Bio-inspired analog architecture for ultra-low power always-on sensing
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Brain-Inspired Edge Computing

Today’s Edge Processing is Inefficient
- All sensed data is naturally analog, yet all edge processing is digital
- Need feature extraction/inference earlier in the signal chain – Discard irrelevant data up front like the brain
- Shift the analog/digital boundary so only the salient representations are digitized
- Mimic the brain with a more efficient edge architecture that eliminates high-power processing of irrelevant data

Unique Analog Capabilities

Sensor Interfacing as Software
- Easy to program
- Flexible and updateable in-the-field
- Programmed Mic+PPG interface

Efficient Programmable Features in Analog Fabric
- Arbitrary signal chains & parameter values
- Optimized features for smaller neural networks
- No ADC power consumption

RAMP Development Environment

High-Level RAMP Programming Environment
- Build up signal chain in scripting language (Matlab/Python)
- Simplicity of analog ML w/ digital processor
- Analog code for features to the left

Analog Feature Development & Training
- Send signal chain to multiple targets
- Compile to hardware
- Model in RAMPsim
- Train in deep learning frameworks

Apps & Performance

Voice
- Analog VAD gates power to higher power processing systems
- Achieve up to 10x system power savings

Low-Power Analog Glass Break Detector
- Developed on DCASE dataset
- 11µA – no ADC power
- Efficient classifier
  - TPR = 97.2%
  - FPR = 0.2%

RAMP Sensor Hub
- Lower-power sensor fusion
- Simplified integration
- Abstracted & programmable sensors

Efficient Operations and Architecture
- 2-bit Multiplication
- Configurable blocks: Filters, Matrix Multiply
- Analog Processor: Parallel, Reconfigurable

Analog Classifier Structure & Training
- Hooks into PyTorch and other training frameworks
- Measured Feedforward 3D Discriminant Examples

Efficient and Programmable Features
- New programmable analog ML chip analyzes raw analog data for relevance to application
- Analog neuromorphic chip enables lower power sensing systems for battery-powered always-on applications
- Integrated, software-programmable sensing stack
- Addresses many high-bandwidth always-on applications with single analog core

Aspiny Edge-Analog First Edge Processing Architecture
- Measured PPG Interface
- Measurement Mic Interface
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RAMP: Programmable Analog TinyML Solution
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