Pannel: SIGNAL 2016

Challenges in High Speed Image processing

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30 June 2016 – Lisboa, Portugal

Introduction

- Signal Processing has to be seen in this wide sense
  - Acquisition
    - Sensor
    - Low level driver
  - Pre processing
    - Analog
    - Signal conditioning
  - High level processing
    - Image processing …

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Single Photon Imaging

- Why photon-counting at high granularity?
- Pros: basically no read-out noise, shot noise limited imaging, analysis of fast phenomena, …
- Cons: After all, it's easier to integrate than to count…
- Possible answers:
- "Real" quantum imaging and quantitative photography
- Better exploit the source's features (e.g. lasers, scintillation phenomena) -> enable use of best estimators (e.g. timing)

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Single Photon Imagers

- Can we bring quantum efficiency and fill-factor on par with CCD/CMOS cameras?
  - Probably with the 3D microelectronic technologies
- Which is the “killer application” which will bring investment? OR…
  - A consumer application is the point. Maybe 3D measurement for gamming or automotive
- Piggyback on industry developments -> reuse 3D integration and/or backside illumination?
- CMOS: How can we move beyond visible (e.g. NIR/mid-IR)? For which applications?
  - A dedicated semiconductor technology can be used (GaAs, etc.)
- Can we reach a “LEGO” type approach – providing building blocks instead of ad-hoc developments?
  - Use SPAD devices as a standard cells require a specific design kit. It is the key to “LEGO” approach.
  - Additionally, a standardized test board for imager can be imagined

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Single Photon Imagers

- Industry wants volume! Where is it?
  - Consumers or automotive applications. Not is scientific application
- Mobile applications, IoT, cameras, point-of-care?
  - Some product are emerging is mobile applications for autofocus assistance…
- Foundry access is key!
- Can we build large surface single-photon imagers?
  - Probably, but the pixel pitch should probably still be high compared to the CMOS/CCD one
- Should we strongly integrate imaging and processing, or go in the opposite direction towards flexible architectures (e.g. LinoSPAD, FPGA-based)?
  - The problem of data extraction of SPAD imager is a key point. The LinoSPAD is an interesting works to reduce data bandwidth requirement
- Firmware developments efforts are often neglected

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Single-Photon Time-Correlated Imaging

- Do we really need multi-exponential fits in FLIM?
  - Can we do with (mono-exponential) approximations to reduce the data rate?
    - In some specific application, such as high throughput Screening in pharmaceutical industry
- Do we really need time stamps for EACH photon?
  - Not in all application, E.g. in PET (Positron Emission Tomography)
- Do we really get a significant advantage from FLIM vs. “standard” intensity fluorescence measurements?
  - Fluorescence lifetime imaging is more relevant than intensity measurement in biomolecular interaction sutdies

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Single-Photon "Extreme" Time-Correlated Imaging

- Suppose that we can time each photon with 10ps accuracy: what do we do with it? At which price?
  - "Direct" reconstruction in PET
  - Single shot LIDAR
  - Concurrence to the Streak camera, which are the fastest direct light detector currently available.
  - …

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Heterogeneous computing

- Heterogeneous sensor/processing
  - Smart Sensor/camera
  - Multi platform computing
    - Parallelization GPU, multicore
    - In sensor embedded processing/ASIC → **REAL PARALLELISM** ?
      - dedicated vs versatile solution
- What about asynchronous computing for low power processing ?
  - Completely asynchronous processor are available for some applications

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Heterogeneous computing

- Low level (analog) processing
- High level programming languages ?
  - Open CL is a high level programming that allows to target heterogeneous processing
    - FPGA, DSP, Microprocessor, ASIC, …
  - This kind of language are probably the key to benefit from the more advanced hardware evolution

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Event driven image sensor

- Special processing from event driven sensor ?
  - SPAD sensor are by essence event sensors…
  - Data extraction ?
- Data compression for high speed burst imagers with limited in situ memory frames.
  - Reducing spatial and temporal redundancy could increase dramatically the temporal resolution
  - Changing the acquisition paradygme:
    - Forget about frame, think about relevant event !

