

ALL PROGRAMMABLE

ANY MEDIA

5G

4K/8K

ANY STANDARD

ANY MACHINE

ANY NETWORK

5G Wireless • Embedded Vision • Industrial IoT • Cloud Computing



Vision with Precision  
Machine Vision

# Xilinx Vision with Precision Webinar Series

- Monitoring Things: **Machine Vision**
- Perceiving Environment / Taking Action
  - *ADAS and the Road to Autonomous Vehicles*
  - *Drones & Other Vision Guided Robotics*
  - *Augmented, Virtual and Mixed Reality*



Machine Vision



Surveillance



Medical Imaging

Differentiate by Design



# Agenda

- Embedded Vision Market Trends
- Machine Vision Technology Drivers
- Challenges Facing Developers
- Xilinx Machine Vision Solutions

# Enabling Embedded Vision



ADAS, Machine Vision, Surveillance, Drones, Medical, ProAV ...

# Rapid Growth of Vision Systems

## Vision System Shipments



Source: Synopsys, consolidated from multiple sources

# Trends in Embedded Vision



## Embedded Vision



## Ubiquity of Embedded Vision

# Trends in Embedded Vision



## Embedded Vision



## Ubiquity of Embedded Vision



## Intelligence from Machine Learning at the Edge

# Trends in Embedded Vision



## Embedded Vision



## Ubiquity of Embedded Vision



## Intelligence from Machine Learning at the Edge



## Open, High-Level Languages and Frameworks

# Trends in Embedded Vision



## Embedded Vision



## Ubiquity of Embedded Vision



## Intelligence from Machine Learning at the Edge



## Open, High-Level Languages and Frameworks



## Multi-Level Security







# Embedded Vision Momentum



## 24 Million, 3X

ADAS Unit Shipments, Increase (2 Years)

