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Neural Signal Compression System for a Seizure-Predicting Brain Implant in CMOS 28nm

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Recent advances in neuroscience tools allow recording brain signals with a large number of electrode channels. These tools allow to further develop an understanding of neural diseases and develop novel treatments for intractable conditions such as drug-resistant epilepsy or blindness induced by age-related macular degeneration.

Designing implantable systems with a high electrode count is challenging due to the large data rate for wireless transmission and the extremely limited power budget to avoid tissue damage. To mitigate this issue, we develop a neural recording ASIC in 28-nm CMOS with embedded neural spike compression which takes advantage of the sparse nature of neural coding. The compression system includes a spike detector, a dimensionality reduction algorithm, and a quantization algorithm.

To determine the optimal compromise between compression ratio, signal quality, and hardware resources utilization, we compare different dimensionality reduction algorithms (autoencoders, principal component analysis) and vector quantization algorithms (quantized neural networks, tree-structured vector quantizers, lattice quantizers). We implement the algorithms using Mentor Catapult and we synthesize with Cadence Genus to get power and area measurements. We evaluate the signal-to-noise and distortion ratio of the reconstructed signal, the synthesized area, and power. Finally, we compare the compression methods in terms of the spike sorting accuracy.

Successfully embedding this compression system into an ASIC allows to significantly increase the number of electrodes in a wireless system. This is a first step toward the development of a seizure-forecasting system for patients with refractory epilepsy.

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