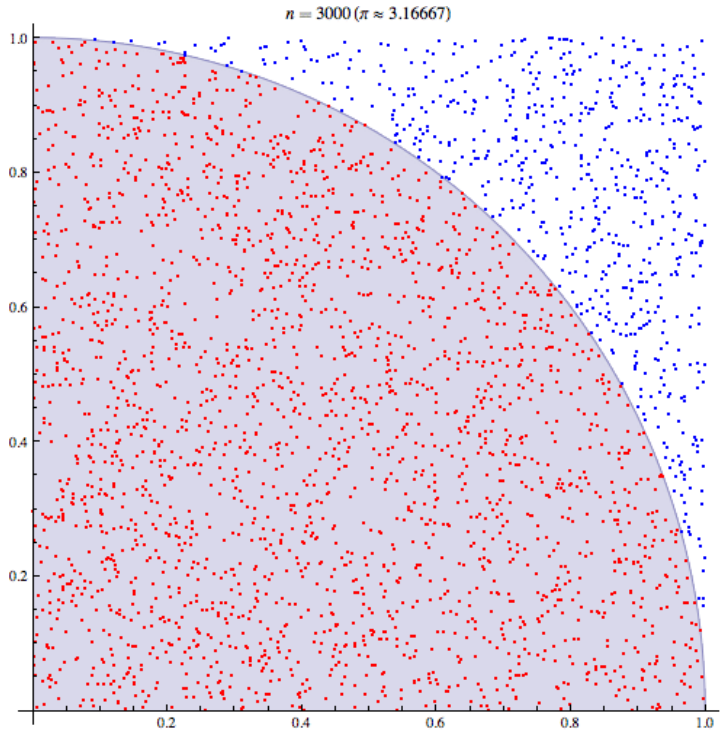
When to Use FPGAs to Accelerate Embedded Vision Applications

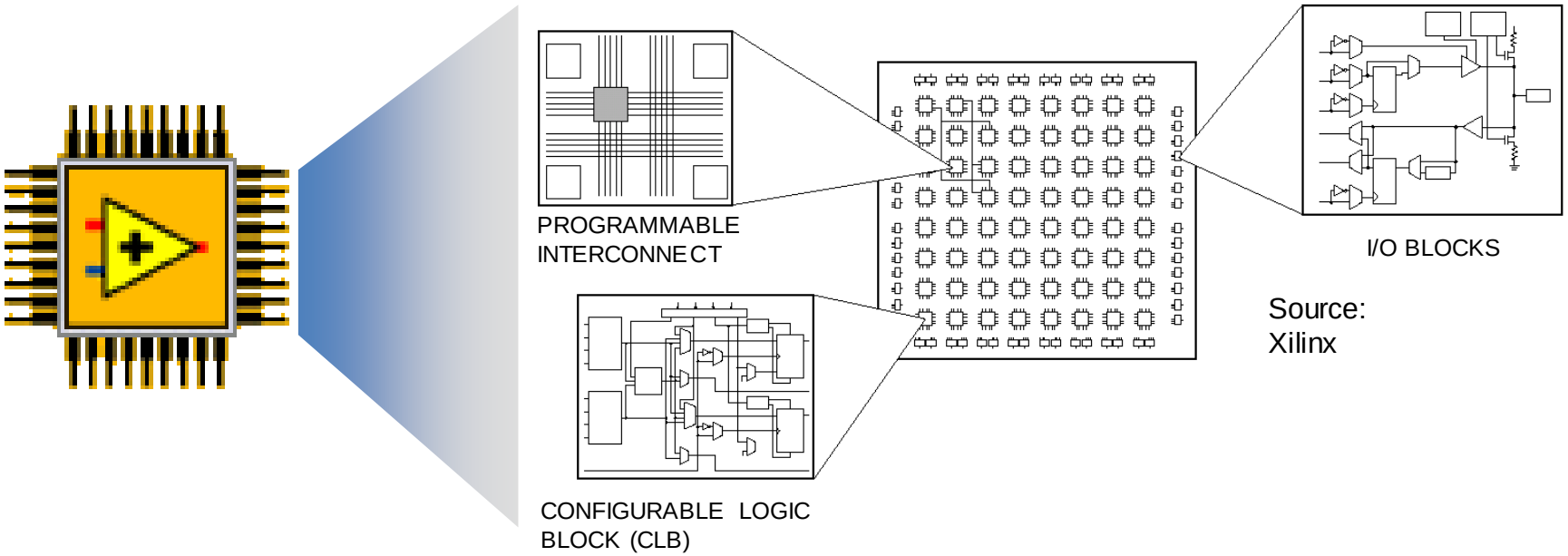
- Who am I?
- Who are you?
- What we will talk about today

Accelerating CPU systems

- Ride the CPU frequency wave
- Automatic hardware acceleration (SSE, Hyperthreading)
- Making software multithreaded
  - OpenMP (multiple cores)
  - MPI (multiple separate machines)
  - Many others
- Some problems divide well
- Others don't



Field Programmable Gate Array (FPGA)

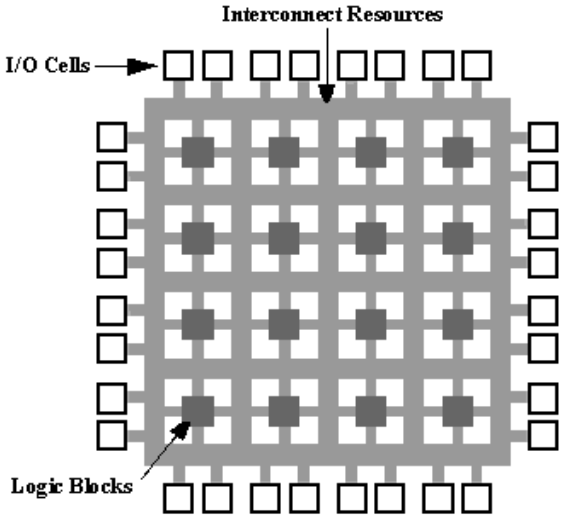


Source:
Xilinx

A semi-conductor device containing many gates (logic devices). A wiring list downloaded to the FPGA determines the gate connections and the functionality.

