Infrastructure and Methodology for Mobile SoC Modeling

Yuhao Zhu
University of Rochester
http://yuhaozhu.com
@yzhu88

UNIVERSITY of ROCHESTER

Mobile Systems Today

Imaging

Computer Vision

Graphics

Video Processing

Stereo Acoustic

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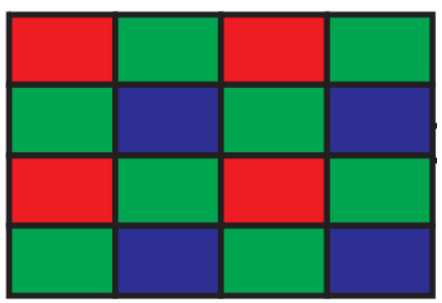

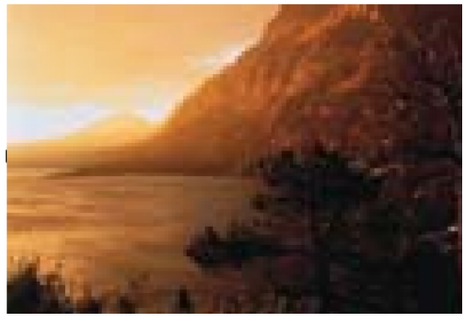

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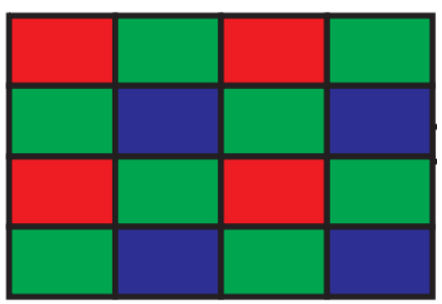
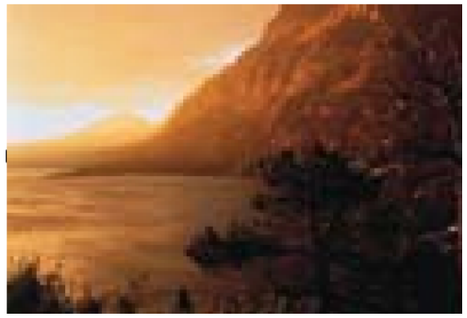


Image Signal Processor



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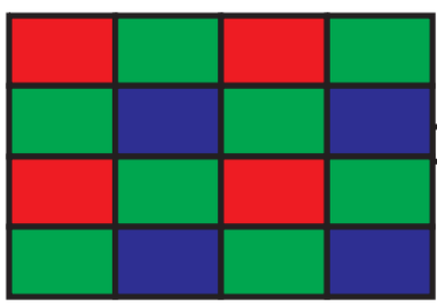

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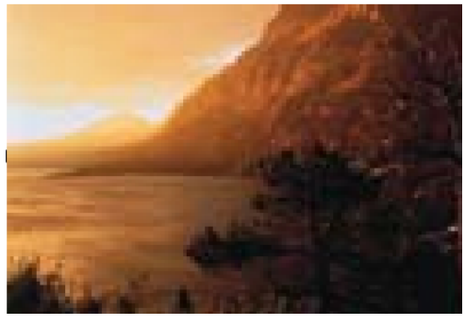

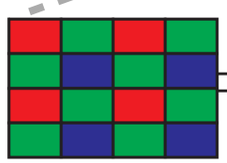

Black Level Adjustment

Noise Reduction

White Balance

CFA Interpolation

RGB Blending

Gamma Correction

RGB to YCC Conversion

Edge Enhance

Contrast Enhance

False Chroma Suppression

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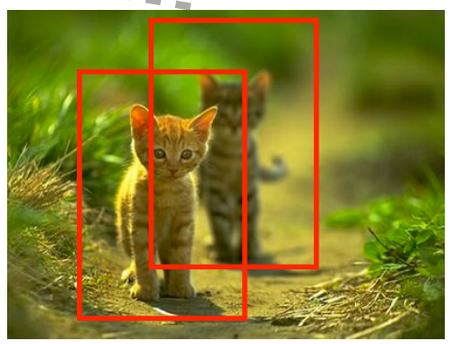