## >80

2016/17 Auto Models Shipping ADAS w/ Xilinx

## >200

Customers Delivering Vision with Xilinx



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## >200

Customers Delivering Vision with Xilinx

## \$100B to \$350B

5 Yr Growth of Vision System Shipments

# >200 Customers Powered by Xilinx

## POWERED BY XILINX

### Camera



>30 Camera Brands

### ADAS



23 Auto Makers, 85 Models

### Industrial



>50 Equipment Manufacturers

### Broadcast



8 Major Broadcasters

### ProAV



>70 Equipment Makers

### Drones



>5 Drone Companies

### VR/AR



8 VR/AR Companies

### Medical



>10 Medical Companies

### Display

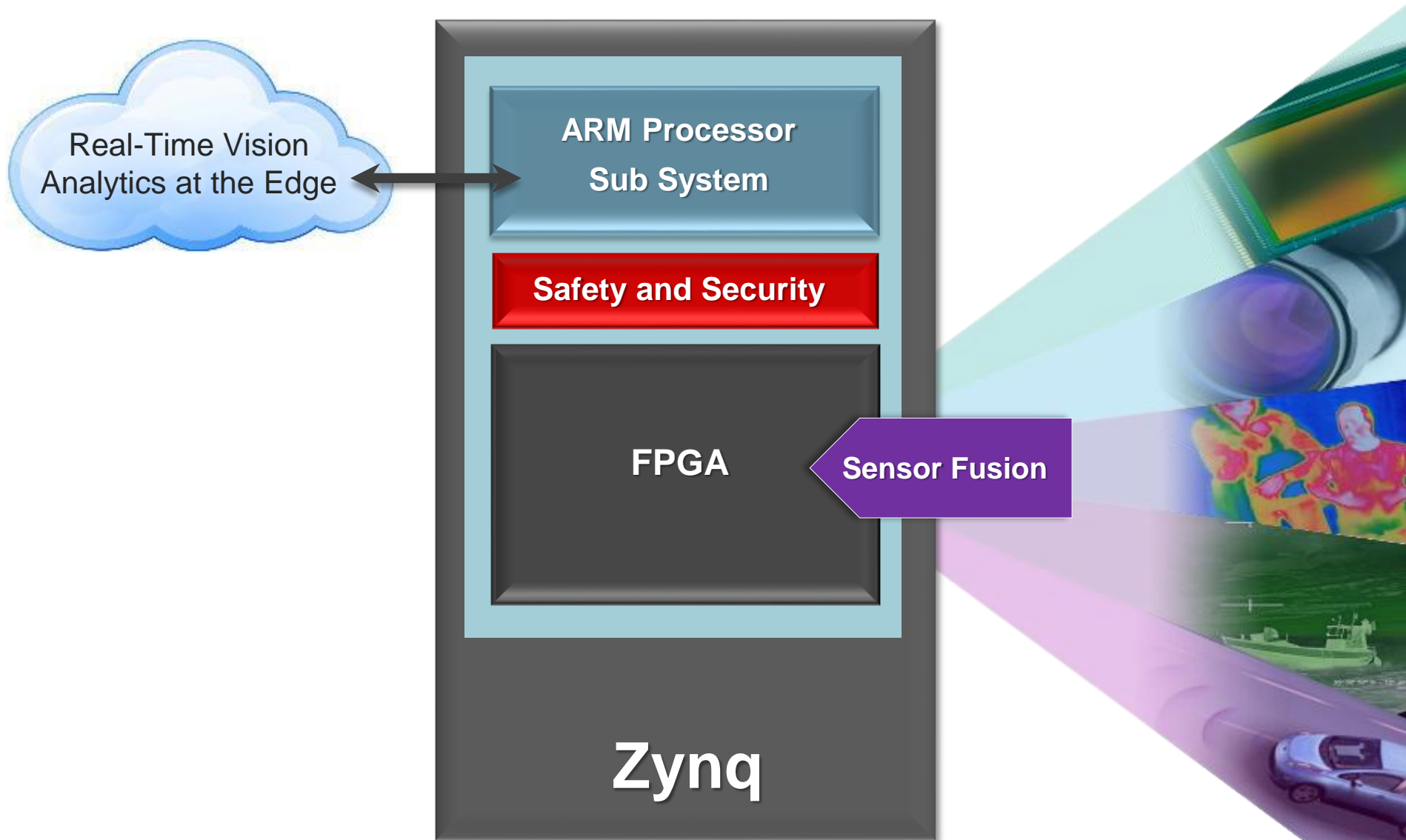


>30 Major Brands

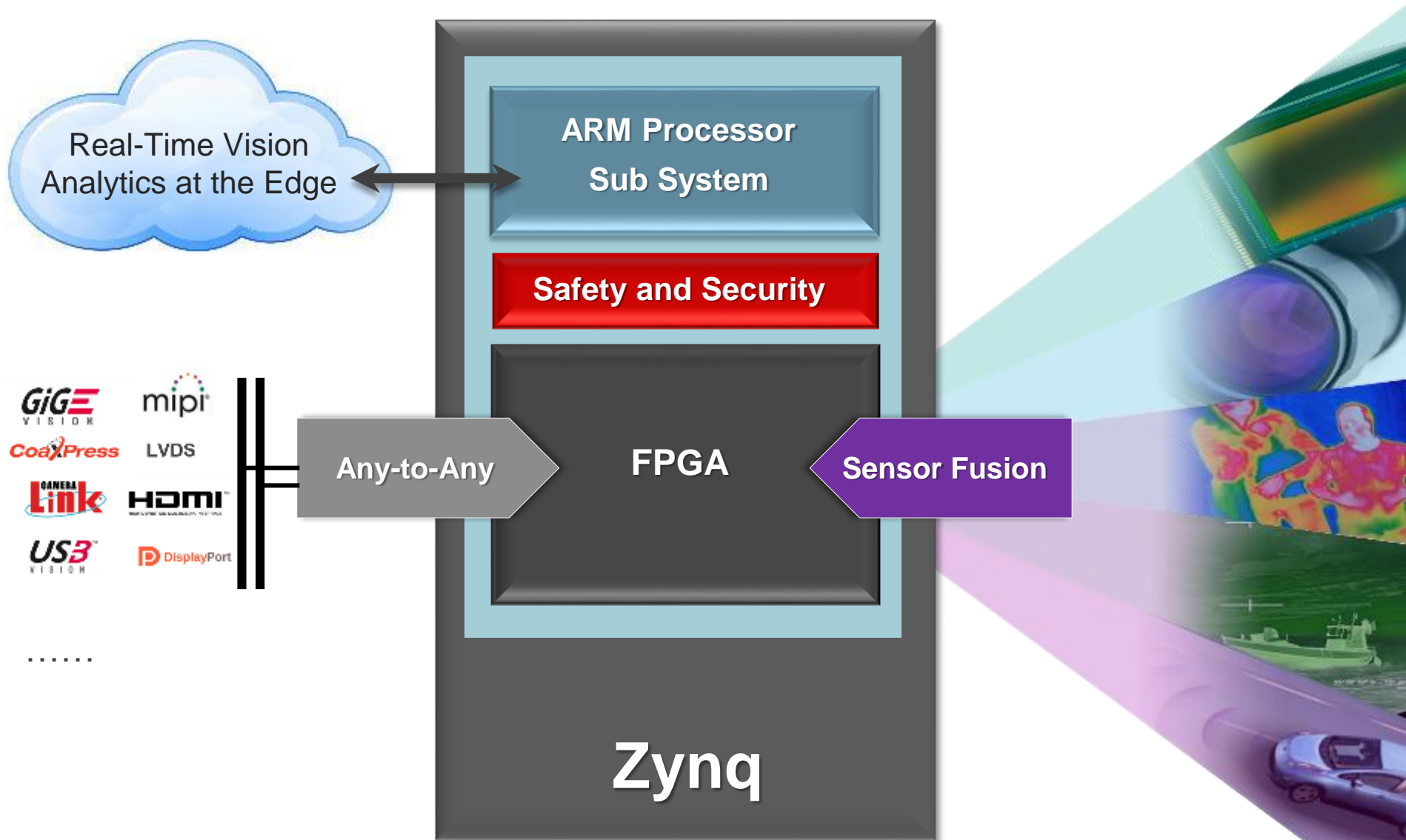
# Best Platform for Embedded Vision



# Best Platform for Embedded Vision



# Best Platform for Embedded Vision





Vision and ADAS

# 5 Differentiating Advantages

"Vision with Precision"

- 1 Real-time Image Recognition and Analytics
- 2 All Programmable Platform Reuse
- 3 Scalable Sensor Fusion
- 4 Highest Performance/Watt
- 5 Only Single Chip Safety and Security



# Machine Vision

# Enabling Rapid Growth of Industrial Vision



# Differentiating Advantages in Machine Vision



## 5 Differentiating Advantages

"Vision with Precision"

- 1 Real-time Image Recognition and Analytics ✓
- 2 All Programmable Platform Reuse
- 3 Scalable Sensor Fusion ✓
- 4 Highest Performance/Watt
- 5 Only Single Chip Safety and Security ✓

- Very high frame rate, recognition and analytics enabled through massive parallelism
- Scalable *sensor fusion* supporting stereo to N vision pipelines & heterogeneous sensors
- Wide variety of IO densities mean unrivaled sensor fusion capabilities
- Only single chip safety and security with support for functional safety and anti-tamper