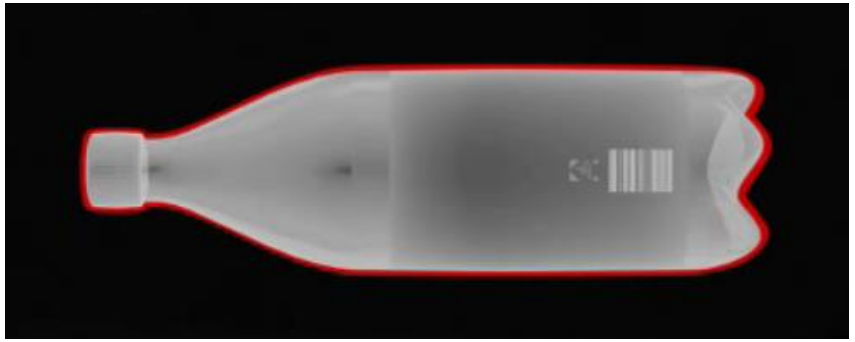
Software-Defined Hardware = FPGA

- Software Programmable (and Reconfigurable)
- Hardware Reliable (and Repeatable)
- High-speed Signal Processing (and Parallel Processing)
- Extreme Determinism (and clock-cycle control)



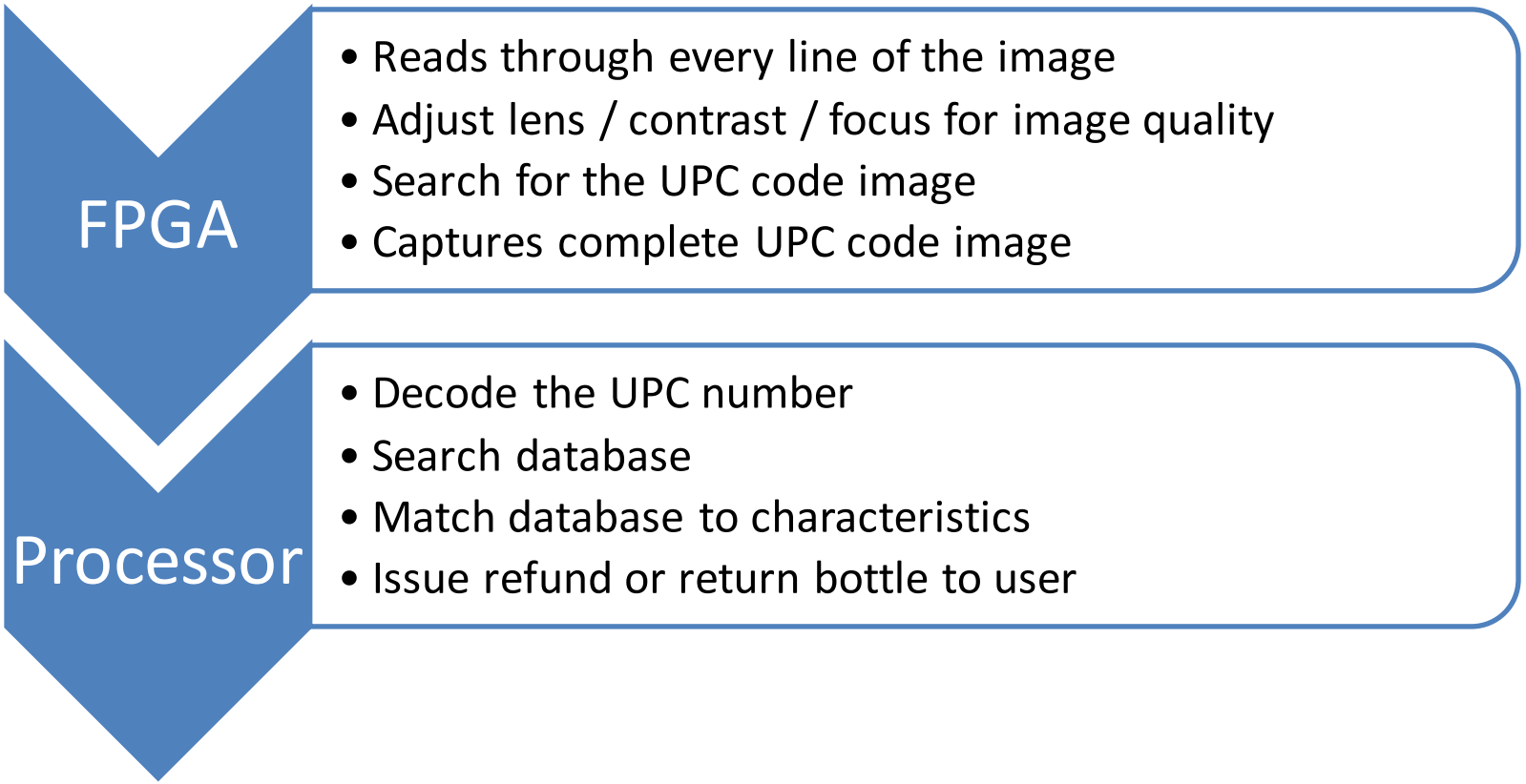
An Example "Pfandautomat"

- Germany's Bottle Recycling System
- System Checks the following
  - UPC code
  - Size, of the Bottle
- Prints Voucher or Returns Bottle