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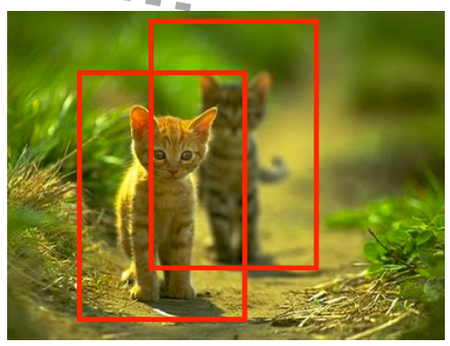
Neural Network Engine



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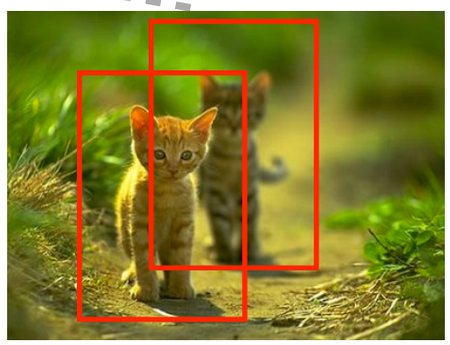
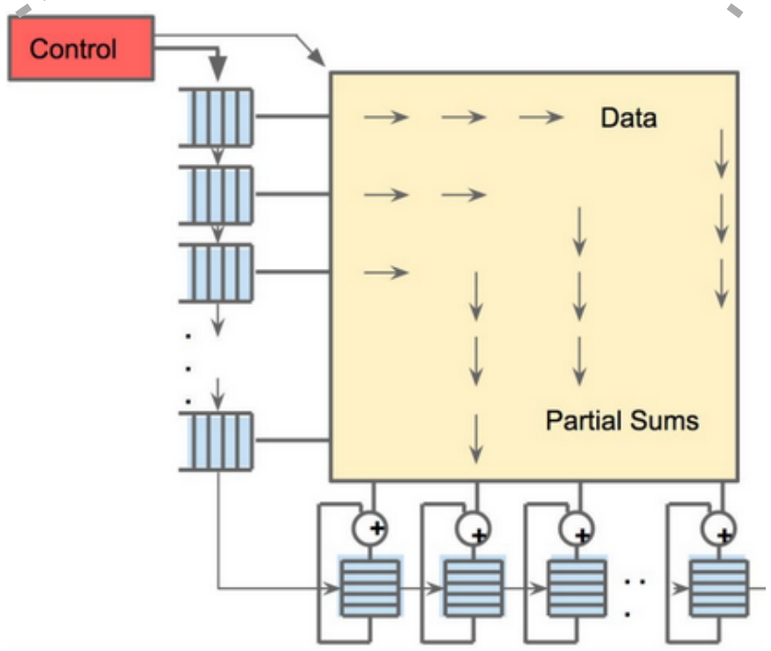
Neural Network Engine





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3D mesh

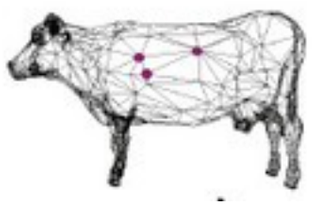

Image Output

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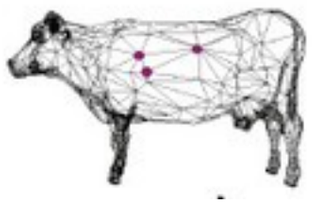
3D mesh