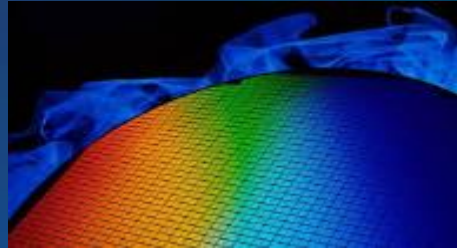
# MARKETS AND APPLICATIONS

## Automotive



Guiding robots, checking parts, identifying codes, inspecting quality, and more

## Semiconductor



Finding defects, tracking lots, and more

## Electronics



Inspecting components, boards, and connectors, verifying solder, tracking lots, and more

Source: Teledyne Dalsa

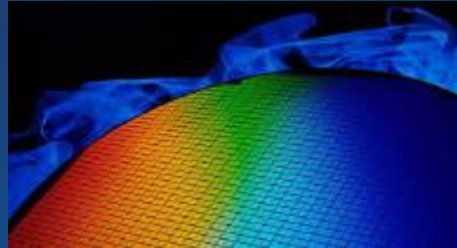
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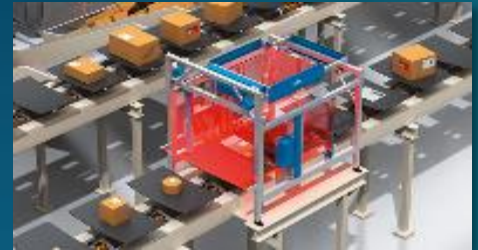
Verifying parts, assemblies and packaged goods

## Solar Panels



Finding cracks and flaws

## Postal/Parcel Sort



OCR, image lift, and more

Source: Teledyne Dalsa

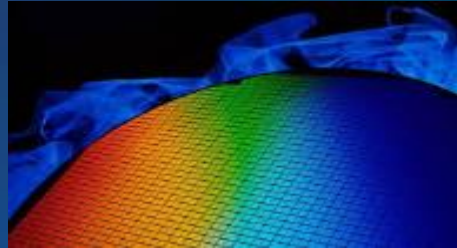
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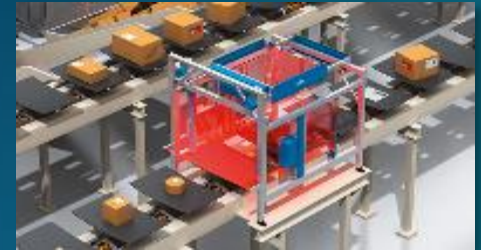
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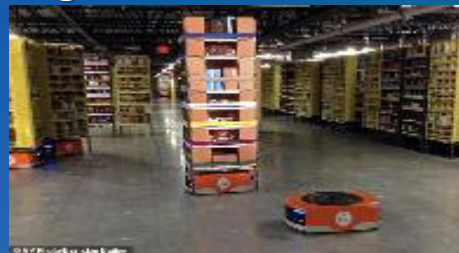
OCR, image lift, and more

## Food & Packaging



Verifying seals, grading products, reading labels, and more

## Logistics/MES



Tracking production parts, reading and verifying product lots and codes

## Industrial X-Ray



Verifying connections, weld quality, and more

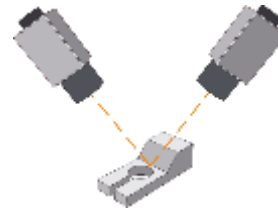
Source: Teledyne Dalsa

# TECHNOLOGY DRIVERS

## Performance

- Higher Quality
- 3D Imaging
- Higher Performance

3D Imaging



Higher Frame Rates

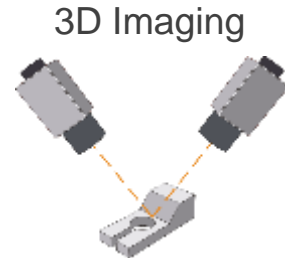


Heterogeneous Sensor Integration

# TECHNOLOGY DRIVERS

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- Higher Quality
- 3D Imaging
- Higher Performance



## Higher Frame Rates

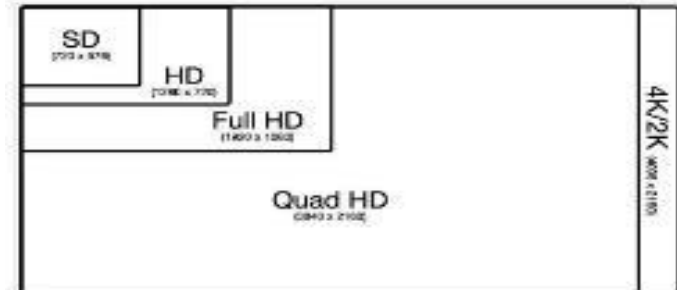


Heterogeneous Sensor Integration

## Resolution

- Increased Resolution
- Higher Speed Connectivity
- Higher Bandwidth

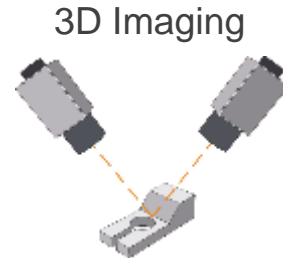
Higher Resolution



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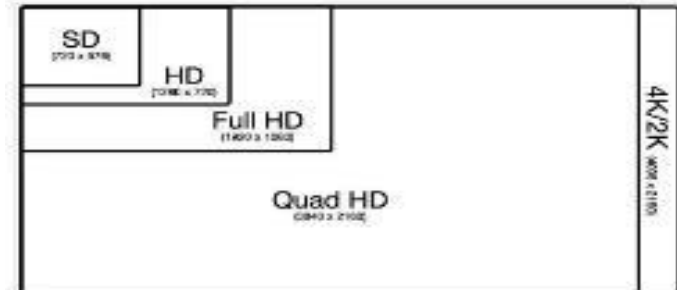