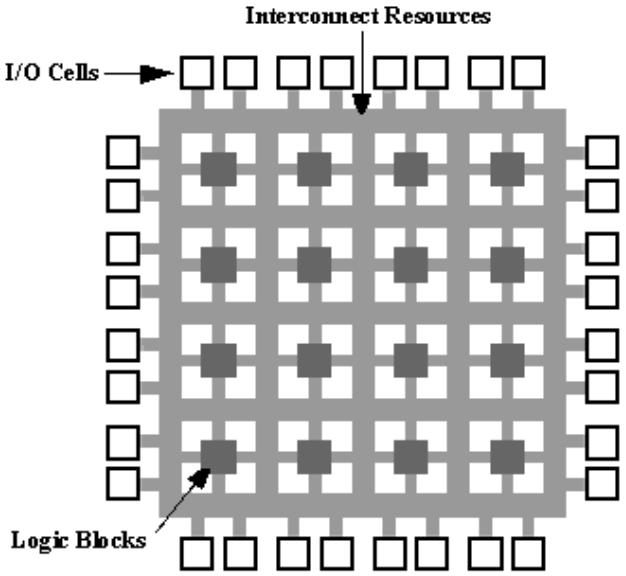
Example Continued

- Can an FPGA do all the tasks?
  - Yes, but….

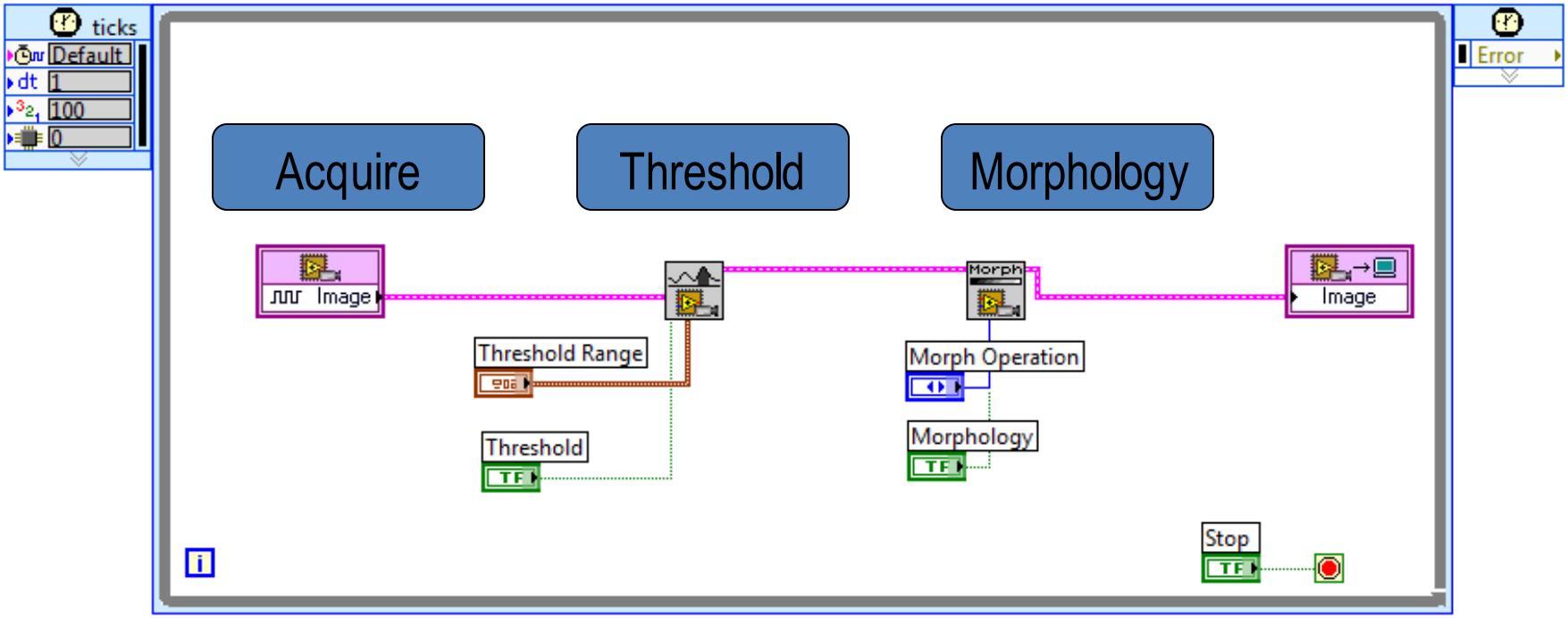


FPGAs

- Latency
- Jitter
- Compute power
- Pipelining
- Security
- Weight / Power / Heat
- Complexity
- Raw Clock Rates
- Limited Floating Point support