Graphics Processing Unit

Image Output

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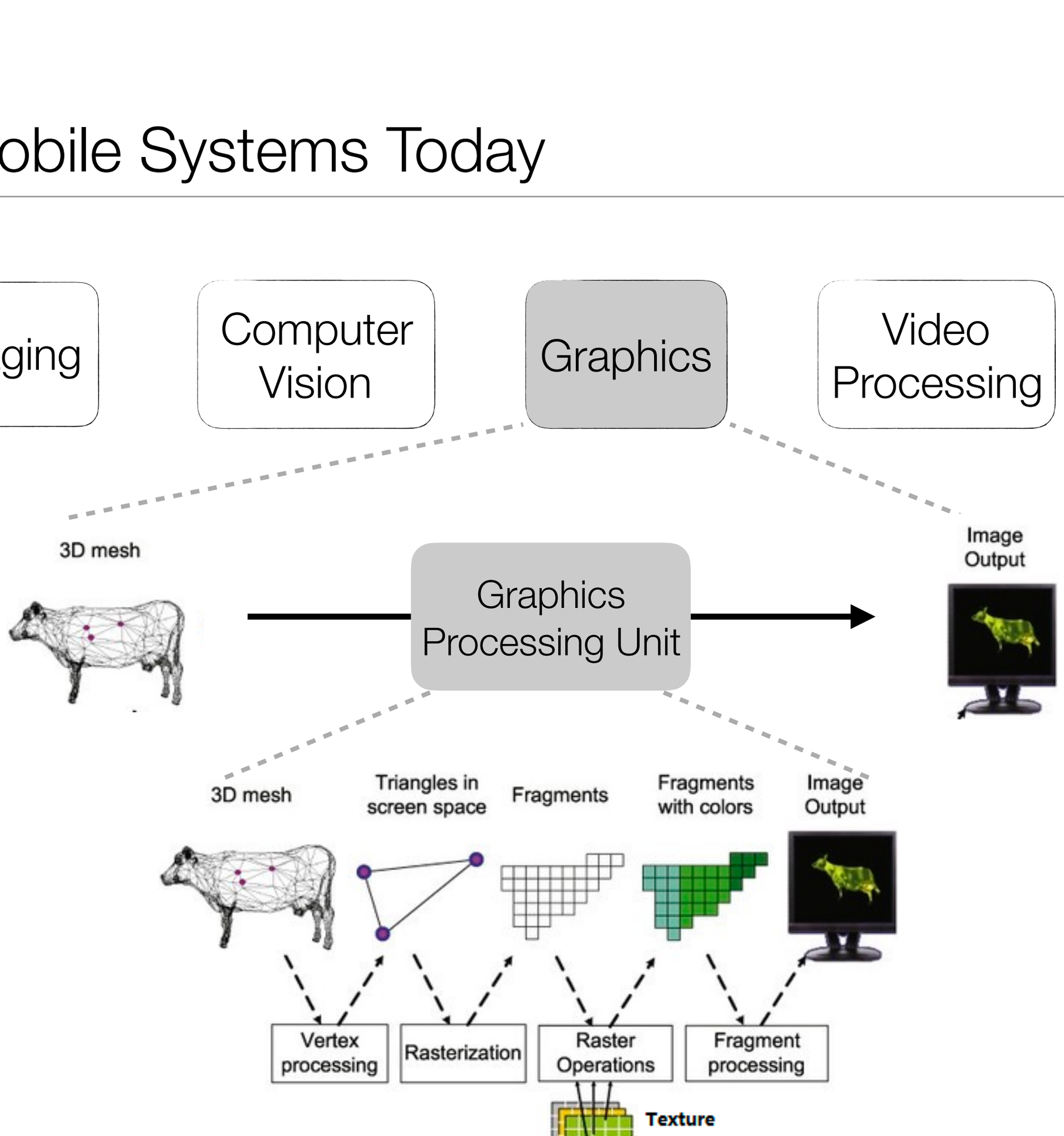

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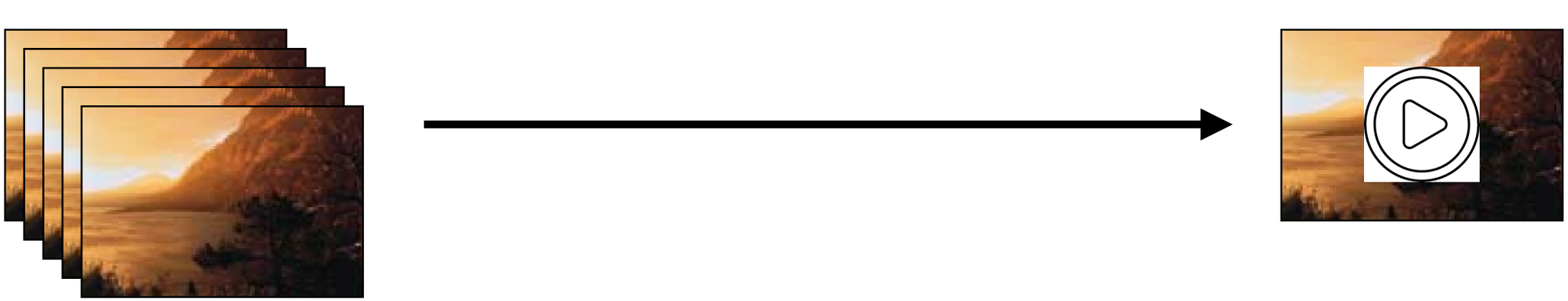

