Imaging Trends for 2019 and Beyond

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Agenda

- Machine Vision Standards
- Evolution of MV camera interfaces
- Where will it go?
- Trends in 2D sensors
Machine Vision Standard

Year of Introduction

Machine Vision Interfaces

2 different approaches

No Frame Grabber Required

Require additional Hardware (Ex: Frame Grabber)

MV Standards based on industry standard hardware components
Machine Vision camera Interfaces

Current options
...Faster options in 2019 & beyond

Frame Grabber required

Custom Hardware

Add-on Card / On-board connection

- **Camera Link**
  - Base CL
  - 10-taps
  - 6.25Gbps / Lane (4x)
  - 12Gbps / Lane (4x)
  - With AOC

- **mipi**
  - CSI-2 D-PHY 2.5Gbps / lane (1 lane)
  - CSI-2 D-PHY 2.5Gbps / lane (up to 4)
  - CSI-2 A-PHY 12 to 24 Gbps / lane

- **GiGE Vision**
  - 2.5GiGE Vision
  - 5GiGE Vision
  - 10GiGE Vision
  - 25 GiGE Vision
  - 50 GiGE Vision

- **USB Vision**
  - 3.1 Gen 1 (5Gbps)
  - 3.1 Gen 2 (10Gbps)

- **New speed grades for the current standards**

- 115MB
- 350MB
- 595MB
- 850MB
- 1.0GB
- 1.1GB
- 2.4GB
- 3.1GB
- 4.8GB
- 6.2GB
- Over 4.8GB

Ref: https://www.visiononline.org/vision-standards.cfm
Machine Vision Camera Interfaces

Ideal for
High Data Throughput

- USB3 Vision
  - 3.1 Gen 2 (10Gbps)
- CSI-2
  - CSI-2 A-PHY
  - 2.5Gbps / lane
- CXP
  - 6.25Gbps / Lane

Ideal for
Multi-camera System and/or Distance

- USB3 Vision
  - 3.1 Gen 1 (5Gbps)
- CXP
  - 12Gbps / Lane
- 10Gbps Vision
- 5Gbps Vision
- 1Gbps Vision

Cable Distance (copper)

1M 10M 15M 35M 50M 100M
Machine Vision Camera Interfaces

Performance vs. Total System Cost

Total system cost includes: Camera architecture (sensor, FPGA type, etc.), Acquisition card and cable(s) cost

Bandwidth: Ref: https://www.visononline.org/vision-standards.cfm
Additional detail on the Machine Vision Interfaces in 2019 and beyond
<table>
<thead>
<tr>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoaXPress v2.0</td>
</tr>
<tr>
<td>2.5 / 5 GigE Vision</td>
</tr>
<tr>
<td>25 GigE Vision</td>
</tr>
<tr>
<td>Mipi CSI-2 APHY</td>
</tr>
<tr>
<td>Future of GigE Vision ...</td>
</tr>
</tbody>
</table>
The CoaXPress digital interface was developed for high speed image data transmission for machine vision applications.

CoaXPress uses 75 Ω coaxial cable as a physical medium (up to 4 cables typically).

CoaXPress is hosted by the Japan Industrial Imaging Association (JIIA).

- **CXP Standard v2.0 added 2 new speed grades**
  - CXP-12 : 12Gbps lane(s) and CXP-10 : 10Gbps lane(s)

- **New connector types (u-BNC) are required to support 10/12Gbps**
  - Older CXP frame grabbers are not compatible to these new faster speeds

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http://www.coaxpress.com/roadmap/
What is **NBASE-T®**?

The NBASE-T Alliance℠ is the worldwide network of companies that breathe new life into network infrastructure.

**NBASE-T™ technology:**
- new type of Ethernet signaling
- x5 faster than GigE Vision,
- up to 100m cables,
- low cost of ownership
**GiGE VISION 2.5 / 5Gbps Ethernet**

Is 5Gbps part of the GiGE Vision standard? **YES**

- GigE Vision Standard v2.0 was updated to cover all Ethernet speeds from ...

  - from 10Mbps to any future “speed grade” added by the IEEE

Is this compatible with today’s machine vision application software?

- **YES**, the vast majority of Machine Vision Software is compatible to standard Ethernet Stack.

  - Only adding a new NIC card (and driver) is required.
**GiGE VISION 2.5 / 5Gbps Ethernet**

What can I expect in terms of cable length?