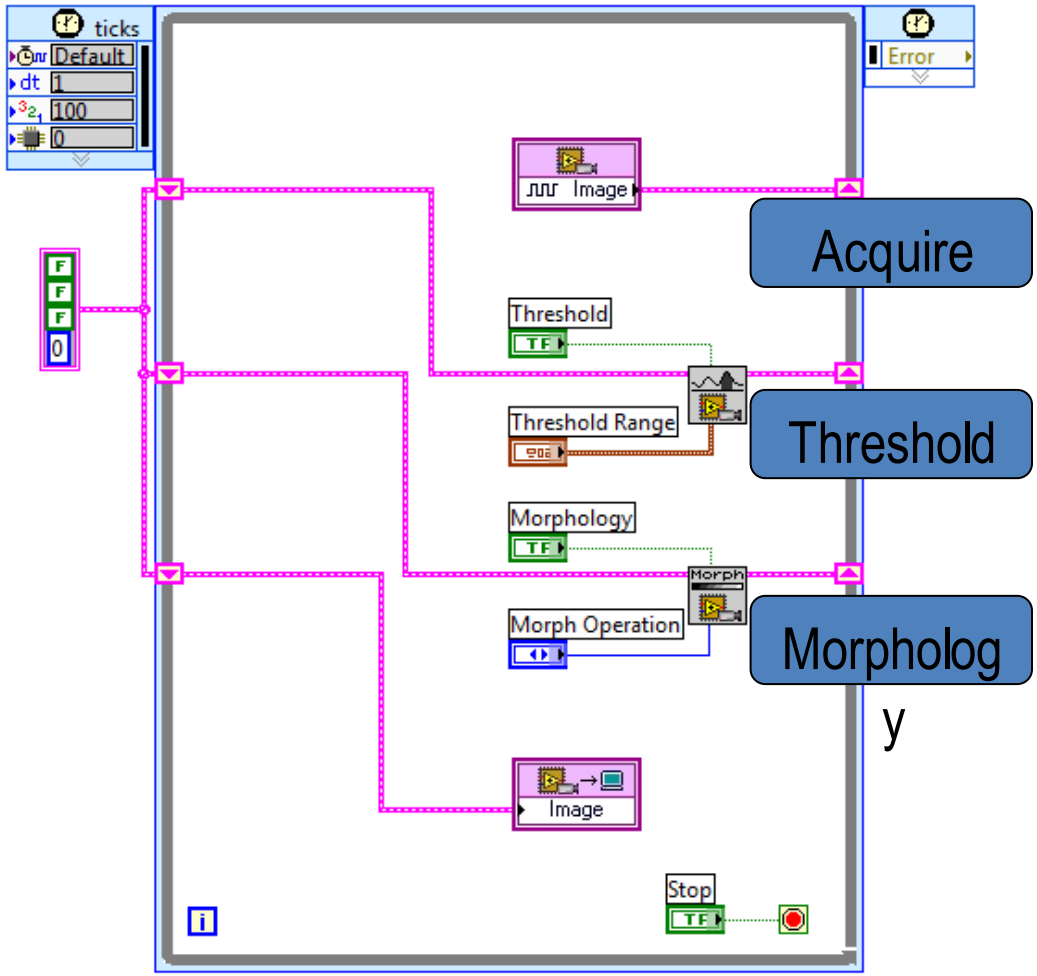


Sequential Image Processing



Pipelining

- Processing loop rate limited by longest delay in loop
- Reduce delays by splitting operations into multiple cycles
- Increases speed, but also latency



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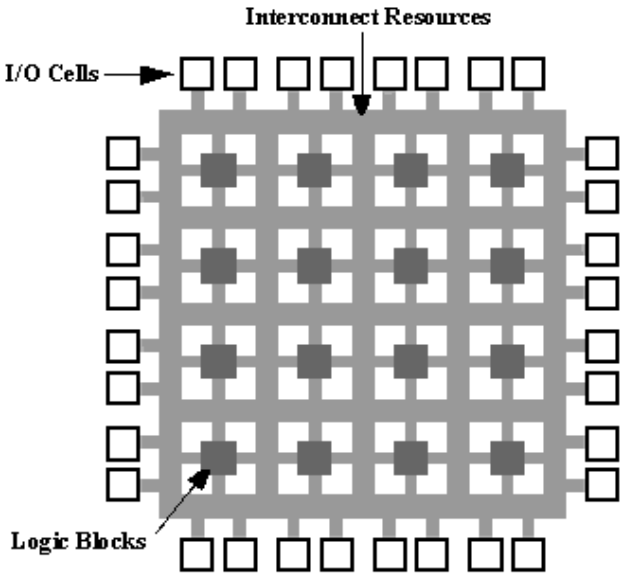
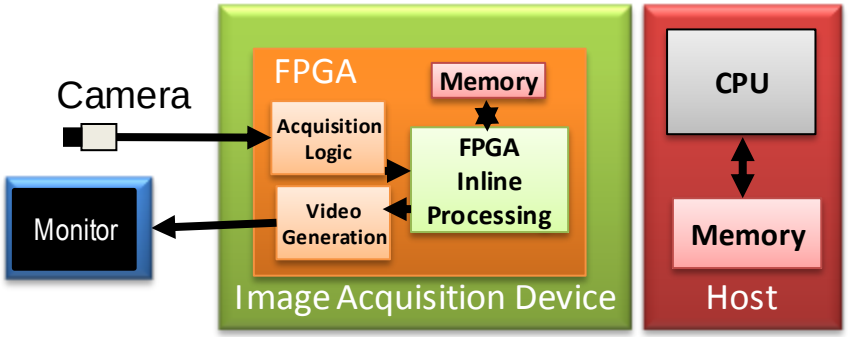