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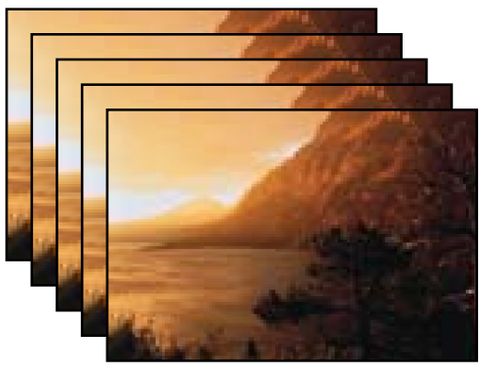

Video Codec

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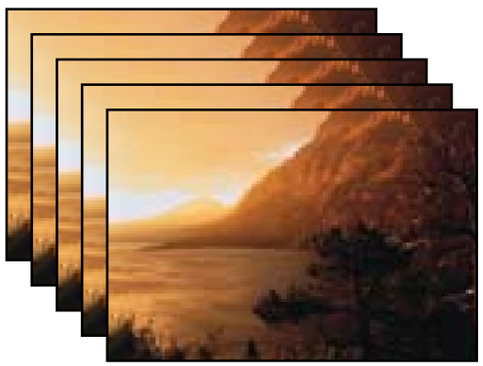

Video Codec

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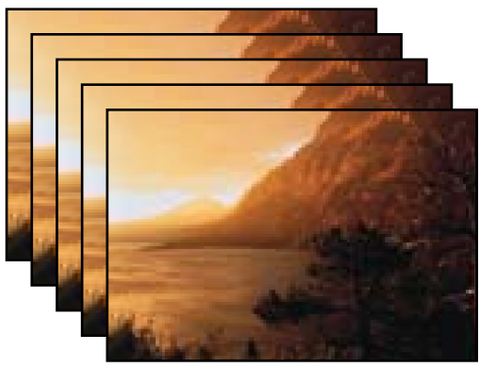
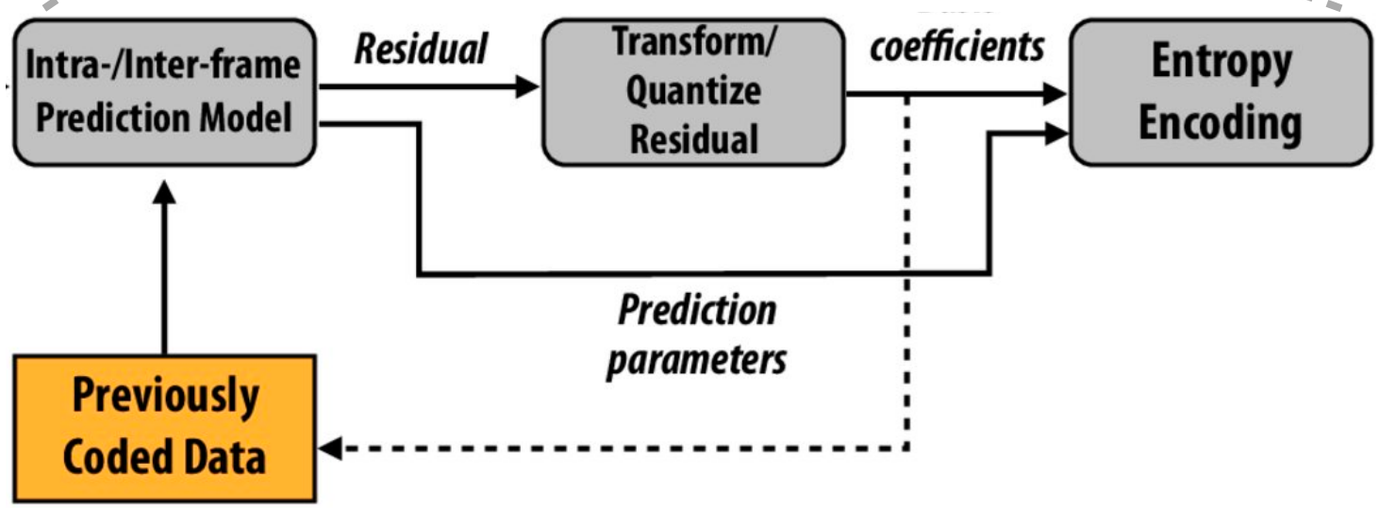


