In-Sensor Processing Techniques for Biomedical Applications

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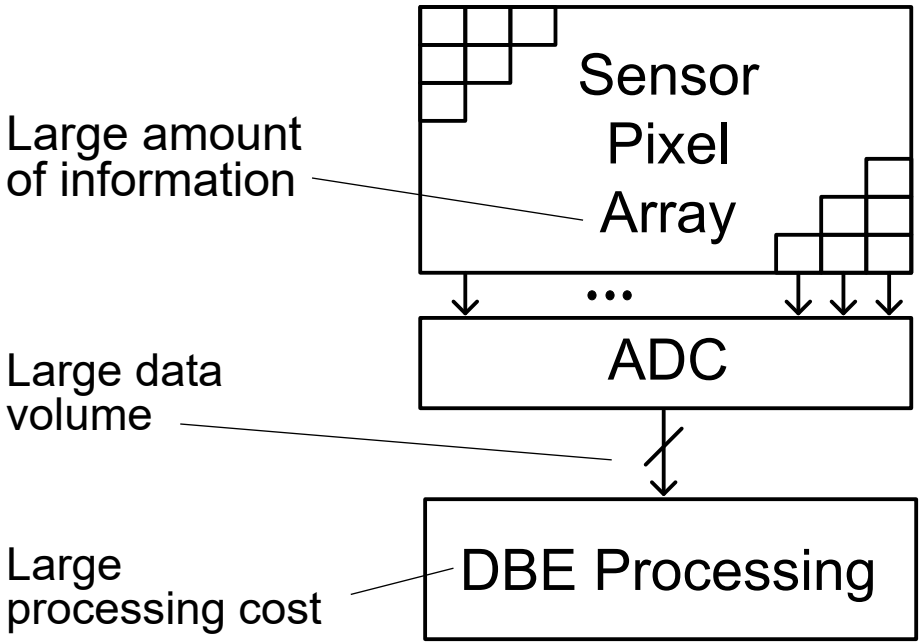
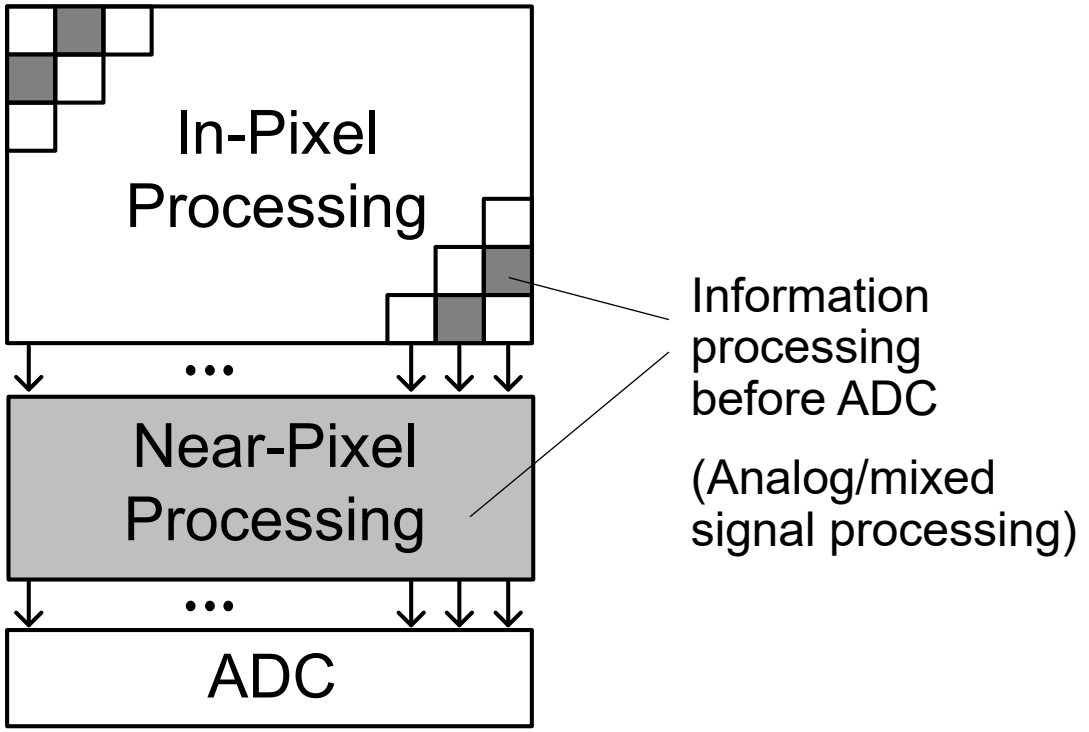
In-Sensor Processing

