

embedded **VISION** SUMMIT 2018

High-end Multi-camera Technology, Applications and Examples



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May 22, 2018

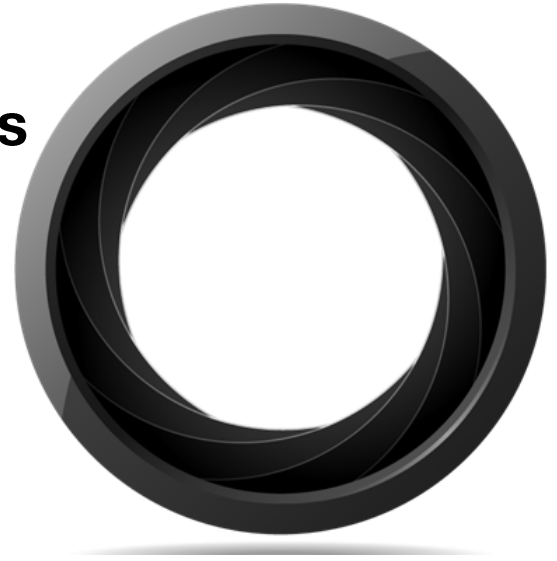
- XIMEA Quick Intro
- Multi-camera Applications
- Technologies to Build a Multi-camera System
- Advantages of PCI Express as an Interface
- Multi-camera System Architecture Based on XIMEA's PCIe Components
- Examples of Multi-camera systems and Performance

XIMEA Quick Intro



- 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

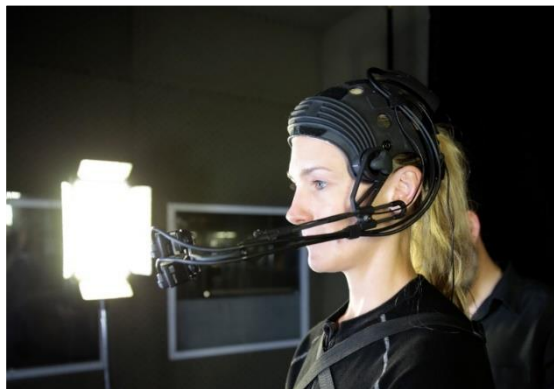
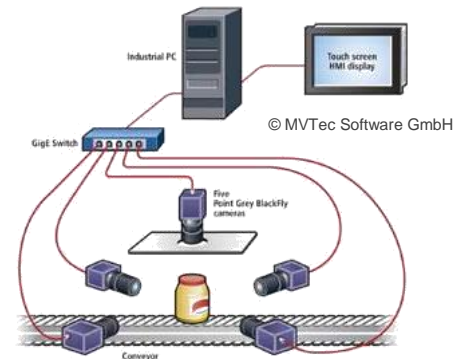


