In-sensor Processing Techniques for Biomedical Applications

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In-sensor processing has emerged as a key enabler in biomedical applications where energy efficiency, spatial resolution, and form factors are critical. This work demonstrates two representative implementations: a wearable photoplethysmography (PPG) sensor [1] and an implantable retinal prosthesis chip [2]. The wearable device integrates a pixelated monolithic CMOS PPG sensor with spiking-neural-network-inspired architecture to locally extract spatial features and cancel ambient light interference using machine learning techniques. This architecture reduces power and system complexity while enabling robust physiological signal monitoring. On the other hand, the implantable retinal prosthesis utilizes time-domain in-pixel image processing to perform real-time edge extraction within each pixel. Combined with a bipolar stimulation scheme, it minimizes power and spatial blurring, enabling high-acuity artificial vision with ultra-low power. Both approaches demonstrate how in-sensor processing can transform traditional readout and processing pipelines into localized, task-optimized architectures. By directly embedding intelligence into the sensor layer, these systems offer scalable and application-specific solutions for continuous health monitoring and vision restoration. Together, they exemplify the future direction of bio-integrated electronics where sensing and processing are co-designed at the pixel level.

References

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