Conventional Sensor + Processing



- Post processing in digital backend (DBE)
- High latency
- Power & area hungry

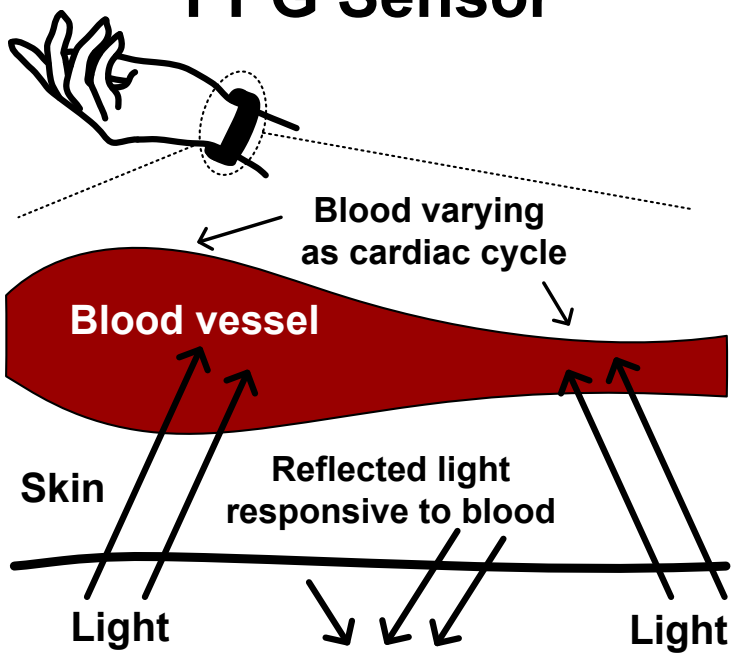
In-Sensor Processing



- Low latency
- High power efficiency
- Area for in/near-pixel processing

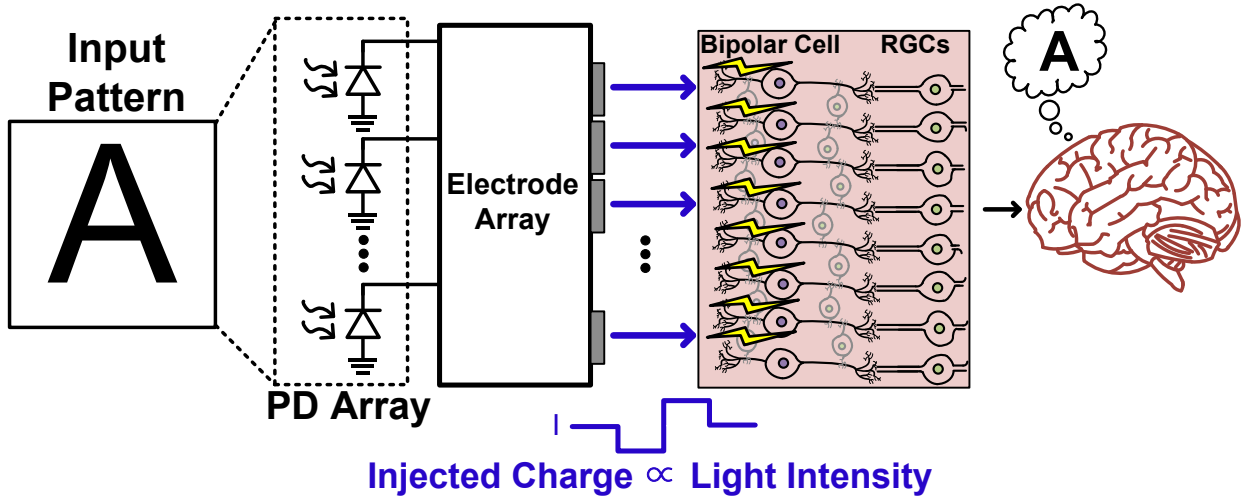
In-Sensor Processing for Biomedical Applications

