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XXXIII Cycle

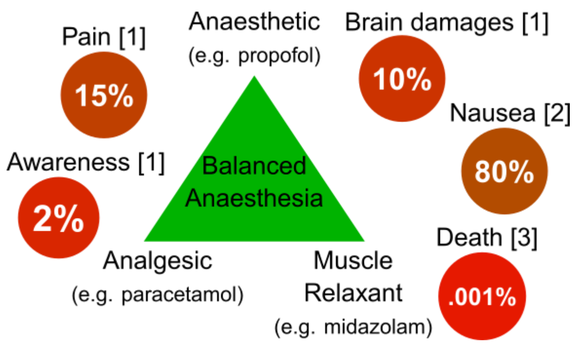
Continuous Monitoring of Anaesthetics Concentration to Control Anaesthesia Delivery

Simone Aiassa

Supervisors: Prof. Danilo Demarchi, Prof. Sandro Carrara

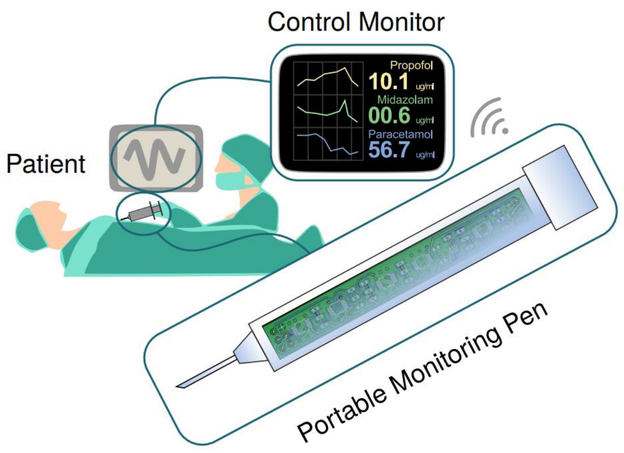
Research context and motivation

- The anaesthesia is a surgical procedure requiring the administration of a cocktail of drugs: hypnotic, analgesic, and muscle relaxant. The usage of prediction models to estimate the right dosage presents today high errors due to the patient's diversity
- Every year, **30,000 people** undergo anaesthesia and **remain awake**, **feeling pain**, many more are put into a uselessly deep or prolonged chemical coma.



Addressed research questions/problems

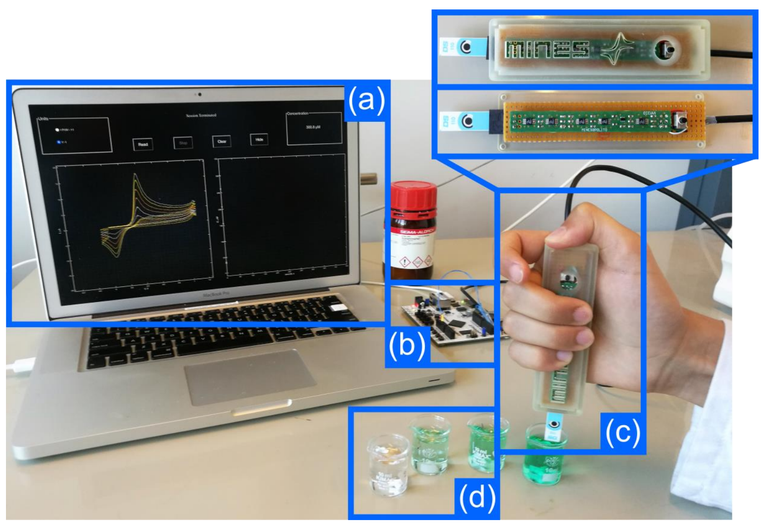
- The **Therapeutic Drug Monitoring (TDM)** can measure the actual drug concentration in the patient, allowing a dynamic adjustment to meet personal requirements.
- Nowadays, **no commercially-available** system can exploit a real-time point-of-care anaesthetic monitoring,



- Electrochemical investigation can be adopted to measure the therapeutic compounds, **Propofol, Midazolam, and Paracetamol.**
- I propose a **portable pen** to monitor at the **point-of-care** the delivery of anaesthetic compounds during surgery.
- The electronic interface requires to **be portable, low power, low cost**, and suitable to fit the barrel of a pen.
- The electrochemical sensor requires to be **needle-shaped**, in **sub-millimetre** scale and **low-affected by fouling** phenomena.
- The detection of drugs must be carried out with new algorithms to overcome **specificity**, **efficiency,** and **repeatability** of the measurement.

Novel contributions

- I propose an **event-based portable pen** able to sense aneastethics.
- Considered the requirements, the design of the system is based on a **bio-inspired event-based approach** to achieve:
  - complexity reduction,
  - easier processing in time,
  - noise reduction,
  - lower energy cost.
- The prototype is composed of:
  (a) software processing,
  (b) **FPGA** custom logic,
  (c) proposed portable pen (**COTS-PCB** and **Screen Printed Electrode-SPE**),
  (d) drug samples.



