Overview

- XIMEA Quick Intro
- Multi-camera Applications
- Technologies to Build a Multi-camera System
- Advantages of PCI Express as an Interface
- Multi-camera System Architecture Based on XIMEA’s PCIe Components
- Examples of Multi-camera systems and Performance
XIMEA Quick Intro
XIMEA Quick Intro

• Versatile camera manufacturer for more than 25 years
• Recognized as an innovator in machine vision and imaging markets
• Located in Germany, Slovakia and USA
• 50% standard and 50% custom/OEM products:
  • Sensor resolutions from VGA to 50 Mpix
  • Frame rates up to 3500 fps
  • API/SDK support for variety of operating systems and hosts
  • Multiple interfaces, short/medium/long distances
  • Extremely compact camera arrangements
  • Aggregation of data from multiple imagers into a single cable
Multi-camera Applications and Technologies
Multi-camera Arrangements

• Inside-out
  • Ozo, Cyclomedia
• Outside-in
  • Stadiums, 3D scanning, Photogrammetry
• Array
  • Lytro
• Cluster - multiple groups of a few cameras each
  • ir-ltd, several groups of 3-4 cameras
Multi-camera Applications

• A few cameras: 2…6 cameras
  • Factory automation
  • UAV payloads
  • Stereo vision, face/motion capture
Multi-camera Applications

- Several cameras: **5…12 cameras**
  - Cyclorama imaging
  - ADAS
  - 360° spherical imaging

Nokia Ozo
Multi-camera Applications

- Multiple cameras: **12…50+ cameras**
  - Sports, goal lines, ball trajectories
Multi-camera Applications

- Multiple cameras: $12\ldots50+$ cameras
  - 3D scanning rigs and photogrammetry

© USC, Institute for Creative Technologies
Multi-camera Applications

- Multiple cameras: **12…50+ cameras**
- AR/VR capturing
Typical Multi-camera Application Requirements

• Camera resolutions 3 to 50 Mpix, and more
• Number of cameras per system from 2 to more than 100
• Frame rates per camera from 10 fps to 240 fps and even higher
• Distance between cameras and the host from few centimeters to hundreds of meters
• Triggering and synchronization:
  • Master-slave
  • External, genlock
Architecture Challenges of Multi-camera Deployment

• Delivery of data from multiple high-end cameras to processor
  • Multi-gigabit data rates
  • Multiple cables, multiple interface cards/controllers
  • Bottlenecks and congestions in the PC host infrastructure
• High-bandwidth storage for real-time recording
  • E.g. 120x 12 Mpix cameras @ 60 fps requires >86 GB/s bandwidth!!!
• In some cases (lossless) compression is required, which adds processing demands
Speed. Distance. Freedom.
Cameras with 64Gbit/s PCI Express interface
Advantages of PCIe as a Camera Interface

• Scalable bandwidth 5…64 Gbit/s
• Multiplexing several camera data streams into one cable
• Heterogeneous downstreams, homogeneous upstream
• Support for different cables:
  • Compact connectors with transceivers (FireFly)
  • Fiber optic up to 300 m, mil-spec MTP
  • Copper cables up to 7 m
• Minimal latencies for image delivery
• Widely available on various computing platforms:
  • PC (NUC, ComExpress), ARM (Jetson TX1/2, Snapdragon, Freescale)
xPlatform – Multi-camera Technology
xPlatform definition

- PCIe and USB 3.1 Cameras:
  - xiX, xiB, xiQ, xiC

- PCIe Aggregation Technology:
  - xSwitch
XIMEA Cameras

- Variety of form factors
  - Board level, compact, full-frame
- Range of sensor resolutions, pixel sizes and framerates
  - VGA … 50Mpix
  - 2.5 to 10 µm
  - 3500 @ HD resolution
- Lens interfaces
  - M12 (S-mount)
  - C/CS-mount
  - Active Canon EF
XIMEA Cameras – xiX Small Form Factor

- PCIe Gen2 x2, C/CS-mount (26.4 x 26.4 x 30.9)
- Sony Pregius and fast CMOSIS CMV sensors,
- Up to 1.1” optical format
- 2 PCIe lanes for up to 10 Gbit/s bandwidth
- Standard C-mount, convertible to CS-mount
- Board-level version available

- Sensors: 2.3, 3.1, 5.0, 8.9 and 12.4 Mpix, b/w and color
- Frame rates: 2.3 Mpix @ 166 fps to 12.4 Mpix @ 69 fps
XIMEA Cameras – xiX Large Form Factor

- PCIe Gen2 x4, Canon EF-mount (60 x 60 x 33.6)
- Integrated active Canon EF lens adapter for dynamic control of aperture and focus
- Large format CMOS sensors
- 4 PCIe lanes for up to 20 Gbit/s bandwidth
- Board-level version available

- Sensors: 12, 20 and 48 Mpix, b/w and color
- Frame rates: 12 Mpix @ 133 fps to 48 Mpix @ 30 fps
## xSwitch – Generic configurations

<table>
<thead>
<tr>
<th>Model</th>
<th>Upstream</th>
<th>Downstream X4G2</th>
<th>Downstream X2G2</th>
<th>Downstream X2G2 FireFly</th>
<th>Downstream USB 3.0 Type-A</th>
<th>Downstream USB 3.0 Flex</th>
</tr>
</thead>
<tbody>
<tr>
<td>XS-4P-X2G2-X4G3</td>
<td>PCIe X4G3</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XS-6P-X4G2-X8G3</td>
<td>PCIe X8G3</td>
<td>6</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>XS-8P-X2G2-FF-X8G3</td>
<td>PCIe X8G3</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XS-12P-X2G2-X8G3</td>
<td>PCIe X8G3</td>
<td>-</td>
<td>12</td>
<td>-</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
xPlatform Demonstrators - 360° rig

- 8x 3 Mpix cameras IMX253, each streaming at 218 fps
- All aggregated into one x4G3 32 Gb/s fiber cable
- Up to 100 m cable length
xPlatform Demonstrators – Generic xSWITCH-L

- 12 PCIe X2G2 ports total, populated with:
  - 4x MX050CG-SY-X2G2-FL,
  - 10 cm PCIe X2G2 flex cables
  - 4x 5.0M Pix at 165 fps each
  - Compact S-mount optics
  - Master-slave hardware synchronization via xSWITCH
  - Aluminum enclosure
xPlatform Deployment Examples

• Customer A:
  • 60x 12 Mpix cameras @ 300 fps
    + RAW recording
• Customer B:
  • 24x 12 Mpix cameras @ 10 fps, over one xSwitch
• Customer C:
  • Scalable rig cluster, each 6x 12 Mpix @ 60 fps, over one xSwitch
    + RAW recording
• Customer D:
  • 120x 12 Mpix cameras @ 60 fps, one xSwitch per 6 cameras
    + RAW recording
Resources

• xiX infographics

• xiX brochure

• xiSwitch infographics

• XIMEA Embedded vision home
  https://www.ximea.com/embedded-vision/systems

• Explanatory diagram

• PCIe page

• Software related
  https://www.ximea.com/support/wiki/apis/Linux_ARM_Support
Speed. Distance. Freedom.
Cameras with 64Gbit/s PCI Express interface

Thank you for your attention
Questions?