<table>
<thead>
<tr>
<th>Bundled cabling length</th>
<th>Category 5e</th>
<th>Category 6</th>
<th>Category 6A</th>
</tr>
</thead>
<tbody>
<tr>
<td>0m to 50m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5GBASE-T</td>
<td></td>
<td></td>
<td>Assured</td>
</tr>
<tr>
<td>5GBASE-T Assured</td>
<td></td>
<td></td>
<td>Assured</td>
</tr>
<tr>
<td>50m to 75m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5GBASE-T</td>
<td></td>
<td></td>
<td>Assured</td>
</tr>
<tr>
<td>5GBASE-T Assured</td>
<td></td>
<td></td>
<td>Assured</td>
</tr>
<tr>
<td>75m to 100m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5GBASE-T</td>
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<tr>
<td>5GBASE-T Assured</td>
<td></td>
<td></td>
<td>Assured</td>
</tr>
</tbody>
</table>

**ALSNR Risk**

- High
- Medium
- Low

**Ref** : NBASE-T Performance and Cabling Guidelines  [www.nbaset.org](http://www.nbaset.org)
GiGE VISION 2.5 / 5Gbps Ethernet

with TURBODRIVE

BY TELEDYNE DALSA

Break through the GigE limit.

TurboDrive technology allows Genie Nano to transfer full image quality at faster frame rates – with no changes to your GigE network.

» Proprietary patent technology
» Does not affect image integrity (in Lossless mode)
» Could slightly affect image quality (in Lossy mode) but can guaranty bandwidth

Download TurboDrive Primer
Get the in-depth technical details on how TurboDrive works.

Download the primer now

Frequently Asked Questions
Get answers to the most common TurboDrive questions.

Read the FAQ

TurboDrive Calculator
See how TurboDrive can increase your performance in the real world. Analyze your own images to see what sort of performance improvements are possible with TurboDrive.

Sample images included. Requires Microsoft Windows 7 or higher.

Download TurboDrive Calculator

https://www.teledynedalsa.com/turbodrive/
GigE Vision 25Gbps Ethernet

ABOUT THE CONSORTIUM

The 25 Gigabit Ethernet Consortium is an open organization to all third parties who wish to participate as members to enable the transmission of Ethernet frames at 25 or 50 Gigabit per second (Gbps) and to promote the standardization and improvement of the interfaces for applicable products. The 25 Gigabit Ethernet Consortium enables industry participants to develop new technologies that function in accordance with the Specification(s) outlined in the consortium agreement in order to benefit consumers and the industry by facilitating accelerated adoption of 25 and/or 50 Gbps technologies.

- Specification for 25G was released in 2016
- NIC are available today from Mellanox
- FPGA are available from Xilinx
- Cable available using SFP28 connector
- Quad cable using QSFP28 connector (for 50 / 100Gbps)

https://25gethernet.org/
About MIPI Alliance

MIPI is a global, collaborative organization founded in 2003 that comprises 300+ member companies spanning the mobile and mobile-influenced ecosystems.

MIPI’s focus has always been on mobile. In fact, every smartphone on the market today has at least one MIPI specification.

With the development of new mobile-influenced markets, you can now find MIPI specifications in a variety of products:
CSI-2 interface

A widely adopted, simple, high-speed protocol primarily intended for point-to-point image and video transmission between cameras and host devices

Quick Facts

Advantages

- Widely used in mobile devices and automotive applications

Fundamental features

- High performance
- Low power
- Low EMI

Physical Layer

- MIPI D-PHY and/or MIPI C-PHY

Use Cases

- Imaging
- Vision
- Contextual awareness
- Biometric recognition
- Surveillance

Industries

- IoT
- Car
- Tablet
- Mobile

Overview

MIPI CSI-2℠ is the most widely used camera interface in the mobile industry. It has achieved widespread adoption for its ease of use and ability to support a broad range of high-performance applications, including 1080p, 4K, 8K and beyond video, and high-resolution photography.

https://www.mipi.org/specifications/csi-2
## CSI-2 interface

### CSI-2 v1.3 (2014)

<table>
<thead>
<tr>
<th>Performance</th>
<th>C-PHY: 5.7 Gbps over 3 wires (scalable)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Embedded clock and data</td>
</tr>
<tr>
<td></td>
<td>D-PHY: 2.5 Gbps over 4 wires (scalable)</td>
</tr>
<tr>
<td></td>
<td>Forwarded differential clock coupled to data</td>
</tr>
<tr>
<td>Virtual Channels</td>
<td>4 Tandem Multiple Exposures / Data Formats</td>
</tr>
<tr>
<td>Command</td>
<td>Bidirectional I2C FM Compatible Commands</td>
</tr>
</tbody>
</table>