Multi-camera Arrangements

- 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



© Dimensional Imaging / Technoprops



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



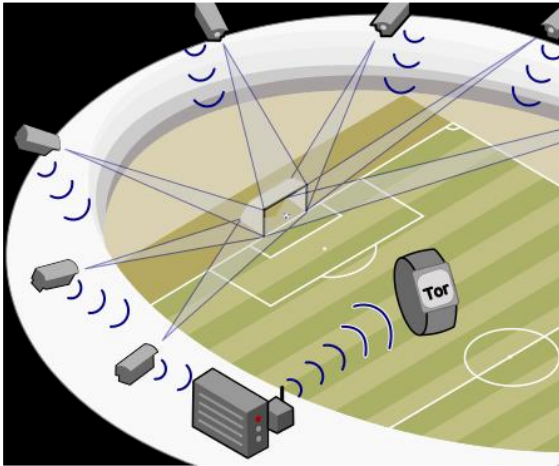
© Cyclomedia



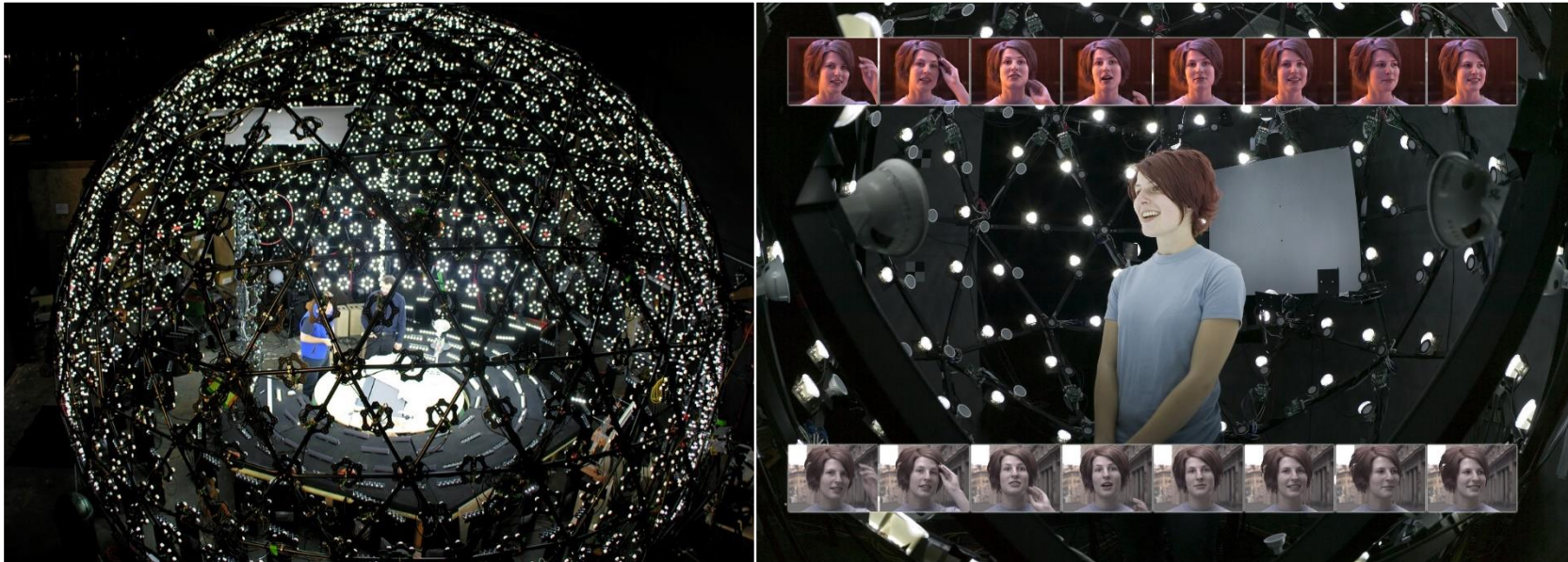
Nokia Ozo

Multi-camera Applications

- Multiple cameras: **12...50+ cameras**
 - Sports, goal lines, ball trajectories