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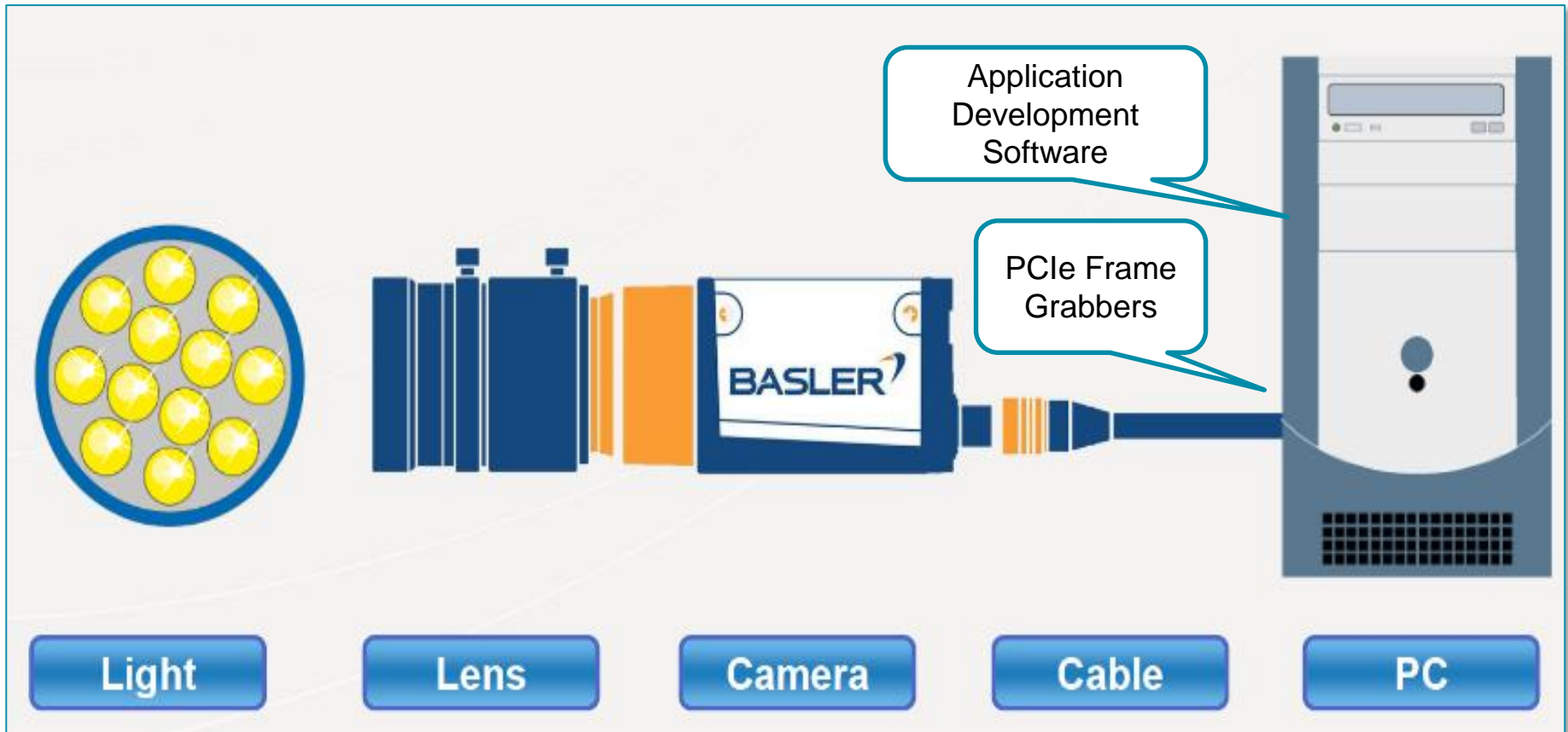
## Economics