FPGA Use Modes

Visualization



High-speed Control

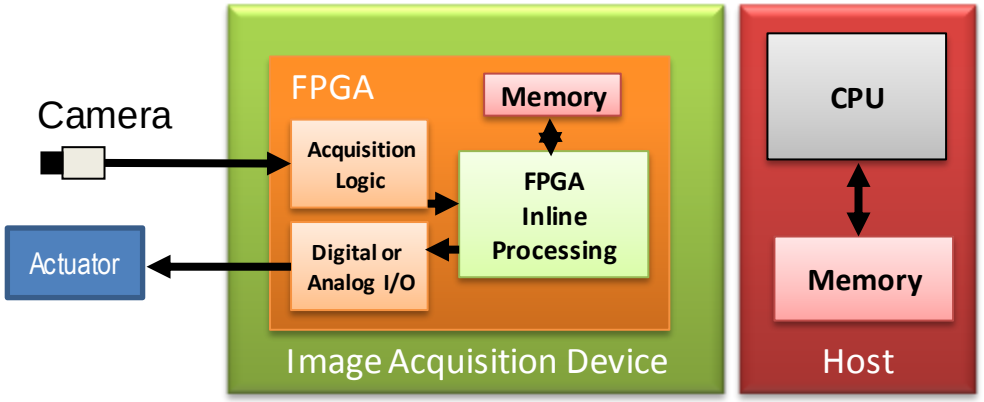
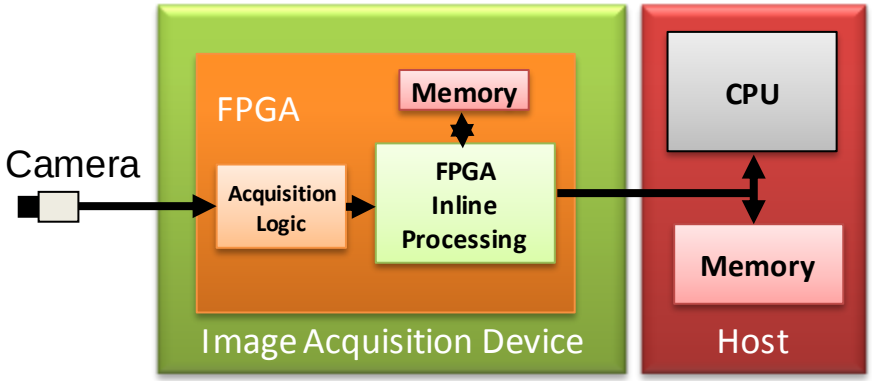
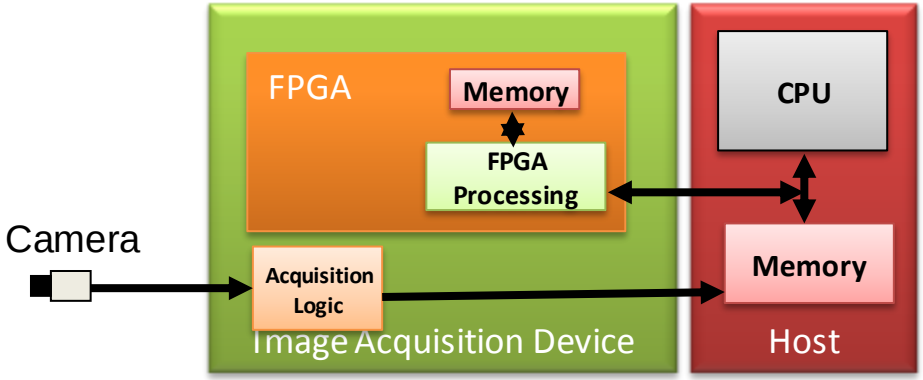


Image Preprocessing

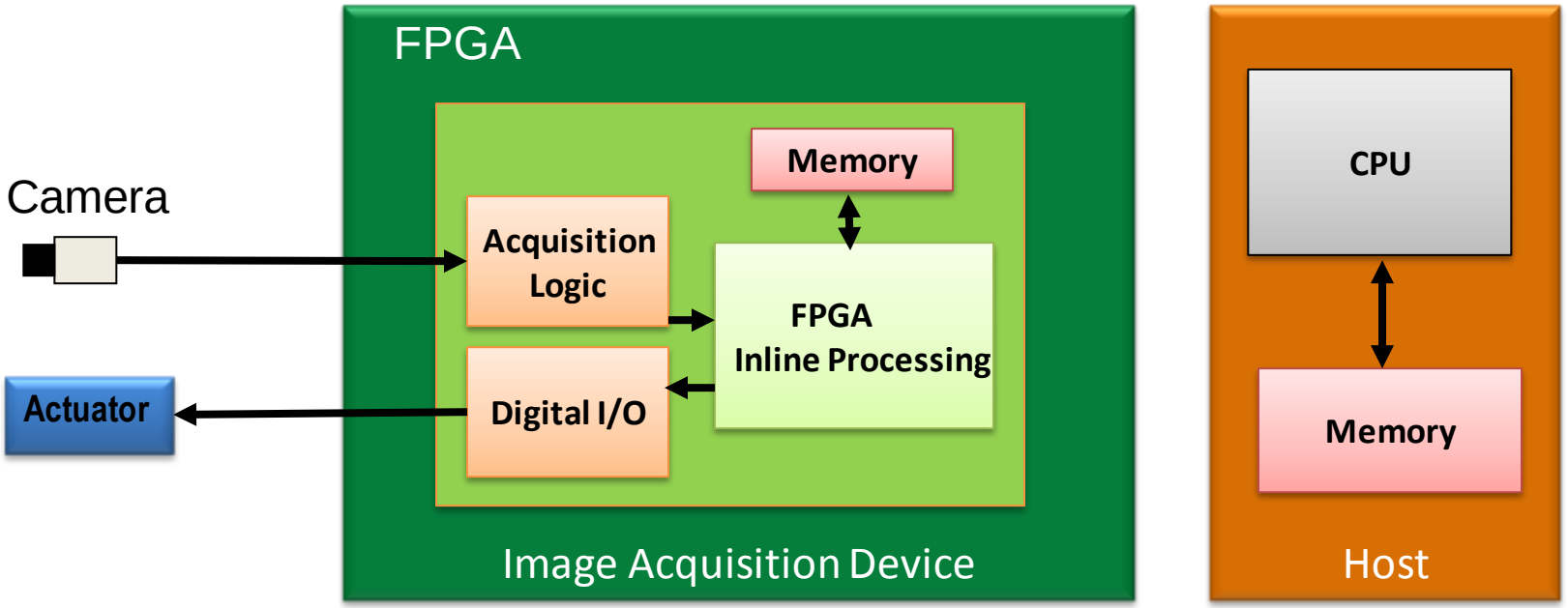


Co-Processing



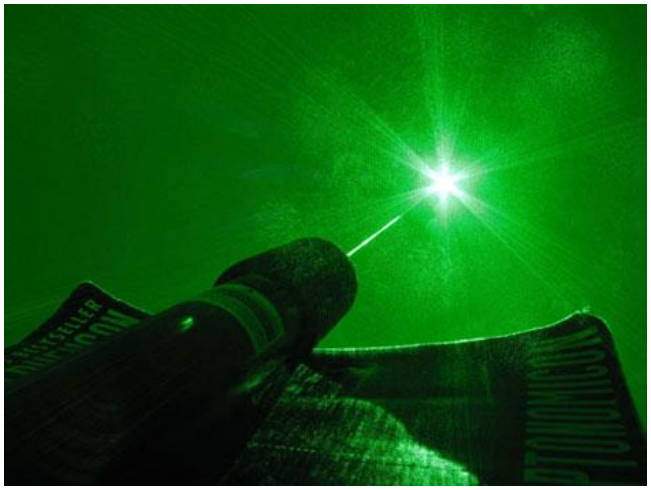
High-Speed Control

- FPGA is directly in the path of the image data
- FPGA generates and outputs control commands directly

