High-Bandwidth Multicamera Systems with PCIe Backbone: Snapshot and Outlook to Technologies and Applications

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Content

- XIMEA Company Overview
- Cameras & Embedded Systems
  - Challenges & Applications
- Existing imager interfaces
- PCIe does it all
XIMEA: SRO, GmbH, Corp

XIMEA s.r.o.
Slovakia, Marianka
Research and Development, Production

XIMEA GmbH
Germany, Münster
Management, Marketing, International Sales

XIMEA Corp.
USA, Denver
Sales South and North America
Company facts - What we do

• Development, manufacturing and support for ultimate imaging and vision products
• All tooling capabilities in-house
• Standard products and custom designs
• Increasing general success through sustainable partnerships
• Company Products
• Customers

[Logos of various companies including Apple, Google, Amazon, NASA, Disney Research, Microsoft, Intel, Audi, Boeing, Boston Dynamics, ZEISS, Leica, Samsung, DLR, Bruker, Olympus, Siemens, Lytro, Philips, and kapsch]
Embedded & Multi-Camera Systems
Mapping/Survey – Autonomous Vehicles

- High resolution
- High speed
- Real time processing or saving
- Multi-camera
- Small components

Street Level
© Cyclomedia

Aerial/orbital
Augmented & Virtual Reality

- High resolution
- High speed
- Multi-camera
- Small components
- Power consumption and dissipation

Nokia Ozo  Facebook Surround 360  XIMEA 360° Demo
Performance Capture

- High resolution
- High speed
- Multi-camera
- Small components
- Long cables

Motion Capture

Face Capture

© USC, Institute for Creative Technologies
Wearables

- High speed
- Multi-camera
  - NIR + color
  - XDR
- Small components
- Real time processing
Challenges

- Bandwidth
  - Multi camera systems
  - High resolution, high frame rate
- Cabling
  - Long distances
- Size
  - Smaller is always better
- Synchronization
- Processing
  - Real time
  - Saving
Existing Interfaces
Existing camera interfaces

- Ethernet
- USB
- Camera Link / CoaXPress
- PCI Express
Ethernet

• Pros
  • Industry standard cables & software (GigE)
    • Hubs & switches easily available
  • Long cable lengths
  • Inexpensive

• Cons
  • Bandwidth is low
USB

• **Pros**
  - Industry standard cables
  - Hubs easily available
  - Better-ish bandwidth
  - Long-ish cable lengths
  - Inexpensive

• **Cons**
  - Multi-camera systems require multiple controllers
  - Not all controllers compatible with all cameras
Camera Link & CoaXPress

• **Pros**
  • Simple cables
  • Long cable lengths
  • High bandwidth
    • Expandable to achieve higher bandwidth

• **Cons**
  • Cameras require interface cards
  • Price
Peripheral Component Interconnect Express (PCIe)

**Pros**
- Interface card is simply a cable adapter – nearly all computers have a PCIe backbone in place
- Highest bandwidth
  - Single cable up to 64Gbps
- No latency
  - Direct to RAM
- Long cable lengths

**Cons**
- Price
- Cabling is non standard
Processing/Saving

- Must be small
- Real time processing
  - AI
- Saving data at high data rates is often non-trivial in execution
Intel products

- NUC platform
  - Often limited in PCIe connectivity
- COM Express
  - Much better for custom developments
Nvidia computing

- High processing capability
- Variable PCIe bus input
  - Nano has only 2 lanes exposed
  - Jetson has 4
  - Xavier has 16
  - Already a new one on the way
Carrier boards

- Allow custom implementation of computing platforms
  - PCIe, USB interfaces
- XIMEA + 3rd party suppliers
PCle
PCle Switch for multi-camera systems

- Allows multiple cameras to input data through one cable/connection
PCIE Switch

XIMEA Standard switches

XIMEA 360 switch
XIMEA XEC2 Jetson Carrier board

• Features
  • Multiple camera connections
    • PCIe (with switch)
    • USB
  • Peripheral interfaces
    • HDMI
    • USB (2&3)
    • Wifi
    • GPIO
    • IMU

Examples of setups and configurations for Embedded vision systems

Drone Concept
4 + 1 XIMEA cameras
XIMEA high resolution camera
Miniature cameras with fast speed
PCle does it all!

- Minimizes latency and CPU overhead
- Seamlessly delivers image data directly to the host memory via Scatter/Gather DMA
- Supports distances from millimeters to hundreds of meters
- Aggregation of multiple imagers into one wire/fiber
- Upcoming PCle generation(s) for still higher speeds
- Ultimate Camera Interface for high throughput sensors and multi camera systems
Future directions

- Gen4 is readily available in PCs
  - 16Gbps per lane
- Faster sensors always coming out
- New cabling utilizing Firefly
Further information

• xiX infographics

• xiX brochure

• xiSwitch infographics

• XIMEA Embedded vision home
  https://www.ximea.com/embedded-vision/systems
Thanks for your attention!

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