- Move to CMOS Sensors
- Smaller Form Factors
- Lower Cost

Smaller Form Factors

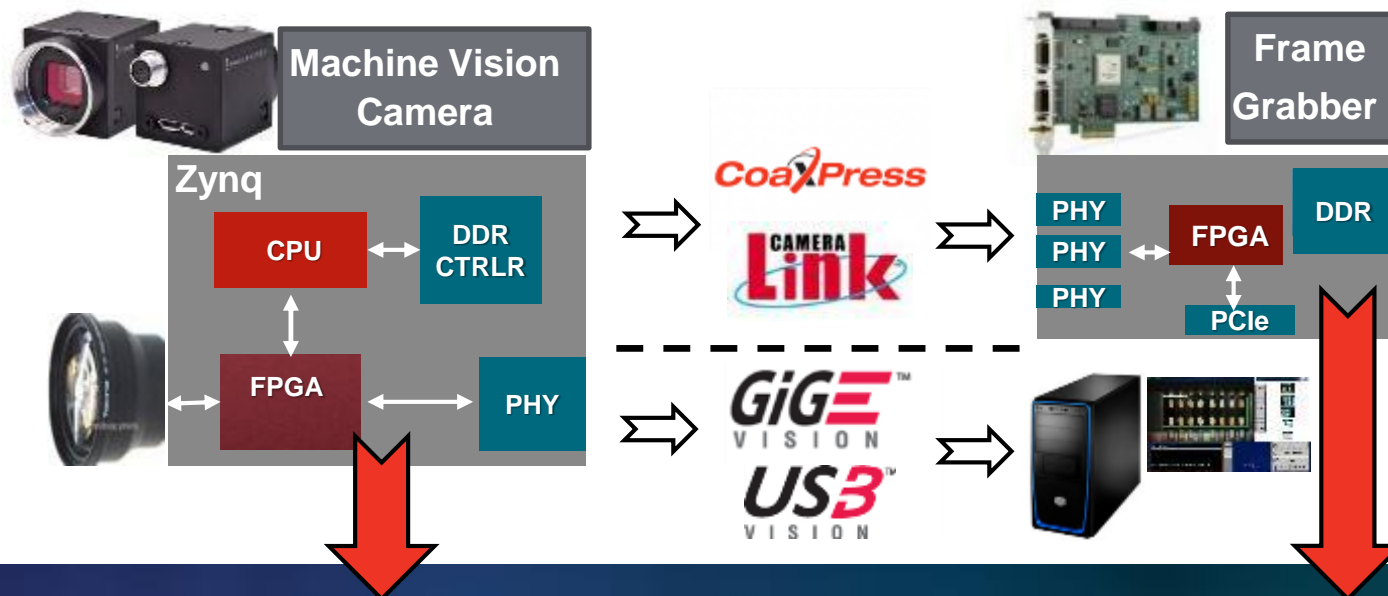


# Machine Vision System Defined



Source: Basler

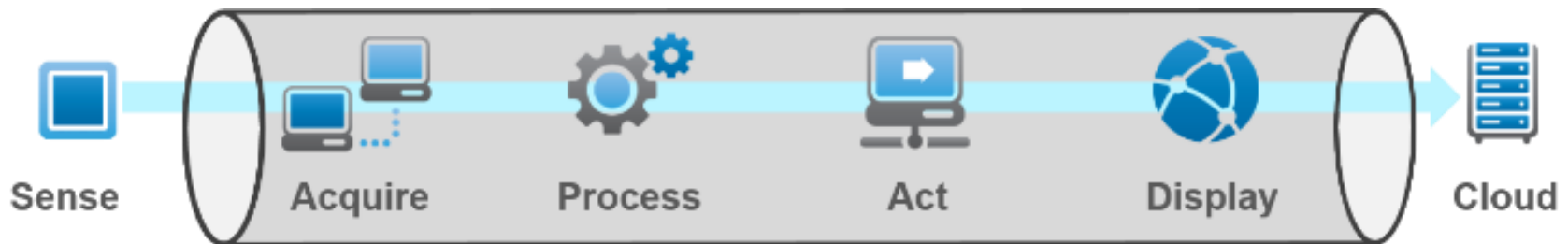
# Ideal Platform for Cameras and Frame Grabbers



| Machine Vision Cameras  | Frame Grabber Cards  |
|---|--|
| <ul style="list-style-type: none"> <li>• Interface to sensor</li> <li>• Pre-processing &amp; Control</li> <li>• Low latency interface</li> </ul>        | <ul style="list-style-type: none"> <li>• High Speed data transfer</li> <li>• Aggregate data (n* Rx) PC card</li> <li>• Image Processing</li> </ul>   |
| <ul style="list-style-type: none"> <li>• 8x8, 10x10, 13x13 pkg size</li> <li>• Low power 28nm, 16nm</li> <li>• All required Interface Tx IPs</li> </ul> | <ul style="list-style-type: none"> <li>• Built-in GT's (PCIe &amp; Interface)</li> <li>• High performance memory</li> <li>• Acceleration support</li> <li>• Machine Vision Interface Rx IPs</li> </ul> |

## Zynq Enables Programmable Platform Reuse

# What is a Typical Image Pipeline



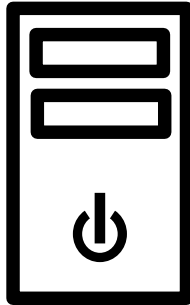
- LVDS
- MIPI

- ISP / Debayer
- Color Space Conversion
- Scaling

- OpenCV / OpenVX
- Deep Learning (xNN)
- Optical Flow
- SLAM
- Stereo Vision

- HDMI
- GigE Vision
- CoaXPRESS
- Camera Link
- USB3
- SDI

# Various Approaches to Machine Vision



## PC-based

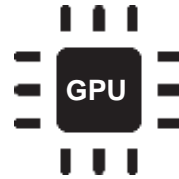
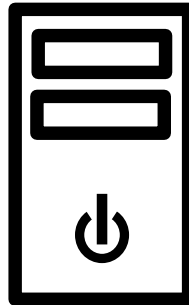
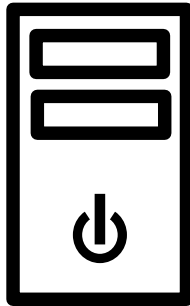
### PROS:

- Easy to deploy
- Large ecosystem
- Software updateable
- Low cost

### CONS:

- Lower performance
- Not as scalable
- Larger footprint
- Power consuming

# Various Approaches to Machine Vision

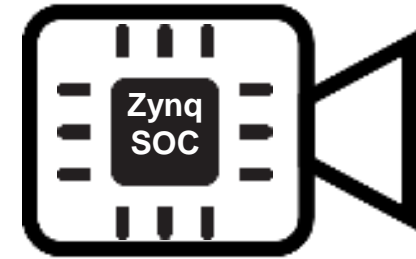
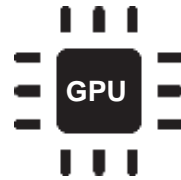
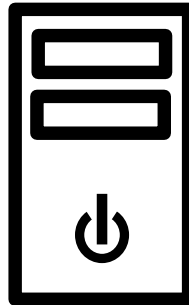
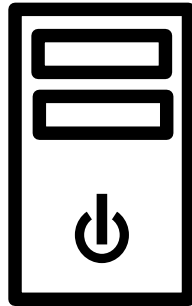