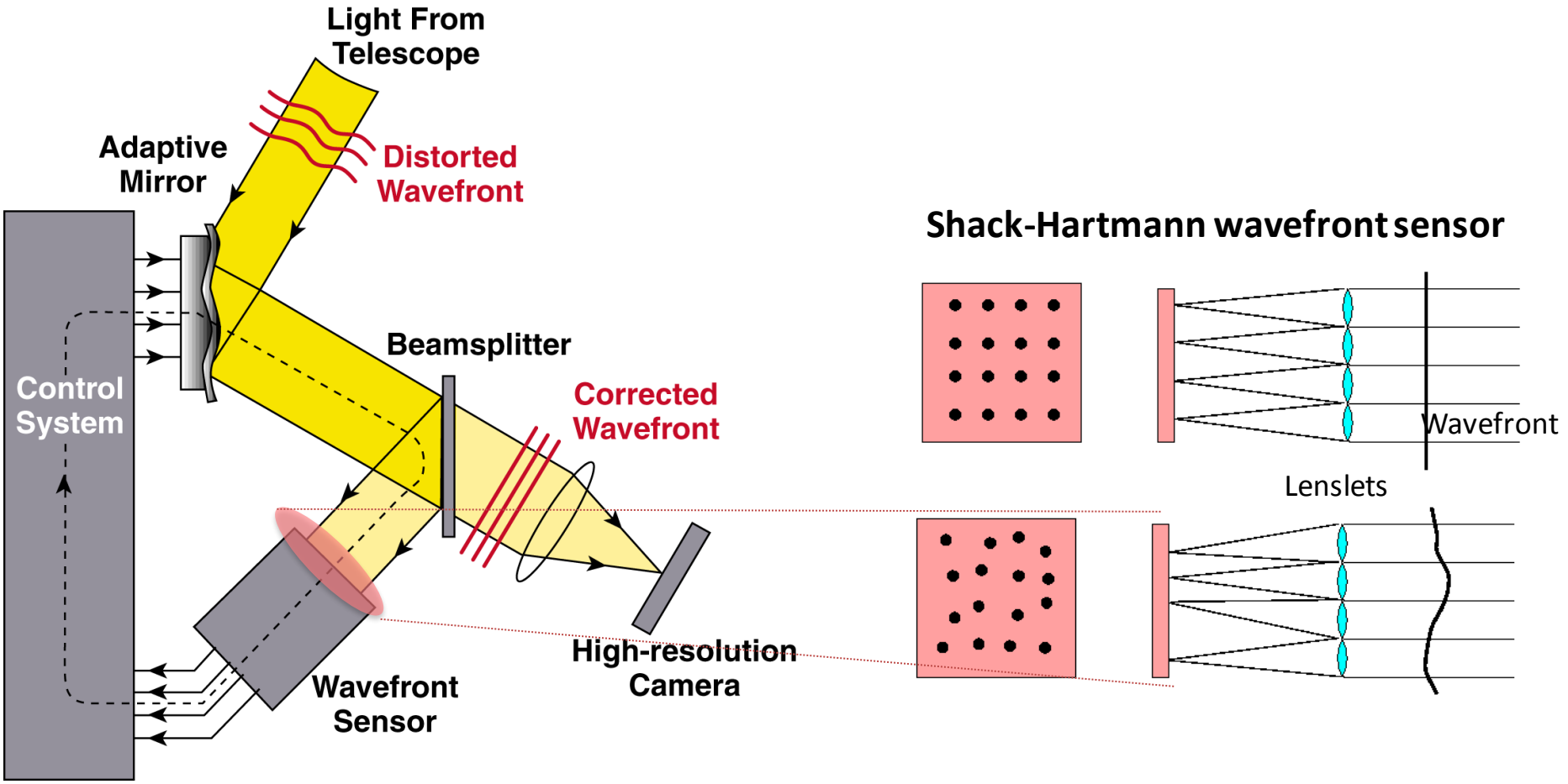


High-Speed Control

- Laser alignment/steering
  - Beam profile/position measurements
  - Low latency control output
- High-speed sorting
  - Segmentation
  - Measure parameters of contaminant
  - Trigger rejection valves
- In Air Sorting
  - Image and inspect falling product
  - Low jitter requirement for decision making and IO