Video Codec



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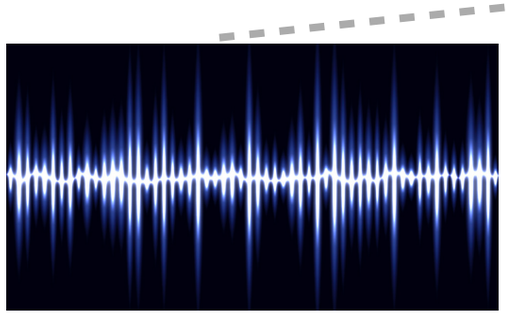

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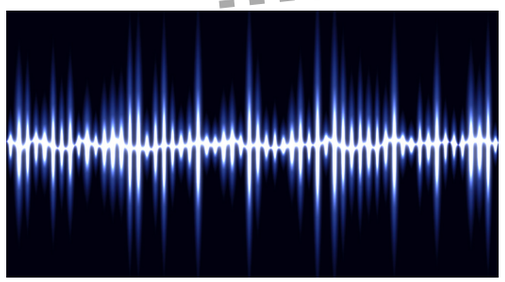

Audio Signal Processor

Mobile Systems Today

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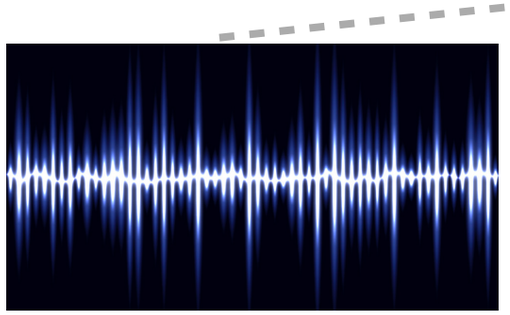

Audio Signal Processor

Sampling Frequency must be defined

bits per sample must be defined

Analog Signal

Continuous in Time
Continuous in Amplitude

Sample & Hold

Discrete in Time
Continuous in Amplitude

Quantization

Discrete in Time
Discrete in Amplitude

Encoding

Digital Signal

Discrete in Time
Discrete in Amplitude

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Today's mobile systems are a collection of segregated sub-systems, each specialized for a domain.

Imaging

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Graphics

Video Processing

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Today's mobile systems are a collection of segregated sub-systems, each specialized for a domain.

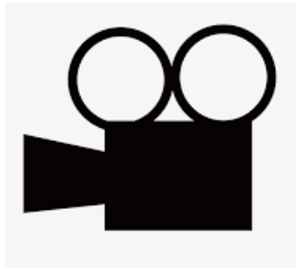
Imaging	Computer Vision	Graphics	Video Processing	Stereo Acoustic
Image Signal Processor	Neural Network Engine	GPU	Video Codec	Audio Signal Processor

Today's mobile systems are a collection of segregated sub-systems, each specialized for a domain.

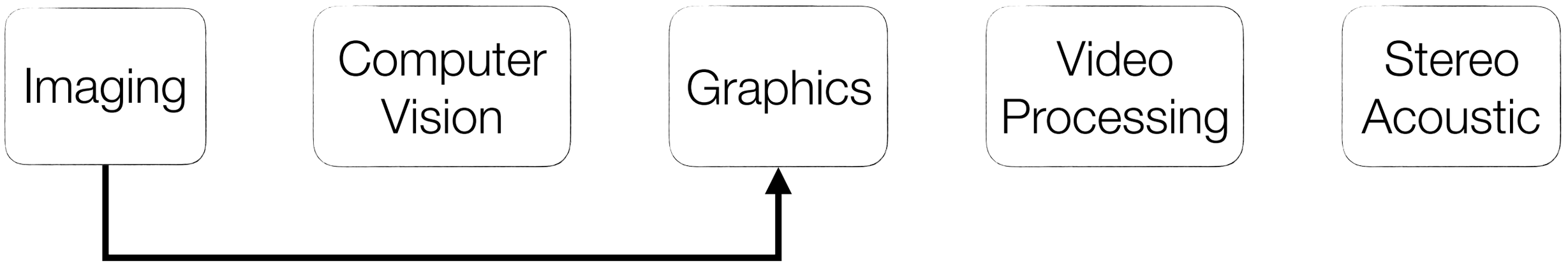
Imaging	Computer Vision	Graphics	Video Processing	Stereo Acoustic
Halide	OpenCV/ PyTorch	OpenGL	Fixed-Function	Some DSP Lang.
Image Signal Processor	Neural Network Engine	GPU	Video Codec	Audio Signal Processor

