Comparative study of data processing techniques for Organ-on-Chip applications

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Organ-on-a-Chips (OoC) are miniature systems designed to replicate the structure and function of human organs on a microscale. Constructed using microfabrication techniques, these chips house animal or human cells, cultured to mimic specific organ tissues.

Microfluidic channels enable the controlled flow of nutrients, oxygen, and other substances, creating a dynamic microenvironment. Equipped with sensors for real-time monitoring, OoC technology provides a valuable tool for studying physiological processes, modeling diseases, and testing drug responses in a more physiologically accurate and controlled in vitro setting. This innovation holds promise for advancing drug development and personalized medicine by offering more relevant and reliable models for experimentation.

Organ-on-a-Chip technology holds significant promise for diabetes research: these chips can be designed to replicate the structure and function of relevant organs, such as the pancreas, muscles, and liver, which play crucial roles in glucose regulation. Our aim, through a collaboration between IMS (Bioelectronics) and CBMN (Cell biology), is to study the role of pancreatic cells interacting with other cell types through recordings of electrical behaviour.

However, while Organ-on-Chip technology presents significant potential, it is accompanied by notable challenges. Integrating sensors onto the chip proves to be difficult due to its compact size and the biological nature of the cultured material. The microfluidic dynamics inherent in these systems also introduce substantial noise during data acquisition. Finally, the real-time constraint of the system requires performing acquisition systems and fast data processing algorithms.

The current system provides real-time processing of the electrical signal delivered by pancreatic cells on a MicroElectrode Array, but does not account for the important biological variability and the perturbations brought by microfluidics.

To address these issues, this work proposes a comparative study in the performance of four robust, real-time data processing algorithms. The algorithms are meant to detect an oscillatory frequency of the signal through event detection or frequency based methods. The evaluations were carried out both on synthetic and experimental data.