**PROS:**

|              | PC-based   | GPGPU Accelerated   |
|--------------|--|---|
| <b>PROS:</b> | <ul style="list-style-type: none"><li>• Easy to deploy</li><li>• Large ecosystem</li><li>• Software updateable</li><li>• Low cost</li></ul>        | <ul style="list-style-type: none"><li>• Same as PC-based</li><li>• Higher performance</li><li>• Rapid prototyping of algorithms</li></ul> |
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**CONS:**

# Various Approaches to Machine Vision

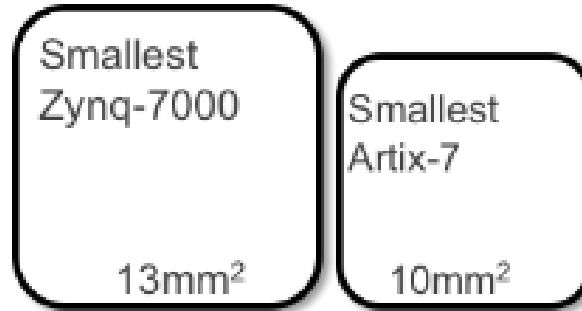


**PROS:**

|              | PC-based  | GPGPU Accelerated   | Zynq SoC  |
|--------------|---|---|---|
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Zynq Offers Highest Performance/Watt

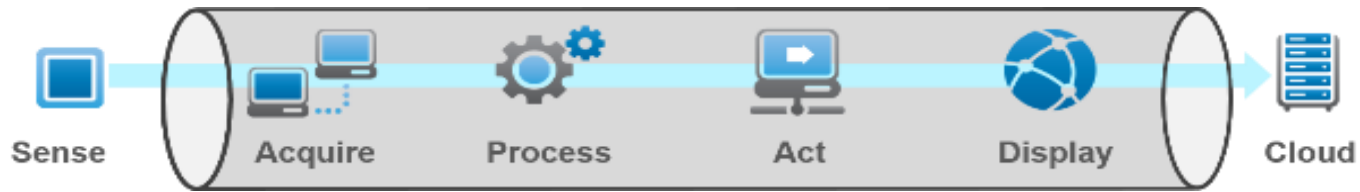
# Good Things Come in Small Packages




- Form factors continue to shrink with cameras approaching 29mm<sup>2</sup>
- Xilinx offers the smallest and lowest power All Programmable SoCs
- Competitors smallest SoC is 19mm<sup>2</sup>
- Zynq-7000 SoC is up to 30% lower power than competitor
- Size, performance and power are key FOMs in designing MV systems

## Clear SWAP-C Advantages with Zynq

# The Xilinx Embedded Vision Ecosystem



## EMBEDDED SYSTEMS ECOSYSTEM FOR VIDEO / VISION

| Sensor Processing  | Video Processing  | Analytics CV / xNN   | Codecs   | Connect  |  |  |  |  |  |
|--|---|--|--|--|--|--|--|--|--|
| <br> | <br><br> | <br><br> | <br><br><br> | <br><br><br> |  |  |  |  | <br><br><br> |
|  |   |  |  | <br><br><br> |  |  |  |  |  |

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|-------------------|------------------|--------------------|--------------|--------------|
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## DESIGN ENABLEMENT

# The Xilinx Embedded Vision Ecosystem



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|-------------------|------------------|--------------------|--------------|--------------|
| <br>              | <br><br>         | <br><br>           | <br><br><br> | <br><br><br> |

## DESIGN ENABLEMENT

## MODULES & BOARDS

Evaluation Boards

Production Ready SOMS

# The Xilinx Embedded Vision Ecosystem



## EMBEDDED SYSTEMS ECOSYSTEM FOR VIDEO / VISION

| Sensor Processing | Video Processing | Analytics CV / xNN | Codecs       | Connect      |
|-------------------|------------------|--------------------|--------------|--------------|
| <br>              | <br><br>         | <br><br>           | <br><br><br> | <br><br><br> |

### DESIGN ENABLEMENT

Logos for design enablement partners: National Instruments, OpenCV, MathWorks, SiliconSoftware (speed up your business), TOPIC EMBEDDED SYSTEMS, VIVADO Hx Editions, and SDSoc Environment.

### MODULES & BOARDS

Evaluation Boards

Production Ready SOMS

Logos for production ready SOMS: ALPHA DATA, ENCLUSTRA, AVNET, Nextera Video, DAVE Embedded Systems, MYR, fidus, DIGILENT, iveia, and trenz electronic.

### DESIGN SERVICES

Logos for design services partners: fidus, OKI, FUJITSU, LogicBRICKS (Designed by XYLON), HCL, Ae Technologies, Omnitek, TOPIC EMBEDDED SYSTEMS, inrevium, DDC, iveia, Adea, CoreEL, and Knowledge Embedded Systems.