Emerging Applications Integrate All Components

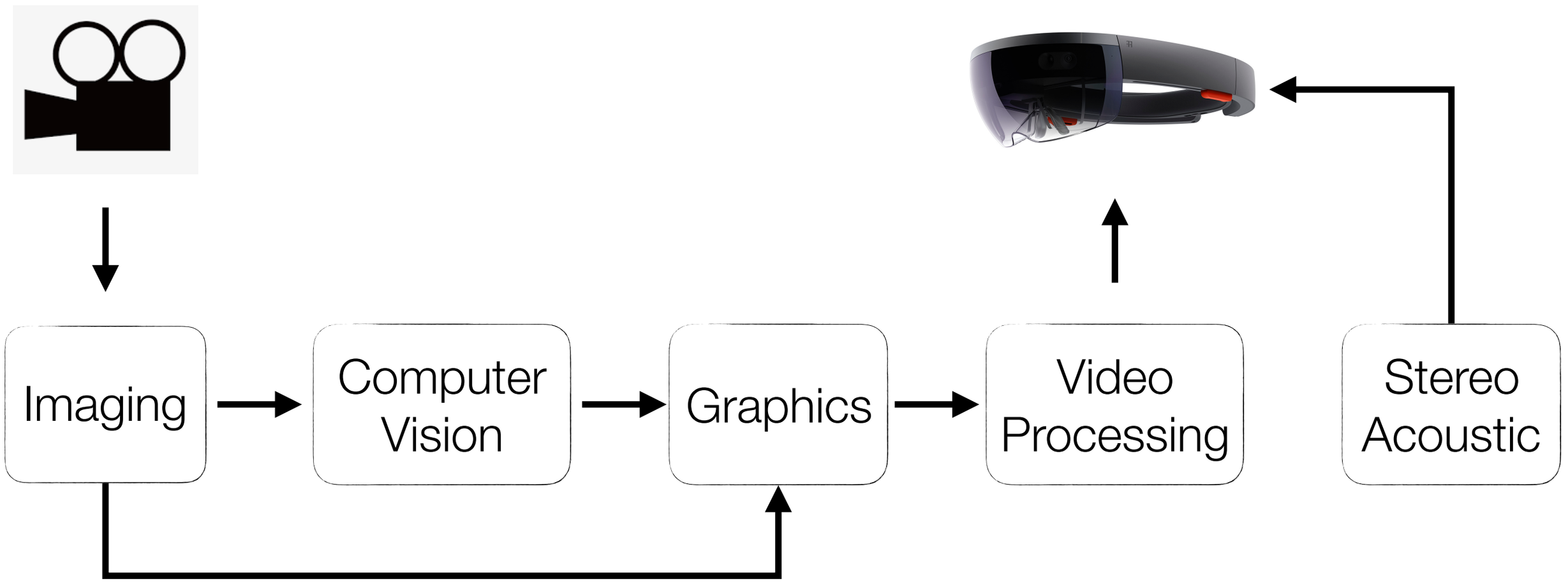
Camera



Headset

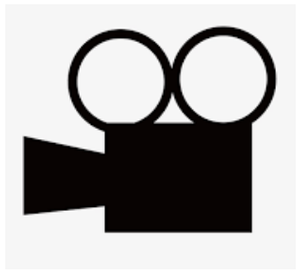


Emerging Applications Integrate All Components



Emerging Applications Integrate All Components

Camera

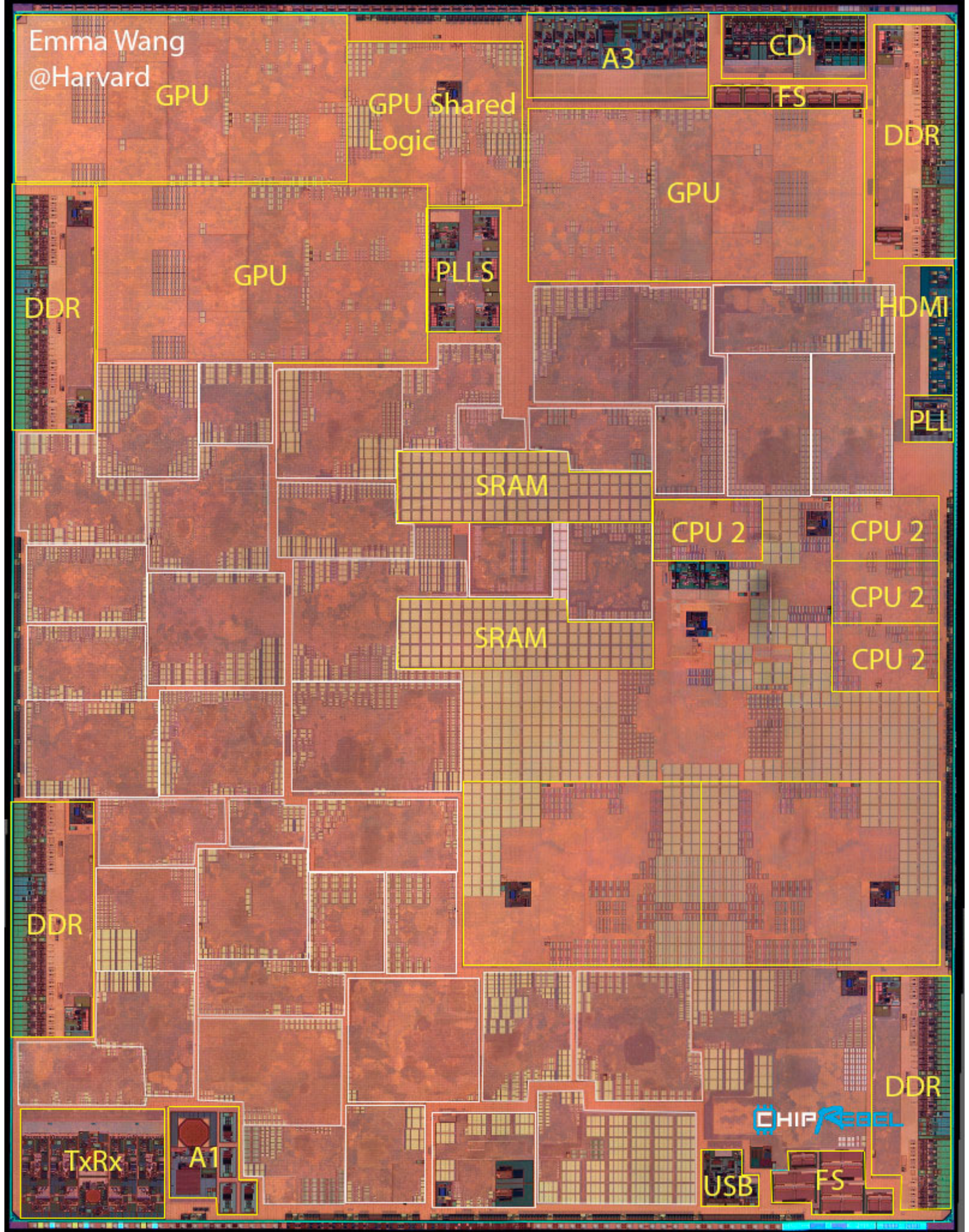


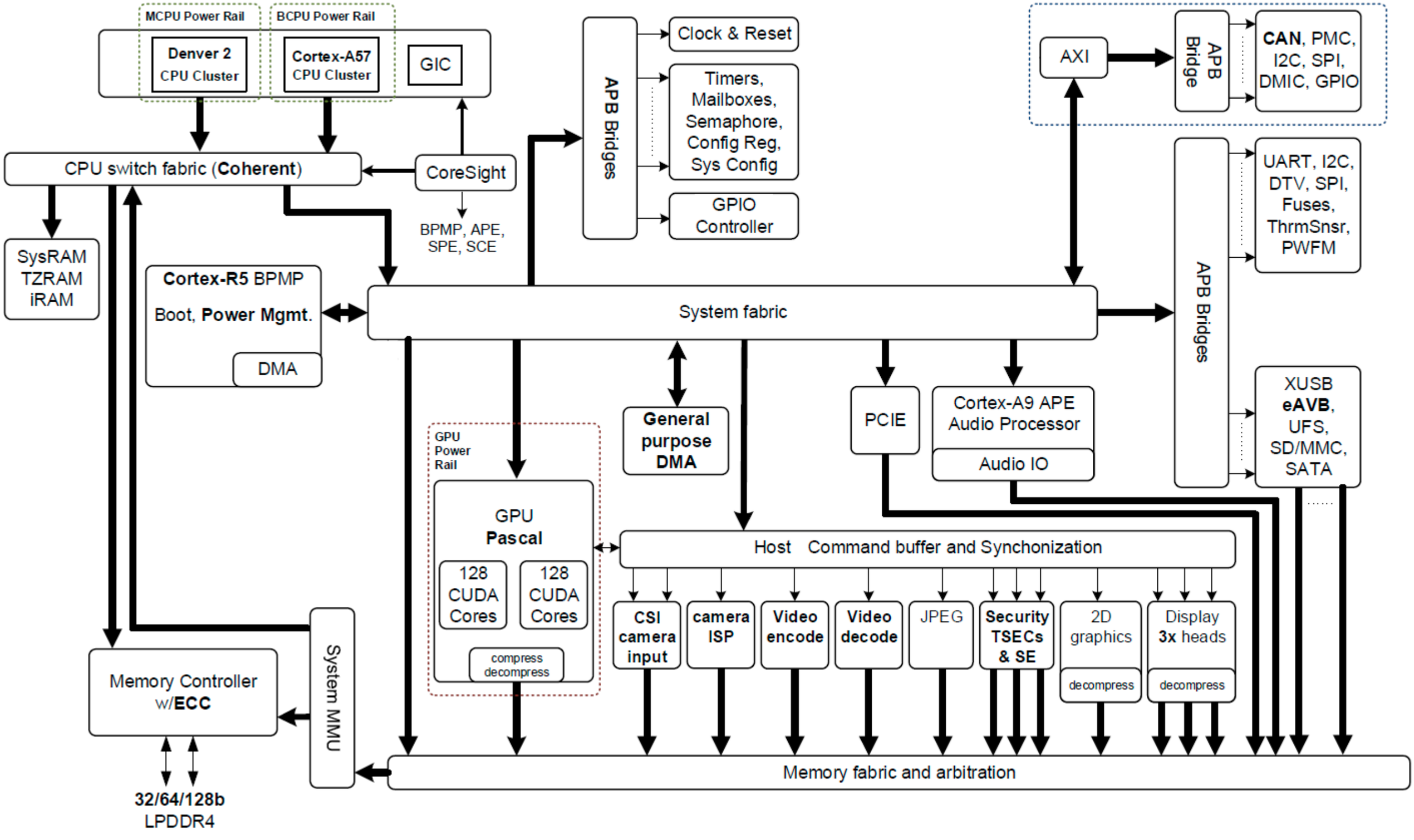
Headset

Imaging → Computer Vision → Graphics → Video Processing

Stereo Acoustic

Co-Optimize/Design Different Computing Domains Across the Entire SoC


Emma Wang
@Harvard
GPU
GPU Shared
Logic
A3
CDI
FS
DDR
GPU
DDR
GPU
PLLS
HDMI
PLL
SRAM
CPU 2
CPU 2
CPU 2
DDR
DDR
TxRx
A1
USB
FS
CHIPREBEL



Nvidia TX2 SoC

You can’t fix what you can’t measure