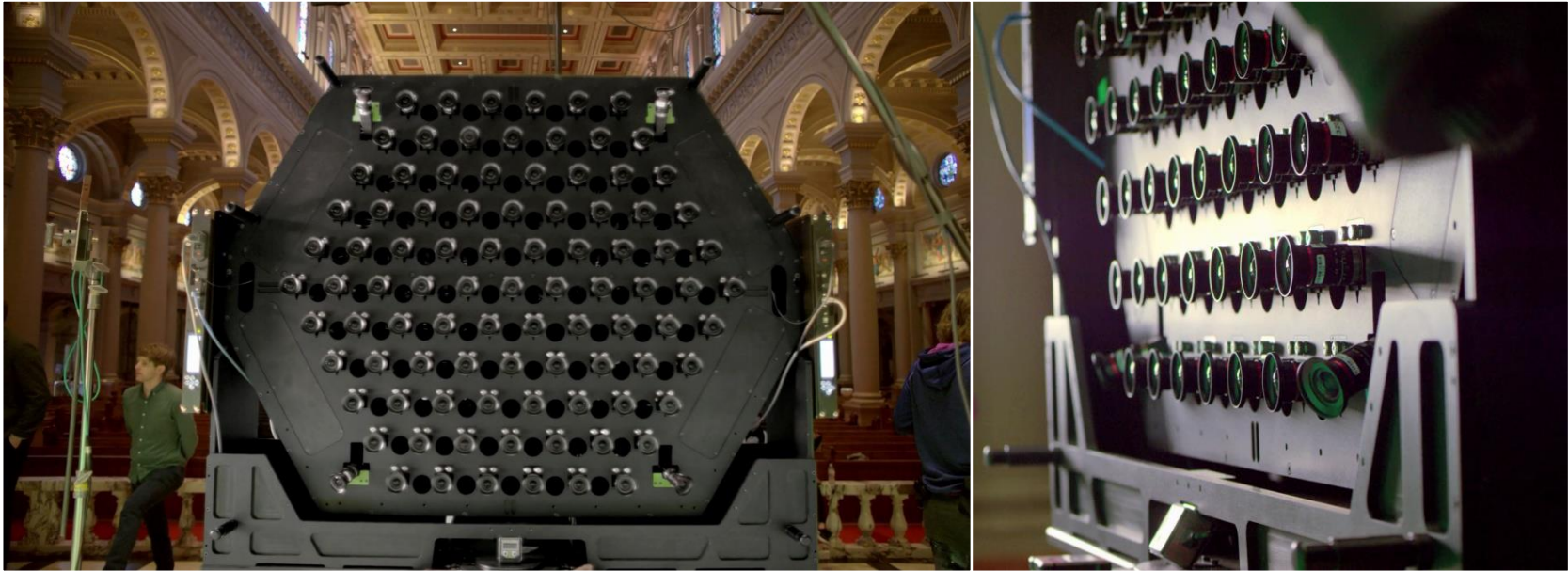


- Multiple cameras: **12...50+ cameras**
 - 3D scanning rigs and photogrammetry



© USC, Institute for Creative Technologies

- Multiple cameras: **12...50+ cameras**
 - AR/VR capturing



© Lytro, www.lytro.com

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

- 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



● ximea

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)