# Many Ways to Realize Your Machine Vision System



- Model-Based Design with MATLAB® and Simulink® reduces hw/sw codesign
- Vision HDL Toolbox™ provides pixel-streaming algorithms for design and implementation on FPGAs and Zynq SoCs

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- Xilinx's software defined environment for Zynq
- Numerous Zynq-based target hardware with available BSPs
- OpenCV library support through Auviz Systems

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- Smart Vision Development Kit
- Sensor to Image connectivity
- Halcon runtime for Machine Vision Applications
- Visual Applets for algorithm development

# The SDSoC Development Environment

SDSoC<sup>™</sup>  
Environment

C/C++ Development

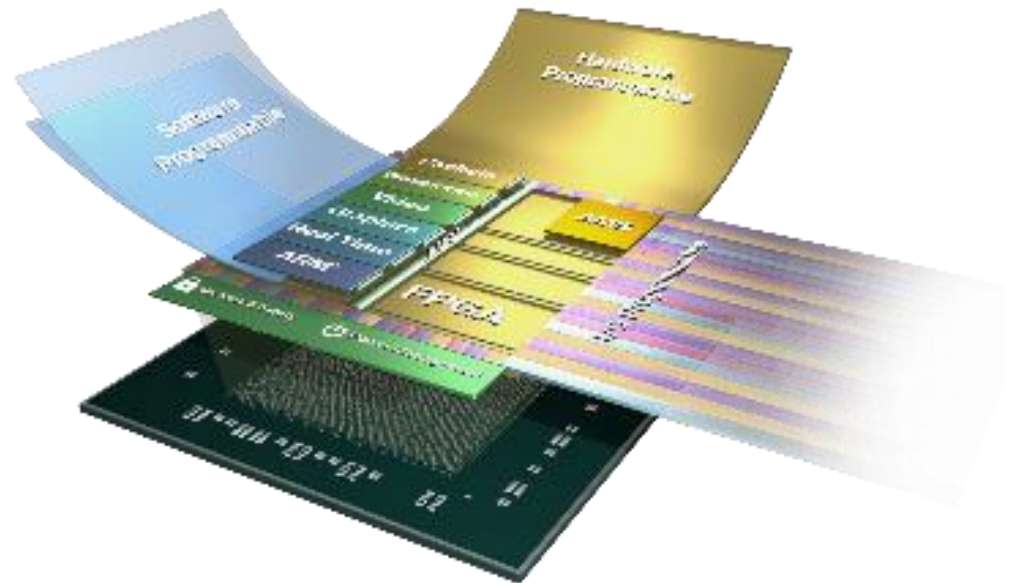
System-level Profiling

Specify C/C++ Functions  
for Acceleration

Full system  
Optimizing Compiler

Rapid System  
Level  
Performance  
Estimation

- ASSP-like programming experience
- System-level profiling
- Full system optimizing compiler
- Expert use model for platform developers and system architects



ZYNQ<sup>®</sup>  
SoC

ZYNQ<sup>®</sup>  
MPSoC

# Machine Vision Solution Stack



## Hardware Platform

- Smart vision development kit

# Machine Vision Solution Stack



## Connectivity IP

- Standard connectivity, e.g. GigE Vision



## Hardware Platform

- Smart vision development kit

# Machine Vision Solution Stack



## Vision Processing Design Environments

- C/C++ or Visual Programming



## Connectivity IP

- Standard connectivity, e.g. GigE Vision



## Hardware Platform

- Smart vision development kit

# Machine Vision Solution Stack

**HALCON**  
the power of machine vision

## Machine Vision Application Stack

- ARM targeted MV software and IDE

SDSoC Environment  
SiliconSoftware speed up your business  
NATIONAL INSTRUMENTS™ LabVIEW™  
MathWorks®

## Vision Processing Design Environments

- C/C++ or Visual Programming

sensor to image

## Connectivity IP

- Standard connectivity, e.g. GigE Vision

**AVNET**®

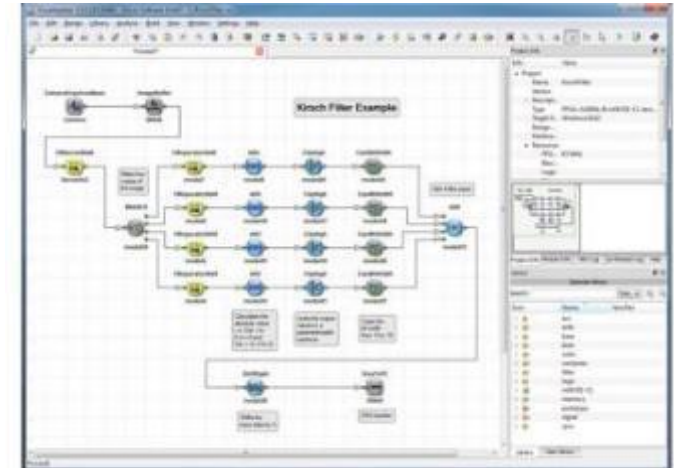
## Hardware Platform

- Smart vision development kit

# Ecosystem Tools to Accelerate Development

## ➤ VisualApplets – SiliconSoftware

- Graphical programming toolkit for image processing
- Structured object-based design; no RTL coding needed!
- Exclusive to Xilinx devices
- Simulate in seconds



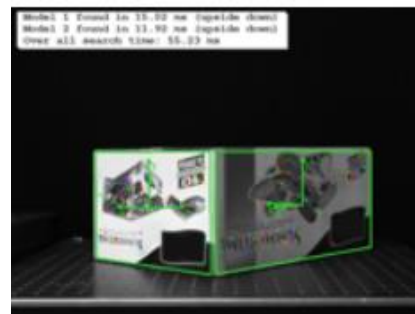
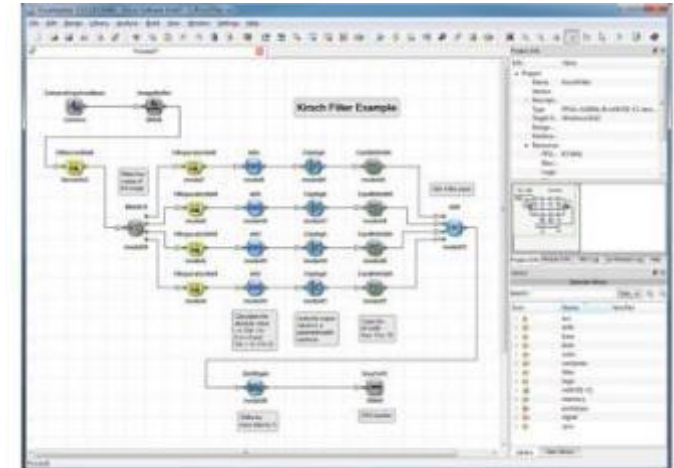
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## ➤ HALCON - MVTec