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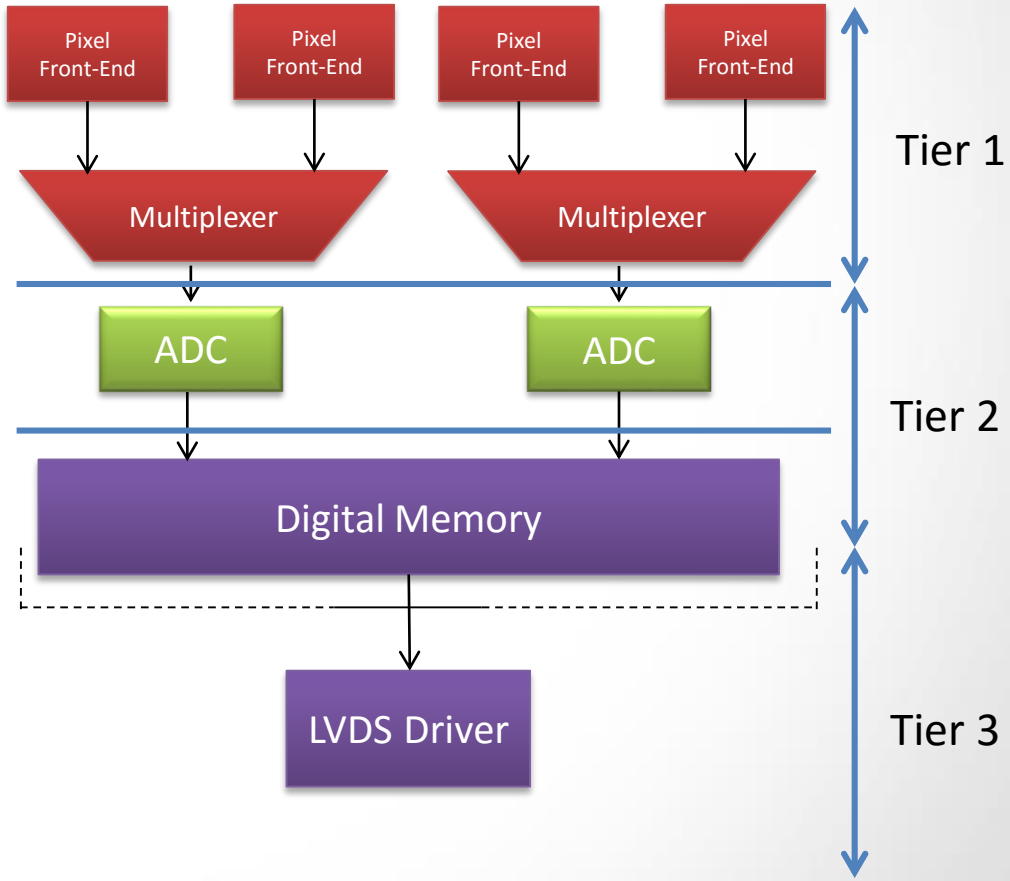
3D microelectronic

- Potential
  - Heterogeneous technologies
- Accessibility
- Cost



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High Speed imaging and processing applications

- Automotive
  - Lidar, stereoscopic, event driven, sensor dedicated to edge/motion/ detection…
- Medical
- Consumer

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SIGNAL 2016
First International Conference on Advances in Signal, Image and Video Processing
June 26 - 30, 2016 - Lisbon, Portugal

