Development of a multiclass classification model to detect blood pressure variations associated with physical or cognitive stress

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Research context and motivation

- Blood Pressure (BP) is considered the most important physiological variable for monitoring. Hypertension is a major risk factor for cardiovascular end-organ damage, morbidity, and mortality. On the other side, Hypotension, is a common and a predictor of mortality following major surgery and in critical care.
- The limitations of cuff-based devices can be grouped in three categories:
  - Unavailability: Cuff devices are not readily available. People with no access to these devices are not aware of their condition or they do not manage properly the disease
  - Lack of comfort: Repeated cuff inflations and deflations are disruptive to patient
  - Intermittent measurement: Oscillometric cuff devices do not provide continuous BP measurement making difficult to track the BP profile of the subject.
- Cuffless blood pressure (BP) measurement offers great promises for addressing the following issues:
  - Hypertension awareness by bringing regular BP monitoring to the masses during daily life
  - Long-term hypertension control by continually monitoring and revealing high BP readings to individual patients
  - Hypotension surveillance and therapy by providing seamless, continuous BP monitoring

Addressed research questions/problems

- Two custom PPG sensors designed particularly for the evaluation of the impact of local blood flow regulation on this parameter and how it affects the BP-PTT relationship, Eq 1.
  \[ PTT = \frac{d}{\Delta P} \]  
- A graphic user interface (GUI) and a dedicated algorithm have been implemented to perform a real-time assessment of the PTT and other features of interest from the signal.
- Three different ML models based on Random Forest classifier have been developed to detect different stress levels using only PPG data.

Novel contributions

- Proposed System
  - Novel PPG sensors
  - Software and hardware system deployable on elbow and thumb
  - Algorithm for PTT detection

Adopted Methodologies

Data Collection Protocol

- Stage 1: At Rest (REST)
- Stage 2: Cognitive Task (CT)
- Stage 3: After Short Exercise (AE)

- Instruction to perform a correct BP measurement:
  - Room with controlled temperature set at 22°C
  - Subject seated-back-supported
  - Feet on the floor, not crossed, knees at 90°
  - Hands on the table at the same heart level

Data Processing

- Bandpass Filtering Stage
- Data Segmentation
- Artifacts removal
- Signal Quality Assessment
- Fiducial Points Extraction
- Fiducial Points Validation

Data Analysis

- Random Forest Classifier whose hyperparameters have been optimized by cross-validated grid-search over a parameter grid.
- Three individual models have been implemented differing for the amount of data used in the training phase:
  - Subject Specific Model (SD): Only data from a specific subject is used for training.
  - Hybrid Models (HM): the training set includes 50% of data from the subject to predict and pulses from other individuals in the dataset.

Future work

- Improvement of the design of the PPG sensors towards a more wearable solution for long term monitoring application
- Deploy an online implementation of the proposed workflow to perform a real-time assessment.
- Development of an ensemble of regressor models to perform the systolic and diastolic blood pressure assessment.

Publications

- Published works: 2 conferences
- Submitted works: 1 journals