Bruno Donato, Francesca Stradolini, Abuduwaili Tuoheti, Federico Angiolini, Danilo Demarchi, Giovanni De Micheli, Sofia Lydia Ntella and Francesca Stradolini, Abuduwaili Tuoheti, Danilo Demarchi, Alkis A. Hatzopoulos and Sandro Carrara, "A completely new biosensing platform is developed and tested, providing fast, fully-automated and simultaneous sensing output of multiple memristive biosensors.

Addressed research questions/problems

1) Anesthesia is a way to control pain during a surgery or procedure by using medicine called anesthetics. In anesthesia, an accurate balanced delivery of several compounds, including anesthetics, analgesics and muscle relaxants is required to achieve a certain target plasma concentration able to assure appropriate sedation and to avoid intoxication or awareness. The effect of anesthesia on patient is expressed as the Depth Of Anesthesia (DOA) which is a very challenging parameter to estimate.

Traditional methods to evaluate this crucial parameter are based on the observation of several physiological symptoms such as patient’s heart rate and blood pressure.

- Inaccurate
- Poor predictivity
- Highly-cost and bulky instrumentation

An intelligent real-time continuous monitoring system for anesthesia is developed in collaboration with EFFE.

- Reliable
- Real-time
- Intelligent
- Portable and low-cost

2) Prostate cancer is the most common cancer among men except for skin cancer, and the detection at early stages is crucial. Memristive biosensors have been proved as excellent candidates for ultrasensitive biosensing in cancer detection. So far, the experimental tests on memristive biosensors are performed using a Cascade Microtech Probe Station and a Hewlett-Packard 4165A Precision Semiconductor Parameter Analyzer, implementing tungsten needles to directly contact the NiS-niS pads of the nanostuctures.

- Inflexible
- Unpractical
- Time-consuming
- High-cost

A completely new biosensing platform is developed and tested, providing fast, fully-automated and simultaneous sensing output of multiple memristive biosensors.

Novel contributions

1) The real-time Continuous Monitoring system for Anesthesia (CoMofA) has the capability of carrying out 3 parallel potentiostatic measurements for the different drugs Paracetamol, Propofol and Midazolam, known as anesthesia cocktail. Comparison between the system and the commercial potentiostat Autolab is done in the following:

- Slow
- Not portable
- >20K$ Manual
- Complex

2) The memristive bio-sensing platform has the capability of reading 12 channel bio-sensor signals and it’s composed of a Raspberry Pi 3 and custom designed PCB.

- 42 min/test
- Not portable
- Expensive
- Manual

Adopted methodologies

1) In CoMofA system, the electrochemical techniques adopted are: CV and DPV.

<table>
<thead>
<tr>
<th>Method</th>
<th>Start-V (mV)</th>
<th>End-V (mV)</th>
<th>V-Step (mV)</th>
<th>Period (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>-100</td>
<td>1100</td>
<td>3.22</td>
<td>32</td>
</tr>
<tr>
<td>DPV</td>
<td>-100</td>
<td>1100</td>
<td>3.22</td>
<td>32</td>
</tr>
<tr>
<td>CA</td>
<td>0</td>
<td>450</td>
<td>3.22</td>
<td>32</td>
</tr>
</tbody>
</table>

2) In the Memristive Bio-sensing Platform, a voltage scan is applied as follows:

<table>
<thead>
<tr>
<th>Voltage Scan</th>
<th>Start-V (mV)</th>
<th>End-V (mV)</th>
<th>Step-V (mV)</th>
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<td>32</td>
</tr>
</tbody>
</table>

Future work

The next plan is to develop an embedded intelligent system that can work both as a sensing platform and an actuator platform. The system shall have the following functionalities:

- Plug and play functionality for bio-sensor drivers
- Cloud data management
- Intelligent data processing
- Self-setting for hardware configuration
- Parallel task implementations
- Low cost and portable

List of attended classes

- 01SGRV – Telemedicine and Distributed Healthcare (19/02/2016, 4)
- 01DCU – Reconfigurable Computing (10/03/2016, 4)
- 01QFRV – Metamateriali: teoria e applicazioni elettromagnetiche (22/03/2016, 4)
- 01QFRV – Two-state Quantum systems with circuits Applications (28/04/2016, 6)
- 01QHHL – Techniques of robust control (27/04/2016, 6)
- 01PIFV – Eletta informatica (11/05/2016, 4)
- 01QFRV – Writing Scientific Papers in English (19/06/2016, 3)
- 02JERF – Programmazione degli esperit industrial (01/07/2016, 5)
- 08BITRV – Project Management (20/09/2016, 1)