Challenges in High Speed Image Processing

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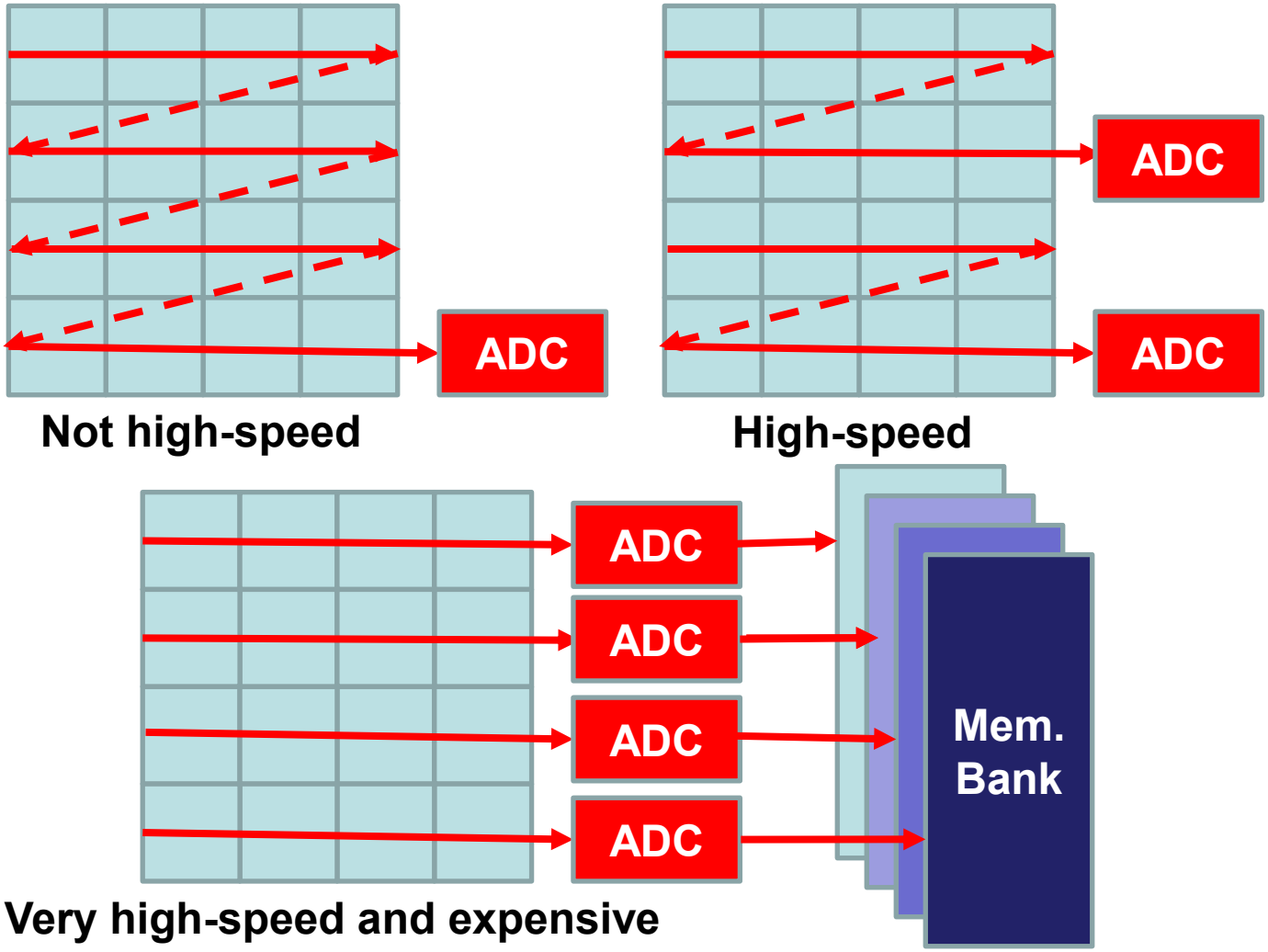
High-Speed Image Sensors



Not high-speed

High-speed

Very high-speed and expensive

Speed is an illusion!

- **A lot of power (Not really green!)**
- **A lot of $/€**

What we really need ?

Manage the temporal redundancies to be faster

Manage the spatial redundancies as well

Solutions to discuss

Sampling

- **Simply reduce the dataflow** to be fast!

Architecture

- "Divide and conquer" if you are not enough fast and **pay the price!**

Image Processing

- Change your mind and look how to **directly process the non-conventional dataflow!**

Non-uniform sampling is the future of digital universe!

Thanks for your attention