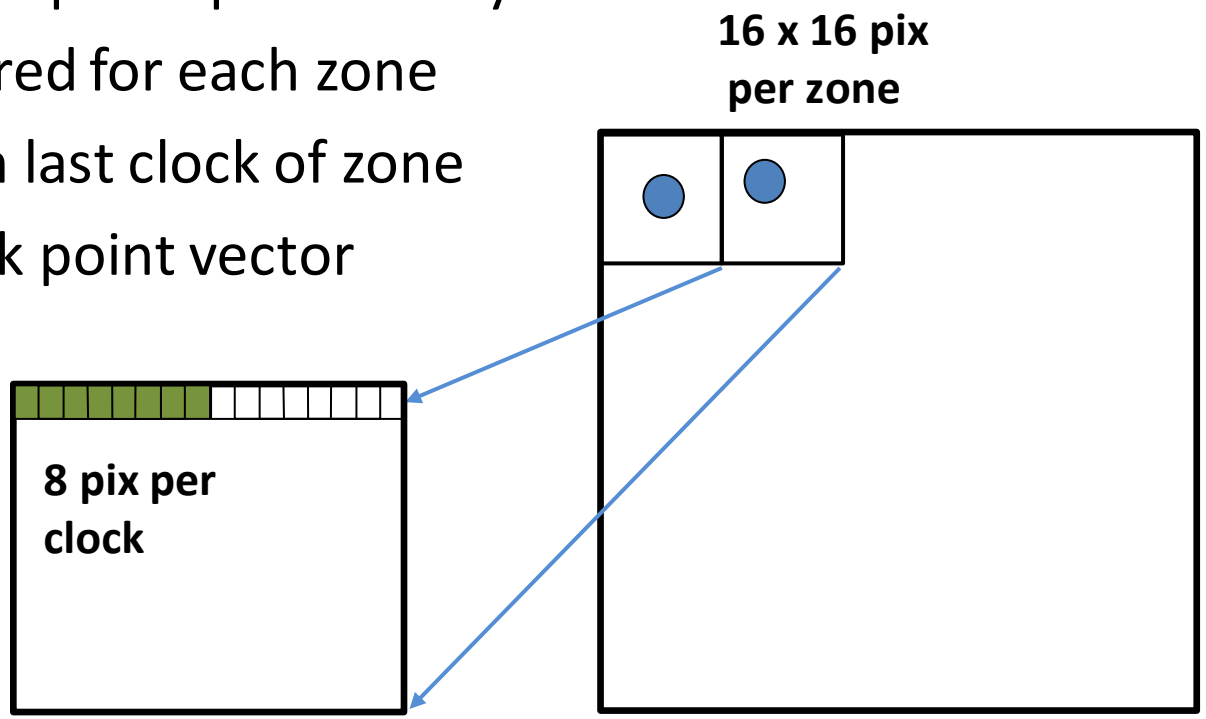


Adaptive Optics – Centroid Computation



Adaptive Optics – Centroid Computation

- 512 x 512 image divided into 16 x 16 pixel zones (1024 total)
- Camera transmits 8 pixels per clock cycle
- Running sums stored for each zone
- Centroid divide on last clock of zone
- Data reduced to 1k point vector



Adaptive Optics – Centroid Computation

- Host based vision starts processing after image transmitted
- FPGA vision can start on first pixel and finish shortly after last pixel
- Latency reduced by almost 1 frame period
- Start of exposure to last result available ~600us

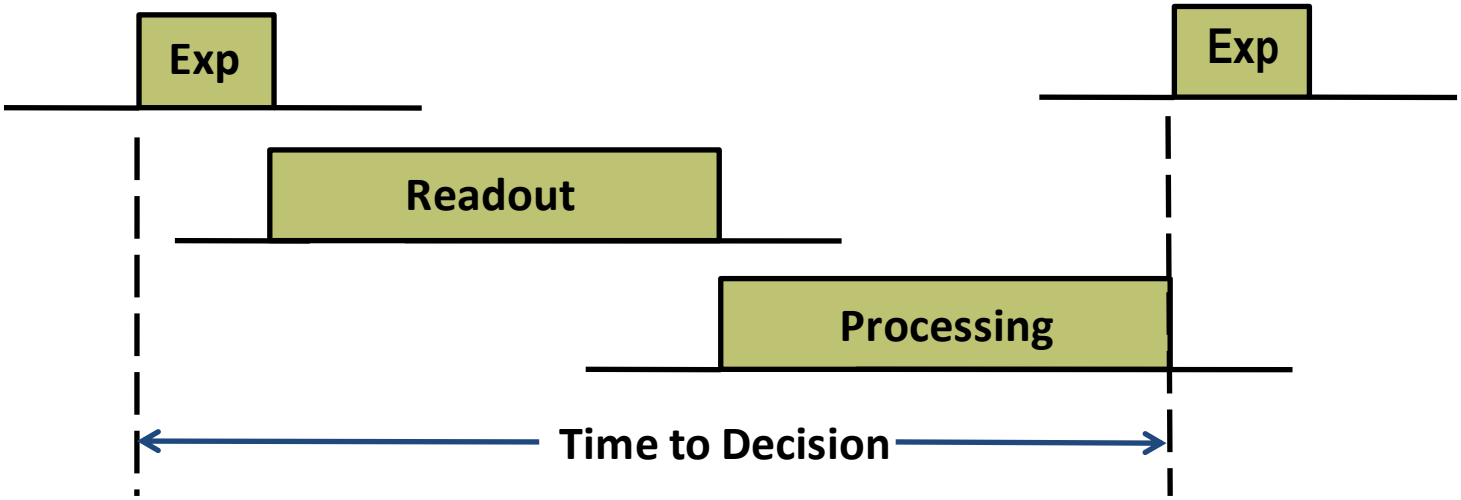


Image Pre-processing

- FPGA is directly in the path of the image data
- Processes pixels as they arrive
- Final image processing handled by the host CPU