Adopted methodologies

- To overcome technological limitation I developed:

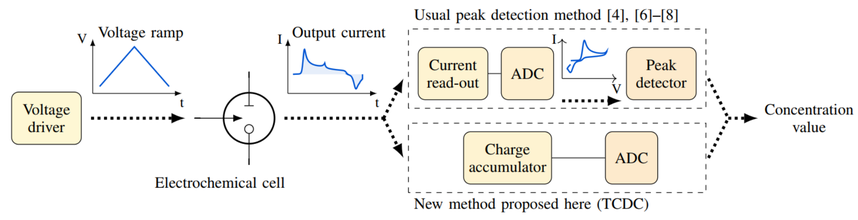
A. New electronic interface

- **Event-based** potentiostat.

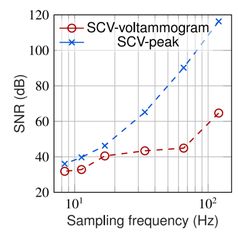
- **Event processing** digital interface.

B. New detection methods and sampling optimization

- **Total Charge** in CV drug-detection method.



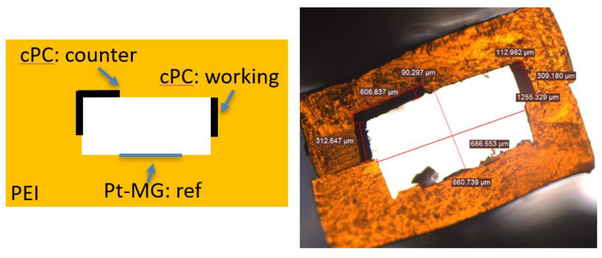
- **Sample-rate** optimization.



C. New electrochemical sensors

- **Pencil mine** for propofol.

- **Metallic fiber** needle biosensor (in collaboration with FIMAP at EPFL).



Future works

- Final assessments on **needle sensor**, tests on new materials.
- **Second prototype** assembly: wireless, optimized processing, new sensor, robust.
- **Bovine blood test**, with the complete prototype.
- On-field **animal test**, for veterinary application.

Acknowledgment

This work is supported by Politecnico di Torino and Compagnia di San Paolo under the initiative *Joint research projects with top universities* in co-operation with École Polytechnique Fédérale de Lausanne.

List of attended classes

- 01SGURV - Intellectual property rights, technology transfer and hi-tech entrepreneurship (22/03/2018, 6 CFU)
- 01SHCRV - Unsupervised neural networks, didattica di eccellenza (09/04/2018, 6 CFU)
- 01LCPIU - Experimental modeling: costruzione di modelli da dati sperimentali (16/04/2018, 6 CFU)
- 01SFURV - Programmazione scientifica avanzata in Matlab (20/04/2018, 4 CFU)
- 01SIHRV - Bio-nano electronics and biomolecular computing (07/09/2018, 4 CFU)

Submitted and published works

- **S. Aiassa**, F. Grassi, R. Terracciano, S. Carrara, and D. Demarchi, "Live Demonstration: Quasi-Digital Portable Pen to Monitor Anaesthetics Delivery", accepted to *2019 IEEE Biomedical Circuits and Systems Conference (BioCAS)*.
- **S. Aiassa**, F. Stradolini, A. Tuoheti, S. Carrara, and D. Demarchi, "Quasi-Digital Biosensor-Interface for a Portable Syringe to Monitor Anaesthetic Delivery", *2019 15th Conference on Ph.D Research in Microelectronics and Electronics (PRIME)*, Lausanne, 2019.
- **S. Aiassa**, S. Carrara, and D. Demarchi, "Optimized Sampling Rate for Voltammetry-Based Electrochemical Sensing in Wearable and IoT Applications", *IEEE Sensors Letter*, 2019.
- **S. Aiassa**, S. Carrara, and D. Demarchi, "Supplementary Material for Optimized Sampling Rate for Voltammetry-Based Electrochemical Sensing in Wearable and IoT Applications", *IEEE Dataport*, 2019.
- R. Terracciano, D. Demarchi, M. Ruo Roch, **S. Aiassa**, and G. Pagana, "Recent Advances in Nanoparticle-based Structures to Fight Cancer", submitted to *Journal of Nanoscience and Nanotechnology*.
- **S. Aiassa**, P. Motto Ros, G. Masera, and M. Martina, "A Low Power Architecture for AER Event-Processing Microcontroller", *2017 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, Turin, 2017.

External activities

- Guest PhD student at Integrated System Laboratory, École Polytechnique Fédérale de Lausanne (June 2018 – November 2018 and June 2019 – up to present)
- Innovation for change program (SEI and CERN, 27/06/2018, 2 CFU)
- Electrochemical nano-bio-sensing and bio/CMOS interfaces (EPFL, 22/06/2018, 1 CFU)
- Product development for medical devices (EPFL, 5/11/2018, 1 CFU)
- Wearables and implantables for personalized healthcare (EPFL, 23/11/2018, 2 CFU)
- Nanocomputing: devices, circuits and architectures (EPFL, 16/7/2019 , 1 CFU)

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PhD program in
Electrical, Electronics and Communications Engineering