Wearable Device – PPG Sensor



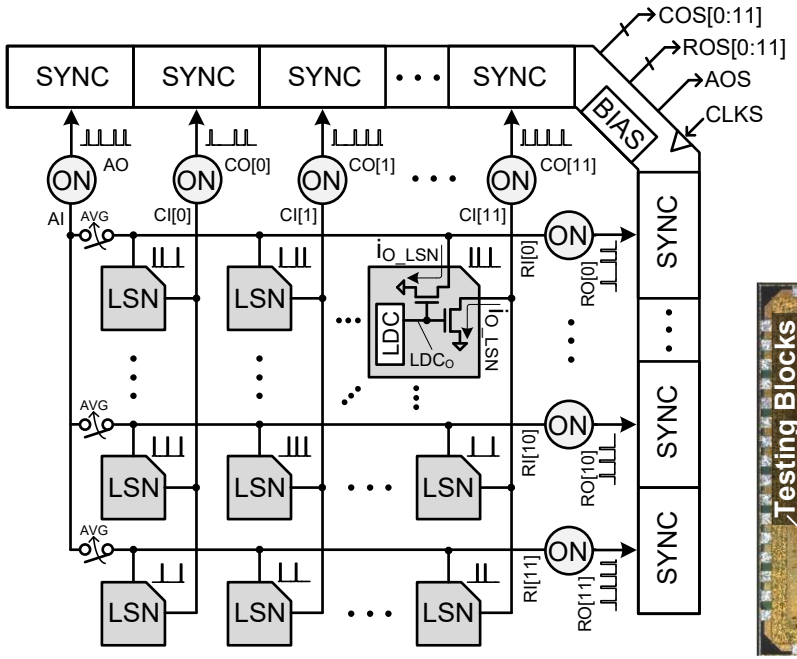
- Minimize cost (manufacturing, power, area, processing)
- Increase robustness (motion/ambient light)

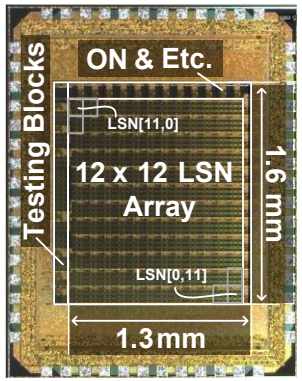
Implantable Device – Retinal Prosthesis Chip

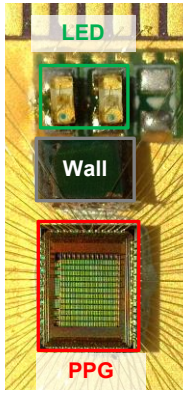


- Minimize power consumption (safety, power delivery)
- Increase spatial resolution (visual acuity)