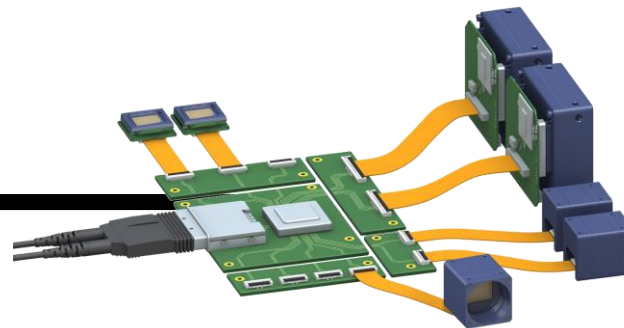


xPlatform

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



- PCIe Aggregation Technology:
 - xSwitch



- 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



- 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

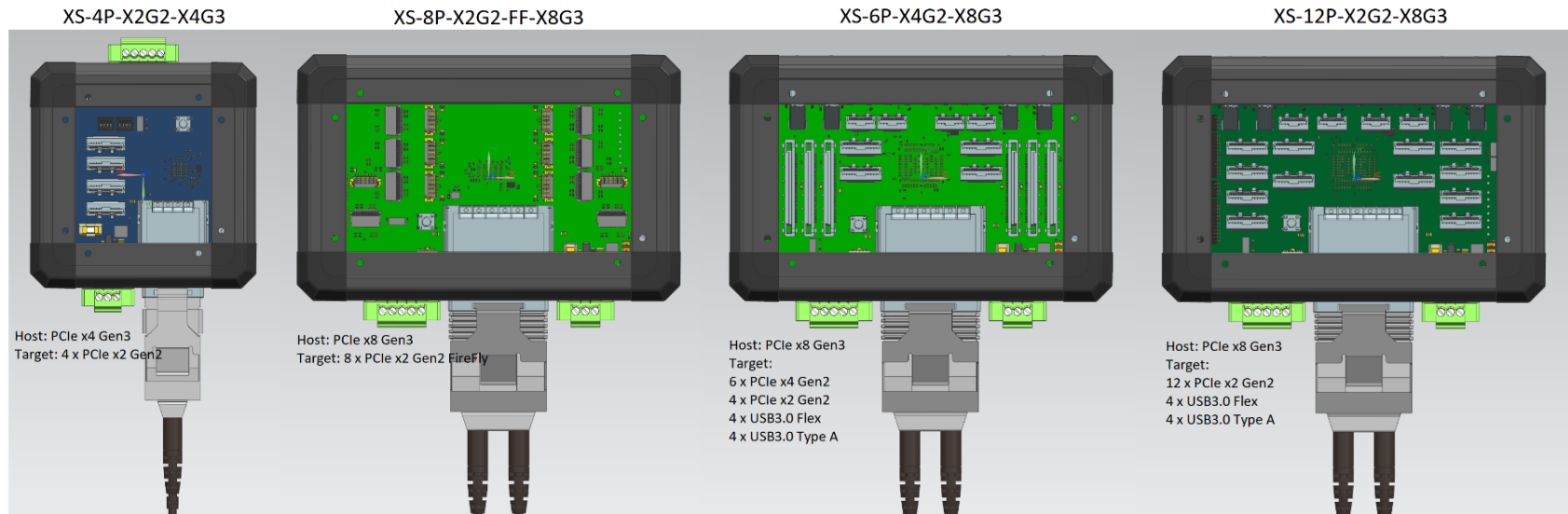
XIMEA Cameras – xiX Large Form Factor

- 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



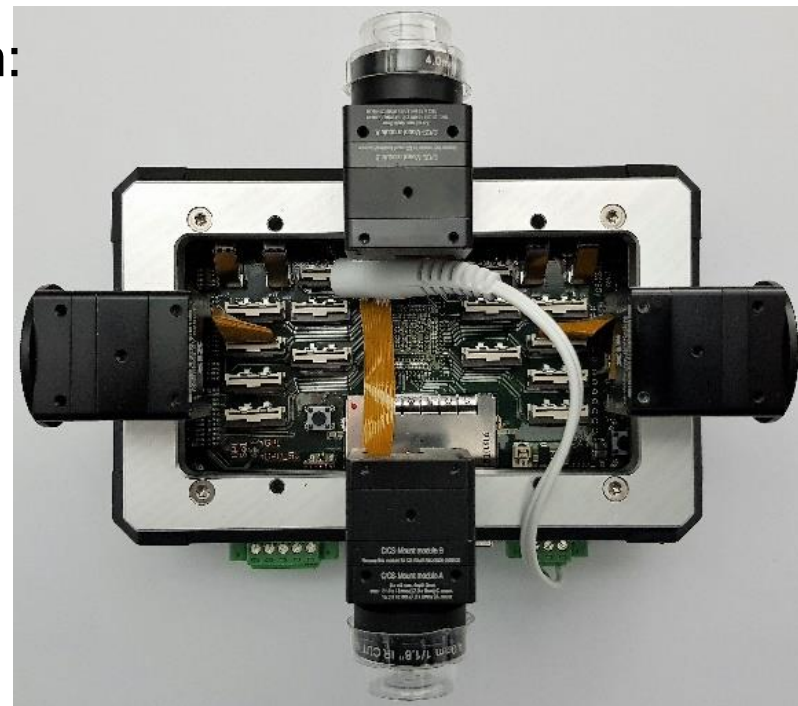
| Model | Upstream | Downstream X4G2 | Downstream X2G2 | Downstream X2G2 FireFly | Downstream USB 3.0 Type-A | Downstream USB 3.0 Flex |
|--------------------|-----------|-----------------|-----------------|-------------------------|---------------------------|-------------------------|
| XS-4P-X2G2-X4G3 | PCIe X4G3 | - | 4 | - | - | - |
| XS-6P-X4G2-X8G3 | PCIe X8G3 | 6 | 4 | - | 4 | 4 |
| XS-8P-X2G2-FF-X8G3 | PCIe X8G3 | - | - | 8 | - | - |
| XS-12P-X2G2-X8G3 | PCIe X8G3 | - | 12 | - | 4 | 4 |

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



- 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



- 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

- xiX infographics
<https://www.ximea.com/files/brochures/xiX%20Infographic.pdf>
- xiX brochure
<https://www.ximea.com/files/brochures/xiX-OEM-cameras-for-integration-2017-brochure-HQ.pdf>
- xiSwitch infographics
<https://www.ximea.com/files/brochures/xiSWITCH%20Infographic.pdf>
- XIMEA Embedded vision home
<https://www.ximea.com/embedded-vision/systems>
- Explanatory diagram
https://www.ximea.com/support/attachments/download/8875/MX-X2G2-FL_Diagram.pdf
- PCIe page
<https://www.ximea.com/en/pci-express-camera/pcie-camera-zone>
- 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?

The Ximea logo, featuring an orange circle followed by the word "ximea" in white lowercase letters.