Project with industrial trainship at Silicon Austria Labs (Master degree in “Electronics Engineering”)

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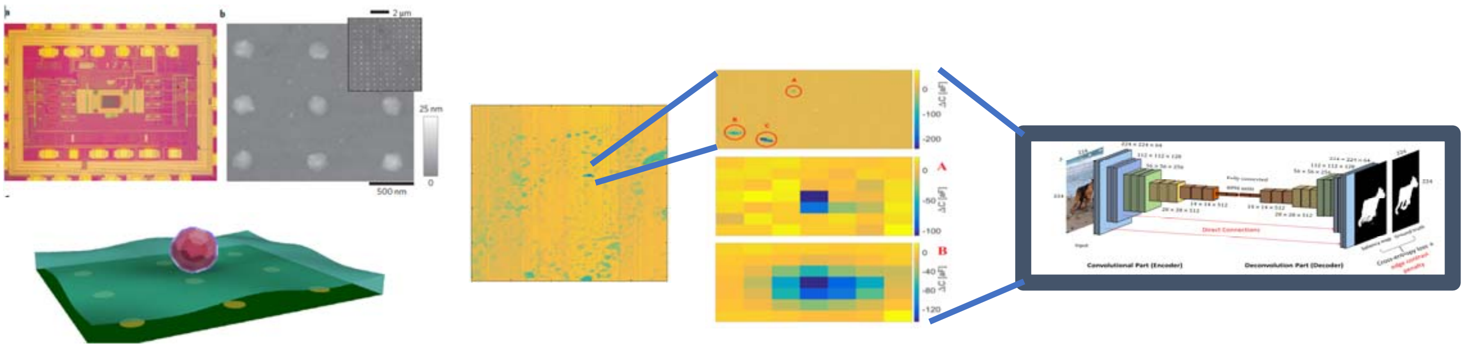
Title: Development of AI algorithms for targets recognition with nanoelectrode array biosensors
Keywords: Internet of Things, Internet of Health, Nanoelectronics, Nanobiosensing, Machine Learning, AI



Introduction: The Internet of Things / Health scenarios foresee the future deployment of trillions miniaturized low-power sensors monitoring physico-physiological and environmental data to improve the understanding and prevention of undesirable conditions for the humans and the environment. In this framework, existing and future large-scale integrated nanoelectronic platforms that offer massively parallel, label-free biosensing can combine all-electrical detection with low-cost integrated circuits technology (e.g., micro-/nano-electrode and ion sensitive field effect transistor arrays). Pioneering examples are currently available to the principal investigators, but their dependability and reliability must improve, especially regarding small analyte detection in the presence of measurement noise.
Research Objectives: 1) Demonstrate nanobiosensors with improved reliability and performance and the potential for AI in biosensors data analysis; 2) Leverage simulations for efficient AI training.
Research Challenges

- Biosensors typically suffer from low reproducibility, due to the many uncontrollable variables in any biological experiment.
- AI methods can learn very complex relations, however needing a large pool of data representing all possible conditions.
- Simulations can easily provide large pools of data for numerous and very controlled conditions, but the simulations need to accurately represent the real-world conditions.
- AI/ML methods have been mainly applied so far on traditional images, it is unclear how much benefit can be gained on spectrocopic biosensor pseudo-images.

Proposed research activity: The objective of the project is the execution of detection experiments with the available nanobiosensing platform and a variety of nanoscale analytes such as beads and rods in a multiplicity of environments (milliQ, IPA, electrolytes of different salt concentration and pH) to acquire a large experimental dataset of capacitance images measured in real time and at different frequency. Furthermore, the candidate will run physics-based simulations of the capacitance images with an in-house developed code or with COMSOL, to predict the expected response. The measurements aand simulations will be fed to ML/AI algorithms developed at Silicon Austria Labs during a 2-3 months stage of the candidate.
Research Approach: 1) use the available biosensor platform developed by NXP Semiconductors (dense matrix of 256x256 nanoelectrodes suitable for capacitance meas. in 1.6–300 MHz band); 2) Analyze capacitance maps from the nanoelectrode array, seen as an image sensor; 3) perform physics-based simulations with the available f.e.m. simulator ENBIOS or COMSOL to create very large training datasets; 4) Demonstrator application: Virus capsids characterization in real time.
Expected Impact: 1) Proof of concept of a new way to tackle the reliability problem of most (nano)biosensor platforms; 2) Show the relevance of ML/AI inspired algorithms in the biosensors field.
Connections with research groups, companies, universities: 1) Silicon Austria Labs (2-3 months stage to connect measurements with ML/AI based data analysis); 2) NXP Semiconductors (experiments); 3) Technical University of Vienna (data analysis with Bayesian techniques)