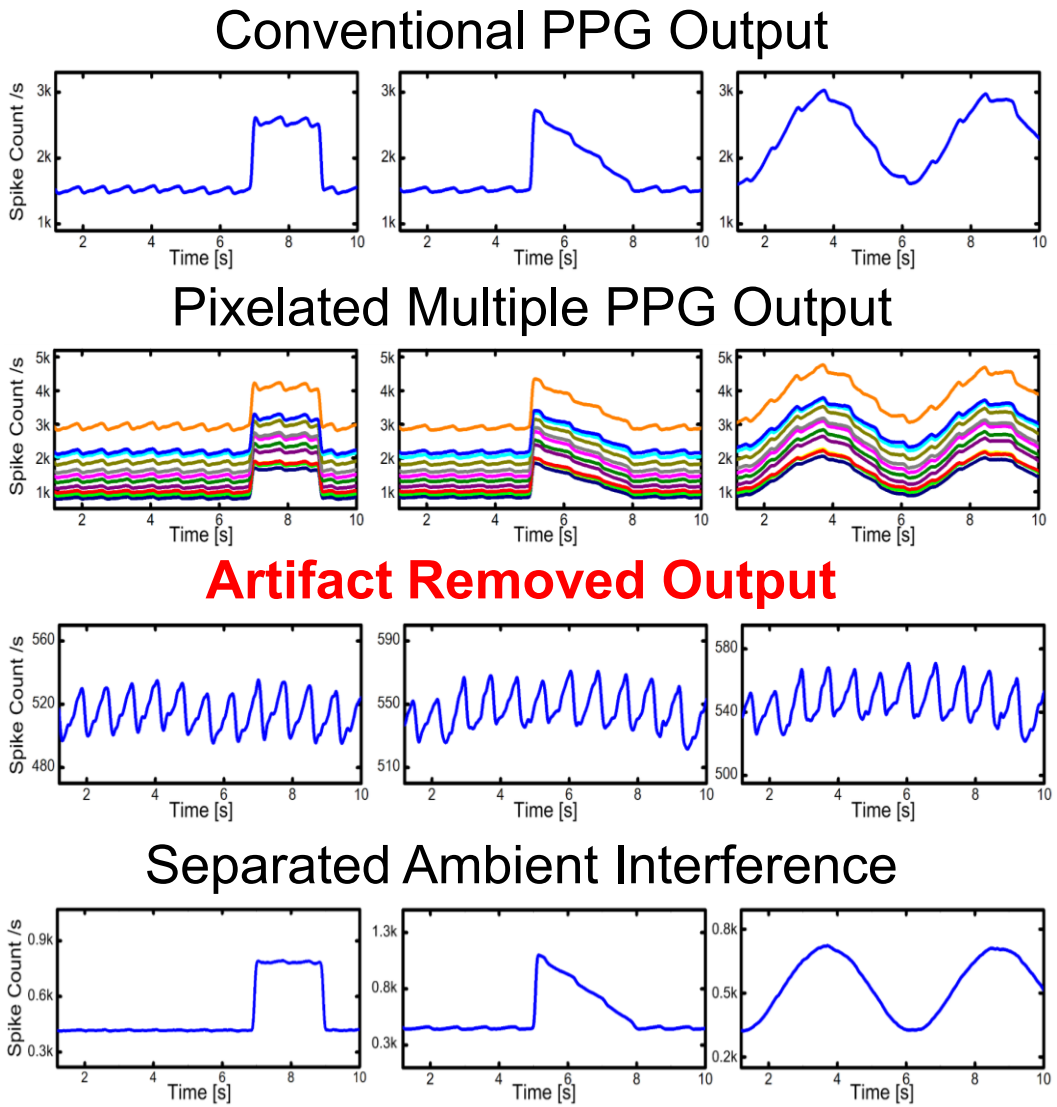
SNN-Based PPG Sensor



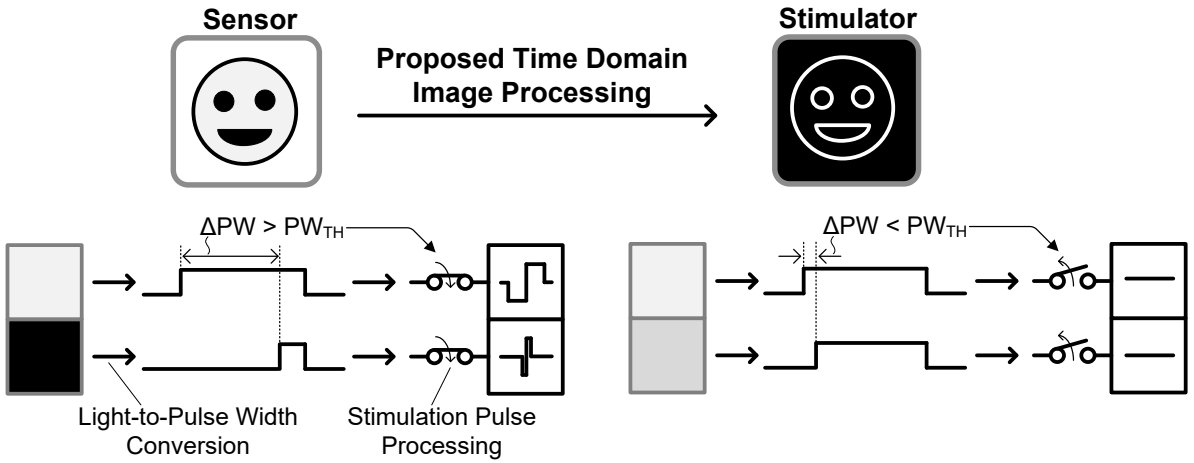


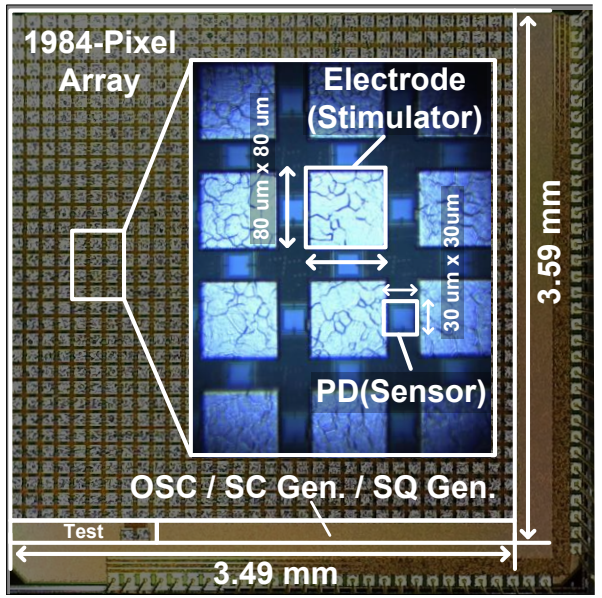


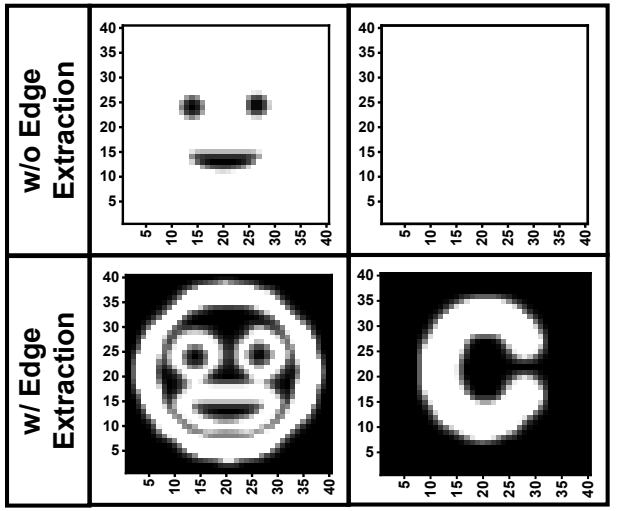
- The 1st Monolithic & Pixelated PPG Sensor [JSSC'23]
- Monolithic – minimizing system cost
  - In-pixel light-to-spike conversion
- Pixelated – extracting spatial information
  - Near-pixel row/col-wise spatial compression

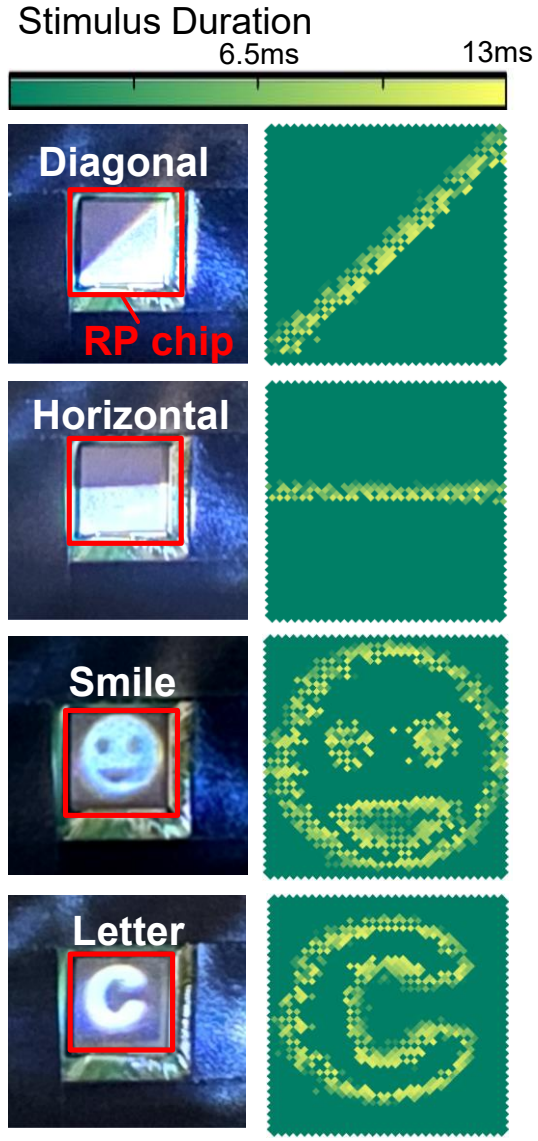


In-Pixel Edge Extracting Retinal Prosthesis Chip









- Time-domain in-pixel edge extraction
  - Light-to-stimulus duration conversion
  - Pulse-width based edge extraction

- x44.7 lower power/pixel & 1984-pixel with 80um x 80um electrode@ 3.6mm x 3.5mm chip area [JSSC'23]

Summary

- This work demonstrates two representative implementations: a wearable PPG sensor and an implantable retinal prosthesis chip

  A Pixelated Monolithic CMOS PPG Sensor for Spatial Feature Acquisition
  SH Kim, SM Ko, Dong-Woo Jee
  IEEE Journal of Solid-State Circuits, Vol. 58, No. 3, pp. 817-826

  A 1984-Pixels, 1.26nW/Pixel Retinal Prosthesis Chip With Time-Domain In-Pixel Image Processing and Bipolar Stimulating Electrode Sharing
  DH Choi, Dong-Woo Jee
  IEEE Journal of Solid-State Circuits, Vol. 58, No. 10, pp. 2757-2766

- In-sensor processing enables task-optimized efficient systems by embedding intelligence at the sensor level, exemplifying the future of bio-integrated electronics.