BIOMED group

DESIGN OF AN INTEGRATED BIOSENSOR FOR AUTOMATED POSTOPERATIVE MONITORING

1 Supervising staff

Maxime Verstraeten (Teaching assistant, maxime.verstraeten@ulb.be)
Thomas Sprockeels (Urologist)

2 Context

Postoperative care is critical in preventing severe complications such as respiratory distress, haemorrhage, and infections. Current monitoring relies on intermittent manual measurements by healthcare personnel, which can lead to:

- **Delayed anomaly detection** due to sporadic checks.
- **Increased workload** for medical staff, contributing to fatigue and human error.
- **Incomplete data integration**, as existing devices measure individual parameters (e.g., heart rate, blood pressure, SpO_2) without centralized analysis.

While wearable biosensors exist, most lack:

- **Multiparametric integration** (combining multiple vital signs into a unified system).
- **Real-time predictive analytics** using artificial intelligence (AI) or regular algorithms.
- **Seamless clinical workflow integration** (automated alerts, long-term wearability, minimal patient discomfort).

This project aims to bridge these gaps by developing an **autonomous, wireless biosensor** that continuously monitors key postoperative parameters and employs **sensor fusion and AI/algorithms** for early risk detection.

The goal is, therefore, to design a unique biosensor capable of integrating all key parameters of postoperative monitoring and automating their real-time collection.
This project, at the intersection of **embedded systems, AI/algorithms, and clinical medicine,** represents a unique opportunity for future engineers to explore the rapidly growing fields of biomedicine and embedded systems engineering. It is a technical and scientific challenge that directly impacts improving healthcare.

3 Work

a) **Hardware Development**:

- Design a **wearable, multiparametric biosensor** capable of measuring:
  - Heart rate (via photoplethysmography, PPG)
  - Blood pressure (non-invasively)
  - Oxygen saturation (SpO_2)
  - Respiratory rate

  - Skin temperature
  - … ECG and other optional measurements
- Ensure **low-power operation** for prolonged monitoring (24+ hours).
- Optimize **wearability and patient comfort** (wireless connectivity, flexible materials, lightweight wearability-oriented design).

b) **Software and Data Processing**:

- Develop **real-time sensor fusion algorithms** to consolidate data into a **unified health indicator**, capable of triggering alerts for the medical team.
- Implement **AI-based anomaly detection** (e.g., machine learning for early warning of complications).
- Compare AI performance with **classical signal processing methods** (e.g., threshold-based alerts).

c) **Validation and Clinical Relevance**:

- **Bench testing**: Verify sensor accuracy against medical-grade devices.
- **Human trials**: Initial testing on the student (self-experimentation), followed by controlled clinical validation (if feasible, in collaboration with physicians).
- **Medical feedback**: Collaborate with physicians to assess parameter relevance and usability in real postoperative care.

The work thus includes these main steps:

- Literature review of the existing sensors, postoperative complications and the relevant monitoring systems.
- Sensor design (modalities selection, breadboard and PCB design, …).
- Firmware and connectivity (data acquisition, wireless connectivity (BLE, …) with a focus on low-power operation.
- Data fusion, algorithms and potentially AI use.
- Validation (test-bench of the prototype versus reference devices, and human application).
- Clinical feedback and iteration.

4 References

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