Ubiquitous Self-Powered Ambient Light Sensing Surfaces

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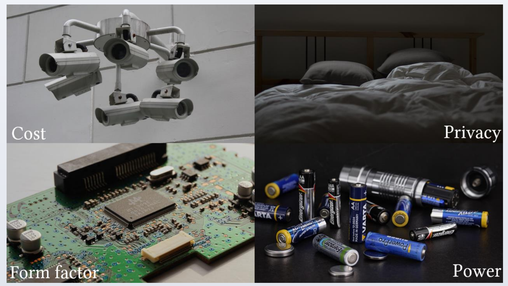
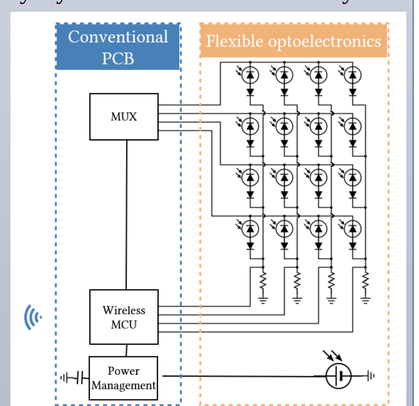
Motivation



- Conventional sensing technologies (e.g. cameras, battery-powered sensors) cannot keep up with large-scale applications due to limitations above
- We need:
  - Tight integration with physical surfaces to obtain high-fidelity signal
  - Self-sustained operation through energy harvesting
  - Novel semiconductor materials compatible with cost-effective manufacturing processes
  - Privacy-preserving sensing techniques

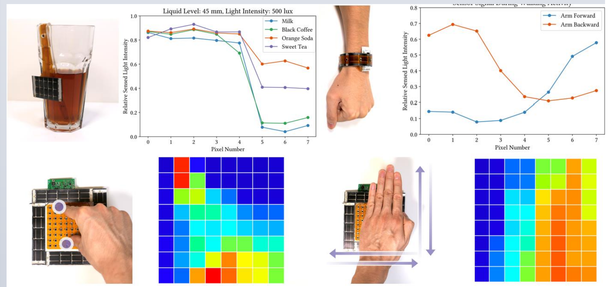
System

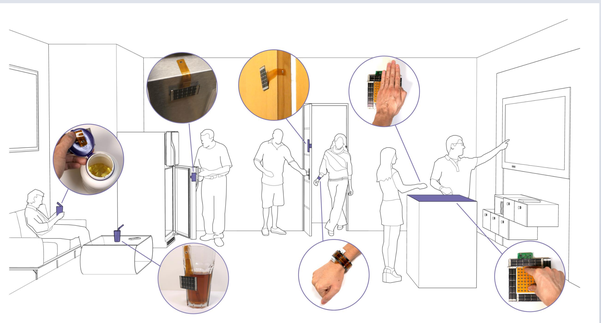
- We develop a self-powered ambient light sensing system on everyday surfaces for human activity sensing.
- A flexible imaging surface of photodetect-ors and solar panels
- A control circuit for power mana-gement, computation, and wireless communication



Application

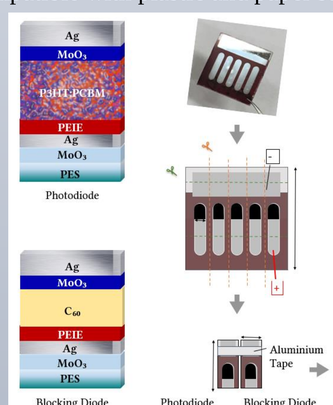
- The system senses ambient light interference patterns on physical objects for real-time human activity and interaction sensing with 90%+ accuracy from our user study, including
  - 0D object open/close state detection
  - 0D human presence detection
  - 1D liquid type and level sensing
  - 1D walking activity sensing
  - 1D indoor traffic sensing
  - 2D multitouch input
  - 2D hover gesture input
  - 2D hover gesture input with range extension

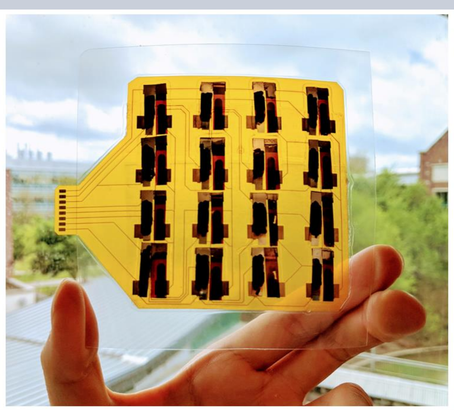




Organic Semiconductor

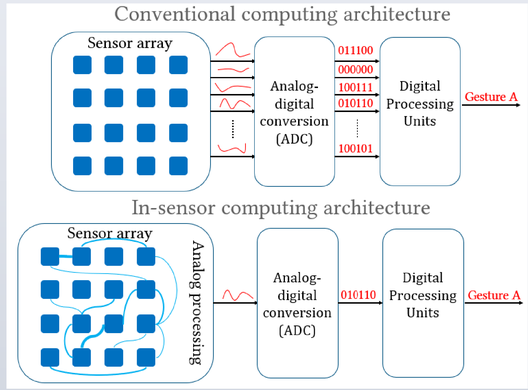
- Organic semiconductors (OSCs) including photodiodes and blocking diodes offer superior form factors – lightweight, thin, flexible, and compatible with plastic and paper substrates
- With additive manufacturing processes such as solution-based printing and coating, they are cost-effective to scale
- We demonstrate flexible organic imaging arrays with comparable performances to silicon devices (e.g. dark current, indoor responsivity)
- OSC-based ambient light sensing surfaces offer a path towards ubiquitous deployment on everyday surfaces





In-Sensor Computation

- Conventional Von Neumann architecture incurs excessive energy consumption and latency from pixel-wise signal acquisition and processing
- We are investigating in-sensor computing architecture for vision feature extraction prior to analog-digital conversion



- We leverage low-latency and self-powered in-sensor computing to pre-process the signal in analog domain, which also better protects user privacy
- OSC devices are inherently compatible with functional patterning for various analog circuit designs

Future Work

- We are exploring various OSC-based computational sensor designs for privacy-preserving, self-powered sensing of human activities and interactions