2020 MASTER AND SEMESTER PROJECT PROPOSALS

Theme: Circuits and systems for neural interfaces

Please submit your applications to arda.uran@epfl.ch with your CV, statement of results and a short paragraph describing your motivation and background to undertake the project.

Low-power analog-to-digital conversion for multichannel neural recording

Category: Mixed-signal circuit design

Project for: 1 M.Sc. diploma student / 2 M.Sc. semester project students.

Description: Implantable devices capable of monitoring brain activity are becoming important tools for neurophysiology research and brain-computer interfaces. Our current research is to design highly power efficient integrated circuits to maintain multi-channel neuronal signal acquisition. Analog-to-digital converters (ADC) are key elements in the signal chain that directly affect the overall system performance in terms of both power dissipation and recorded signal fidelity.

This project targets the design and evaluation of two popular types of ADCs in this context, namely SAR and VCO-based architectures. The student(s) will first survey the recent trends using both approaches, and then model them accurately in software to establish a high-level understanding of their operation. The main task of the project is the transistor-level design of the circuits and post-layout performance evaluation. The student(s) will gain considerable experience in spec-to-silicon design procedure and in the use of design tools.

Prerequisites:

Solid understanding of analog design fundamentals.
Acquaintance with full-custom design flow in Cadence Virtuoso.

Project breakdown:

10% Literature review
20% Modeling and sensitivity analysis
30% Full-custom design of the SAR ADC.
30% Full-custom design of the VCO-based ADC
10% Reporting results.

Supervisors:

Arda Uran (arda.uran@epfl.ch)
Prof. Volkan Cevher

Hardware-friendly selective feature extractors for neural classification tasks

Category: Machine learning

Project for: 1 M.Sc. diploma student / 2 M.Sc. semester project students.

Description: Neural signal classification requires large amount of data to be sampled through neural interfaces. Hardware cost of sending recorded data is a current bottleneck for multichannel signal acquisition systems. We are currently researching hardware-friendly feature extractors that will reduce the data transfer burden by preprocessing it at the interface level.

This project targets the dimensionality reduction in such feature extractors that can also be ported to implantable hardware. The student(s) will first survey the current state of the art for hardware feature extractors aiming different applications (epilepsy, ERP, motor). The main task of the project is to make the classification network (DNN) select features such that the final point in the complexity/performance tradeoff is close to optimal. The student(s) will gain considerable experience in neural signal classification and hardware-oriented signal processing.

Prerequisites:

Experience with neural networks.

Project breakdown:

10% Literature review
40% Neural classification experiments
40% Selective feature extraction experiments
10% Reporting results

Supervisor:

Arda Uran (arda.uran@epfl.ch)
Igor Krawczuk (igor.krawczuk@epfl.ch)
Thomas Sanchez (thomas.sanchez@epfl.ch)
Prof. Volkan Cevher

Ultra-wideband (UWB) wireless data transfer for neural recording implants

Category: System design and measurement

Project for: 1 M.Sc. diploma student / 2 M.Sc. semester project students.

Description: Wireless data transfer for neural implants require large bandwidth yet they are constrained with stringent power requirements to prevent thermal and electromagnetic hazards. Ultra-wideband (UWB) is a promising technology that achieves both these requirements for short distance communication and with data-dependent low power operation.

This project aims to demonstrate the feasibility of a learning-based neural data compression algorithm in terms of communication power efficiency. The student(s) will first study UWB technology and neural data compression techniques. The main task of the project is to control and test transmitter and receiver boards based on the Decawave IC that simulates the wireless link between the implant and the short-range target. The student(s) will gain considerable hands-on experience in electronics design and test environment.

Prerequisites:

Acquaintance with FPGA or MCU (Raspberry Pi, Arduino, MSP, PIC etc.) programming.

Project breakdown:

40% Transmitter and receiver board setup
20% Compression algorithm study
30% Measurements
10% Reporting results

Supervisors:

Arda Uran (arda.uran@epfl.ch)
Dr. Kerim Ture (kerim.ture@epfl.ch)
Prof. Catherine Dehollain