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Methods and apparatus for hierarchical event readout of pixel array

Stanford researchers have developed a hierarchical event readout method that solves a major latency problem in event-based image sensors. Event-based sensors output data only when pixels change, enabling fast and efficient sensing. However, existing readout approaches process events row by row. When many pixels change at once, events begin to queue, and readout latency can increase by hundreds of times, limiting use in applications that require low latency.

This technology addresses that limitation by reading out pixel events hierarchically instead of by rows. Events are merged from increasingly larger regions of the pixel array and transmitted asynchronously through a tree-like structure. This approach prevents congestion and keeps latency low even at high event rates.

Proof-of-concept designs demonstrate that hierarchical readout can reduce latency by up to 8,000-fold, cutting delay from 240 microseconds to 28 nanoseconds while supporting millions to billions of events per second. The architecture scales efficiently to megapixel arrays and is well suited for high-speed, low-latency sensing applications.

Applications

- Image sensors for monitoring industrial machinery
- Particle detectors for high-energy physics experiments
- Event-based and neuromorphic sensing systems requiring low latency

Advantages

- Prevents readout latency from ballooning at high event rates
- Reduces latency by up to 8,000× compared to state-of-the-art approaches
- Supports very high event rates while scaling to large pixel arrays
- Enables reliable low-latency operation for demanding sensing applications

Patents

- Published Application: WO2026213201

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