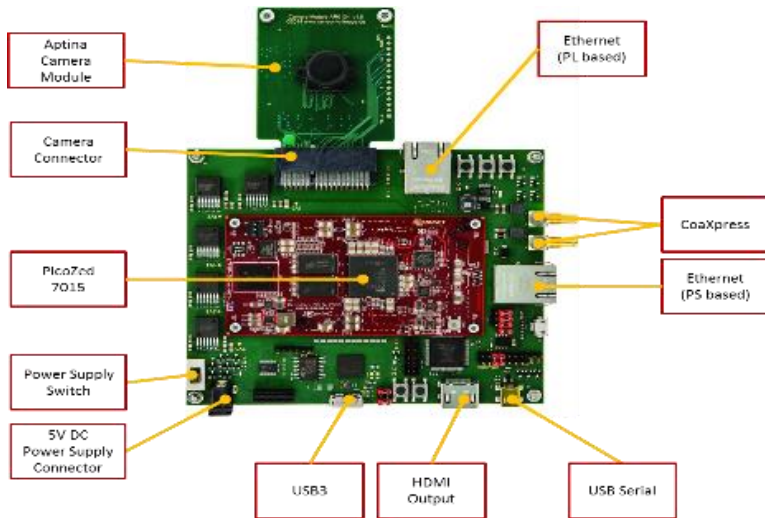
- Application software that runs on Linux
- Targets machine vision processing
- OCR, bar code, object analytics, measurement
- HALCON embedded on Zynq available



the Power of Machine Vision



# Smarter Vision Development Kit (SVDK)



## What's Included

- ✓ Universal Power Adapters
- ✓ Mini-USB-B to USB-A cable
- ✓ Ethernet cable
- ✓ Vivado Design Edition – Device Locked
- ✓ Documentation and reference designs

| Components        | Details   |
|-------------------|---|
| Hardware          | <ul style="list-style-type: none"> <li>• Zynq-7015 SOM (From Avnet)</li> <li>• Machine Vision carrier board</li> <li>• Aptina 1.2MP Image sensor board</li> </ul> |
| Software          | <ul style="list-style-type: none"> <li>• Evaluation of Embedded VisualApplets</li> <li>• Evaluation of HALCON</li> <li>• Evaluation of Vivado HLS</li> </ul>      |
| IP                | <ul style="list-style-type: none"> <li>• Evaluation of GigE Vision, CameraLink,</li> <li>• Evaluation of CXP, USB3.0</li> </ul>                                   |
| Reference Designs | <ul style="list-style-type: none"> <li>• Image Processing SW vs. HW benchmark</li> <li>• Various machine vision protocols</li> </ul>                              |

# Software Availability and Support

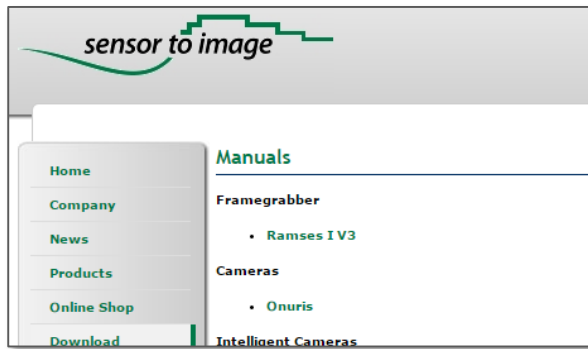


| HALCON Software       | Action        |
|-----------------------|---------------|
| Trial Version on SVDK | Download Free |
| Evaluation Version    | Download Free |
| Production Version    | Contact MVTec |



| Embedded VisualApplets | Action                   |
|------------------------|--------------------------|
| Demo Version on SVDK   | Download Free            |
| Evaluation Version     | Contact Silicon Software |
| Production Version     | Contact Silicon Software |

# IP Availability and Support



## What's Included (After Registration)

- ✓ GigE Vision IP firmware programmed default on SVDK
- ✓ USB3 Vision & CoaXPress IP firmware available
- ✓ Reference Design (GigE Vision, USB# Vision, CoaXPress)
- ✓ Schematics
- ✓ Layout

| Connectivity IP  | Action                         |
|--|--------------------------------|
| <b>Demo Version on SVDK</b> <ul style="list-style-type: none"><li>• 30 minute time bombed</li></ul>  | <b>Download Free</b>           |
| <b>Production Version</b> <ul style="list-style-type: none"><li>• Standard licensing variants and cost</li><li>• Services around GigE, CXP and U3V</li></ul> | <b>Contact Sensor to Image</b> |

# Smarter Vision Development Kit Resources



## What's Included

- ✓ SVDK Quick Start Card
- ✓ SVDK Getting Started Guide
- ✓ SVDK Hardware User Guide
- ✓ FAQs

## Getting Started Reference Designs

- ✓ SVDK GigE Vision
- ✓ SVDK USB3 Vision

# Conclusion

- The Embedded Vision market is fast growing
- Performance, resolution and economics driving machine vision
- Sensor fusion and real time analytics advances state of the art
- Address multiple markets with All Programmable platform reuse
- Accelerate your next machine vision project with...
  - Avnet SSDK; Silicon Software; Halcon and Sensor to Image
  - The MathWorks
  - National Instruments LabVIEW
  - Xilinx SDSoC

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