### CSI-2 v2.0 (2017)

<table>
<thead>
<tr>
<th>Performance</th>
<th>C-PHY: 8 Gbps over 3 wires (scalable)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Embedded clock and data</td>
</tr>
<tr>
<td></td>
<td>D-PHY: 4.5 Gbps over 4 wires (scalable)</td>
</tr>
<tr>
<td></td>
<td>Forwarded differential clock coupled to data</td>
</tr>
<tr>
<td>Virtual Channels</td>
<td>Extended Tandem Multiple Exposures / Data Formats</td>
</tr>
<tr>
<td></td>
<td>[C-PHY: 32]</td>
</tr>
</tbody>
</table>

[https://www.mipi.org/specifications/csi-2](https://www.mipi.org/specifications/csi-2)
Physical layer specification (up to 15m) advancing autonomous driving and other automotive applications

Quick Facts

Key Highlights
- Targeted for autonomous driving systems (ADS), advanced driver assistance systems (ADAS) and other surround sensor applications
- Enabling lidar, radar and camera integration for autonomous driving
- Functional safety support
- Also well-suited for Internet of Things (IoT), industrial and other applications

Fundamental Features
- 12-24 gigabits per second (Gbps)
- Asymmetric data link layer
- Wiring, cost and weight optimization
- High-speed data, control data and optional power share the same physical wiring
- Point-to-point topology
- Reuses generations of mobile protocols
- Low electromagnetic interference (EMI)

Use Cases
- ADS
- ADAS
- Human machine interfaces (HMI)
- In-vehicle infotainment (IVI)
- In-vehicle data recorders (black boxes)

Industries
- Car
- IoT

Versions
- Current Version:
  In development, targeted for late 2019

https://mipi.org/specifications/a-phy
The Future of GigE Vision

Is there a path for faster link in GigE Vision?

➤ YES

Let’s see what else exist in the Ethernet world...
GigE Vision 50Gbps Ethernet
On Single-Lane

What’s next in Highspeed Ethernet.

50 Gb/s, 100 Gb/s and 200 Gb/s Ethernet
IEEE P802.3cd Task Force

The IEEE P802.3cd Task Force will develop the new 50Gbps Ethernet rate as well as a set of PHYs for 50 GbE, 100 GbE and 200 GbE that can cost-effectively leverage common 50Gbps optical and electrical signaling technologies.

The creation of 50Gbps single-lane signaling was the catalyst for the creation of the IEEE P802.3cd project.

The timeline for completion of IEEE P802.3cd 50Gbps Ethernet was the first half of 2018…

➢ Released on 2018-12-05
200 / 400Gbps Ethernet

Extreme High speed Ethernet.

200 Gb/s and 400 Gb/s Ethernet IEEE P802.3bs Task Force

The IEEE P802.3bs 400GbE project includes the definition of the new rate of 200 GbE and 200Gbps single-mode fiber PHYs within its scope.

✓ The work of the IEEE P802.3bs Task Force completed with the approval of IEEE 802.3bs-2017 by the IEEE-SA Standards Board on December 2017
Current Trends in 2D CMOS Sensors
Current Trends in 2D CMOS Sensors

- Increasing resolution:
  - More in the 25 to 150+ MPixels range

- Greater bandwidth
  - From ~10Gbps to 60Gbps

- More sensor with MIPI interface option
  - CSI-2 d-phy type (current offer at low speed)

- More “filter” options in CMOS chip
  - Hyperspectral
  - Multispectral (including RGB-NIR)
  - Polarization
On-sensor Polarization
On-sensor Polarization

SONY Polarsens
Sony IMX250MZM
5.1 M Pixels

Teledyne Imaging
Everywhere you look
On-sensor Polarization

A shorter distance between the polarizer and the photodiode improves the extinction ratio and the incident angle dependence.

On-Glass Polarization

Vs.

On-Sensor Polarization
On-sensor Polarization

Improved Extinction Ratio

The ratio of the polarization component over the reflection component
On-sensor Polarization

What can it do for MV applications?
Surface inspection

Example: Missed spot of Black Paint on Black Anodized Metal
Enhancement
Recognizing dark objects in low contrast
Enhancement

Highlighting the depth of object to inspect
Shape recognition
Stress points

...and much more
What’s next?
Color version of the current 5.1M sensor

Sony IMX250MYR
COLOR Quad Polarized Sensor

Resolution : 5.1M
Pixel size : 3.45 um

https://www.sony-semicon.co.jp/products_en
Thank you ...