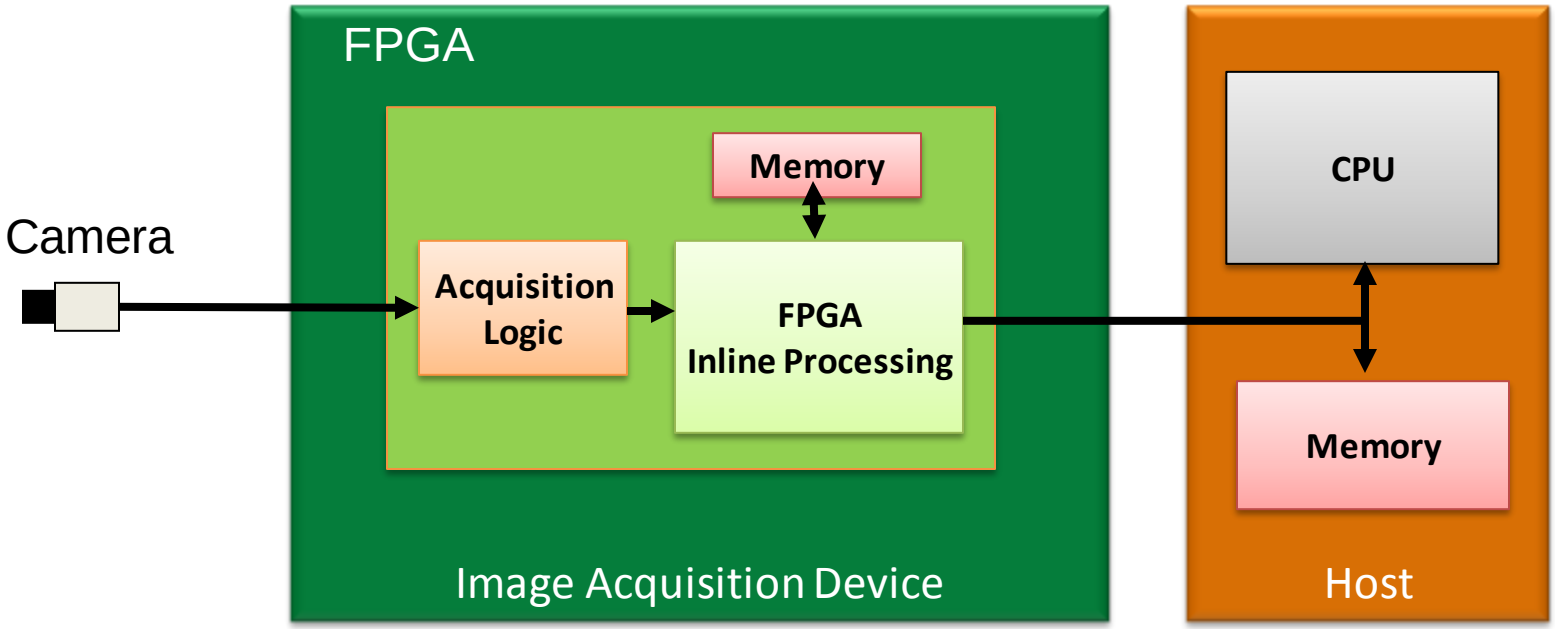
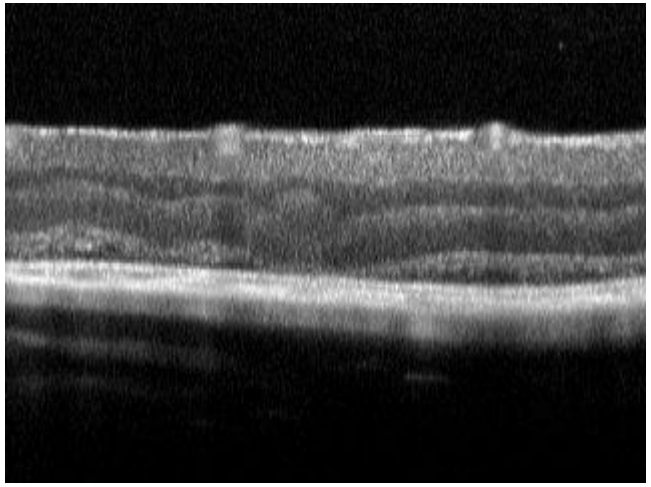


Image Pre-processing

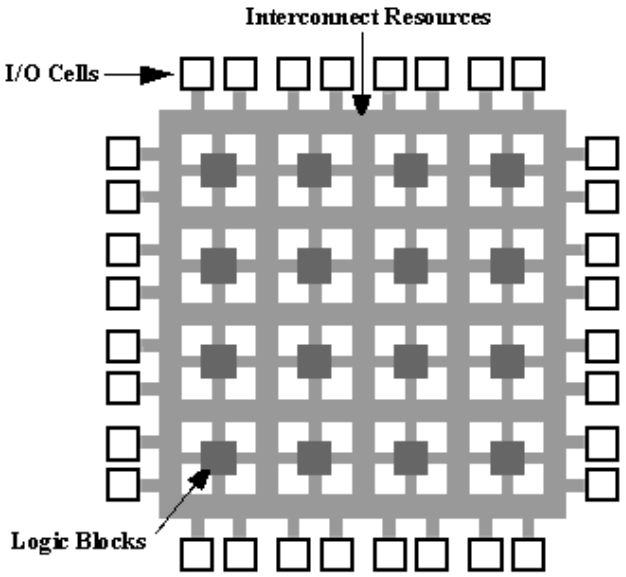
- Optical Coherence Tomography (OCT)
  - Data scaling
  - FFT
  - Logarithmic LUT
  - Image display (host)



- Web and surface inspection
  - Flat field correction
  - Thresholding
  - Particle analysis

FPGAs

- Latency ✓
- Jitter ✓
- Compute power ✓
- Pipelining ✓
- Security ✓
- Weight / Power / Heat ✓
- Complexity ✗
- Raw Clock Rates ✗
- Limited Floating Point support ✗



Starting an FPGA Vision Project

- Create an FPGA value statement
  - What is the value an FPGA is adding?
- Model the algorithm in software
  - Have you chosen the right algorithm?
- Compare FPGA behavior with a bit-accurate software model
  - Have you implemented the FPGA version of the algorithm correctly?

The Embedded Vision Alliance

Free Resources on Embedded Computer Vision

The Embedded Vision Alliance web site, at www.Embedded-Vision.com, covers embedded vision applications and technology, including interviews and demonstrations

Register on the Alliance web site for free access to:

- The Embedded Vision Academy—free in-depth tutorial articles, video "chalk talks," code examples, and discussion forums.
- Embedded Vision Insights—bimonthly newsletter with industry news and updates on new resources available on the Alliance website.

Embedded vision technology and services companies interested in becoming sponsoring members of the Alliance may contact info@Embedded-Vision.com

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- Technical presentations on sensors, processors, tools, and design techniques
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- Cool demonstrations and opportunities to meet with leading vision technology suppliers

Co-located with UBM Electronics' DESIGN West

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The Summit is free, but space is limited. To register to attend, go to www.embedded-vision.com/embedded-vision-summit