Architecture Modeling Infrastructure

Target	Tool
CPU	Gem5/Marss86
GPU	GPGPUSim/GPUWattch
DRAM	DRAMSim2
DNN Accelerator	SCALESim/RTL
SoC	PARADE/GemDroid

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Why Do We Need Another SoC Modeling Tool?

Requirements for SoC-Level Modeling

- Do we need cycle-accurate CPU models in SoC Simulation?
- Do we need cycle-accurate GPU models in SoC Simulation?
- At what granularity should we model the SoC?
- What are evaluation metrics should we care about?
- What IP blocks should we support, and how do we support new IP blocks?
- First-order bottleneck analysis vs. detailed perf. model

Different Modeling Levels and Strategies

- Hardware Modeling
  - Analytical Model
  - Simulation Model
- Task-level Modeling
  - SoC-level tasks (case-study: continuous vision)
  - IP-level tasks (case-study: DNN accelerator)

Rest of the Agenda

- **Introduction and Welcome (Yuhao Zhu, Rochester)**
- Mobile Computing and SoC Analytical Modeling (VJ, Harvard)
- Platform Architecture Modeling Tutorial (Jun Qi, Synopsys)
- Platform Architecture Simulation Model of Gables (Xiaoyang Li, Synopsys)
- Task-level Modeling: A Continuous Vision Case-Study (Yiming Gan, Rochester)
- Joint Optimization of Hardware and Compiler -- Modeling AI Accelerators using Platform Architect (Xiaoyang Li, Synopsys)