A Biosignal-Specific Processing Tool for Machine Learning and Pattern Recognition

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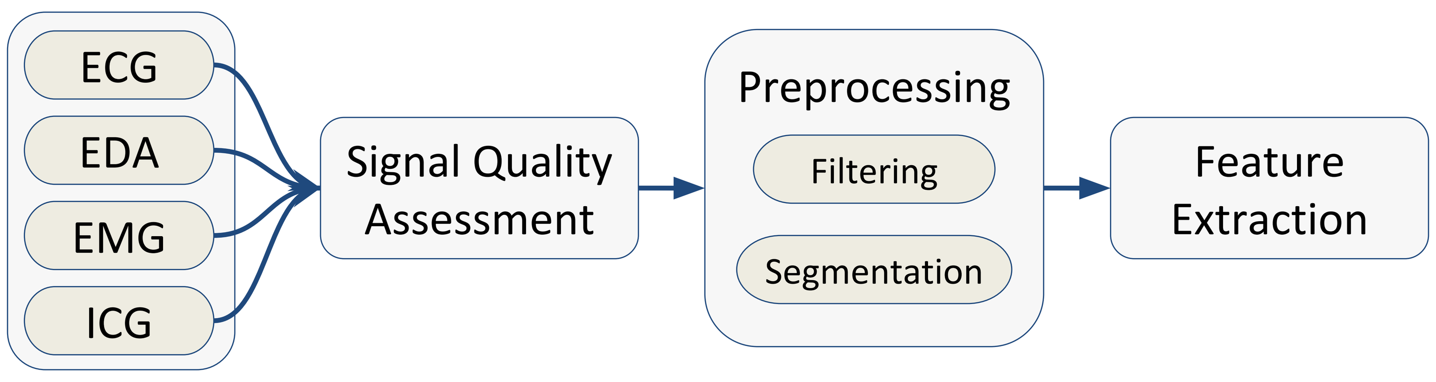
Motivation

- ➢ Electrocardiogram (ECG), Electrodermal Activity (EDA), Electromyogram (EMG) and Impedance Cardiography (ICG) are widely used in various biomedical applications including health tracking, sleep quality assessment, early disease detection/diagnosis and human affective state recognition [1].
- ➢ A significant amount of knowledge is required to properly process these biosignals since distinct methods for noise and artifact removal, segmentation and feature extraction are needed for each signal modality [2].
- ★ The present work aims at providing an open-source biosignal-specific tool for psychologist, neuroscientists and researchers in machine learning and pattern recognition to extract feature matrix from these bio-signals automatically and reliably.

Framework



★ This tool is an open-source software written in MATLAB and made compatible with MathWorks Classification Learner app for further classification purposes such as model training, cross-validation scheme farming, and classification result computation.

Dataset & Quality Assessment

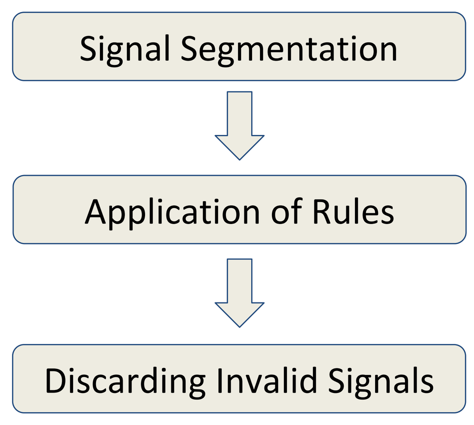
A. Dataset :

- ➢ Recorded ECG, EDA, EMG and ICG signals from 100 participants, including 40 males and 60 females. (Collected by the Affective Computing group in NEU.)
- ➢ 20% of the dataset was employed for algorithm testing and verification purposes.

B. Signal Quality Assessment:

Simple rules for determining invalid data:

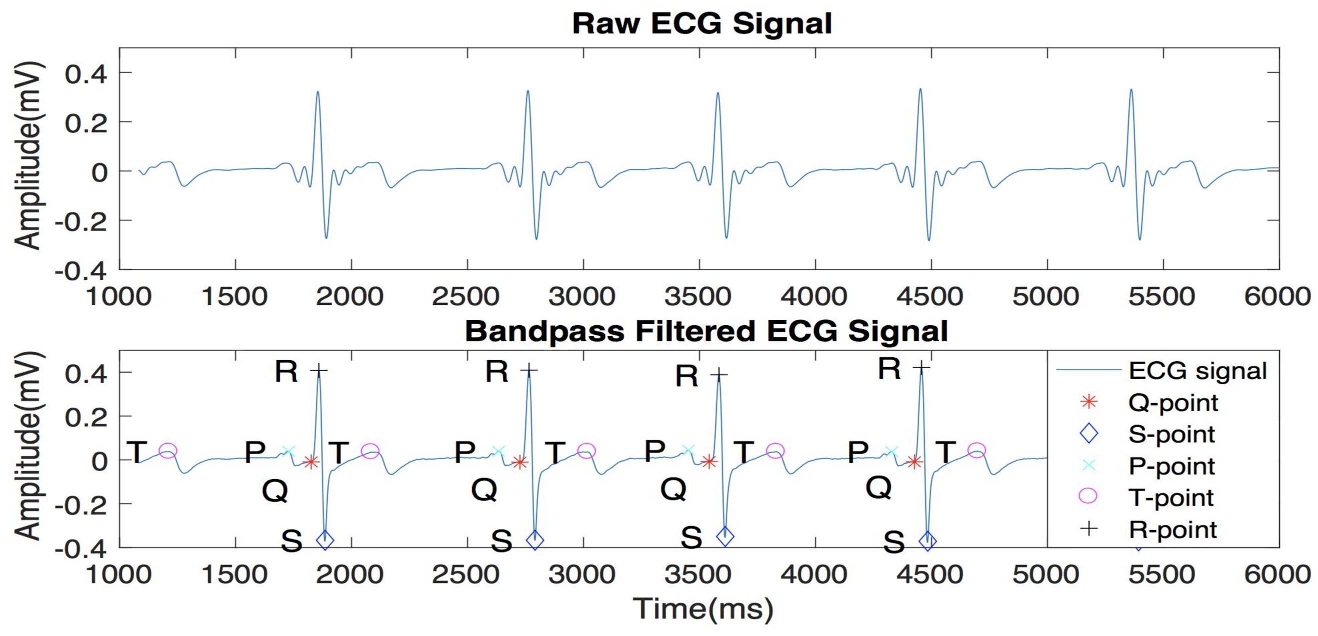
- ➔ Is signal out of range?
- ➔ Does it changes too quickly?
- ➔ Is it constant for an extended period?
- ➔ Is it surrounding by invalid portions?



Methods and Materials

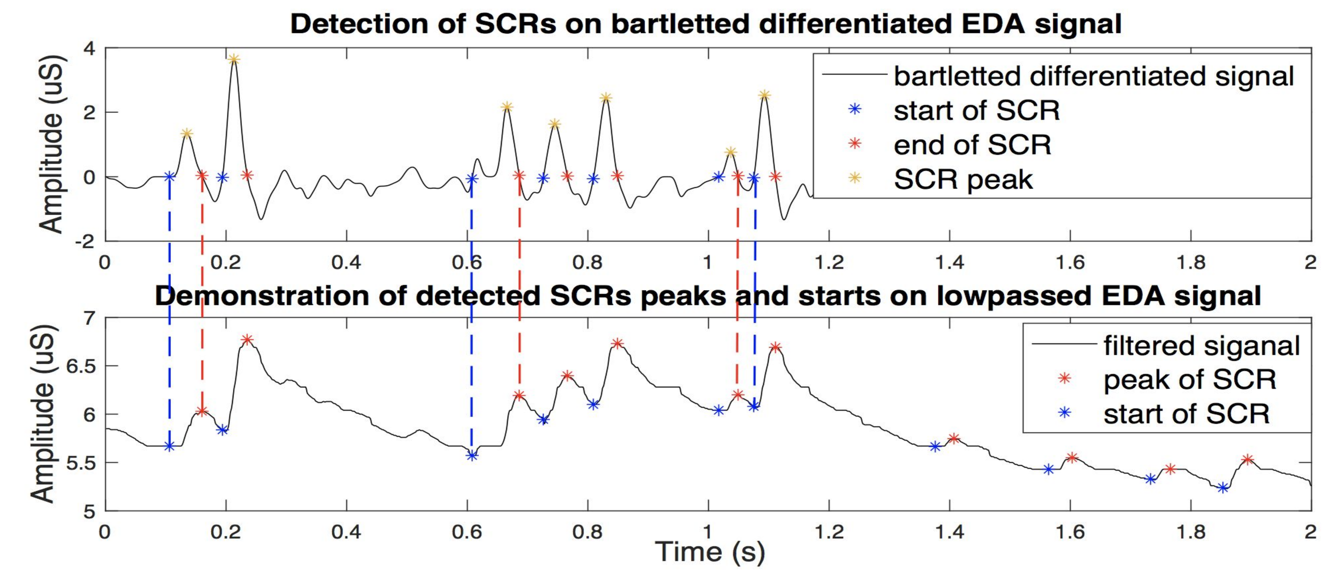
Electrocardiogram (ECG) :

- ➢ A band-pass Elliptic filter was provided for the noise removal as a pre-processing step.
- ➢ Inspired by Pan-Tompkins [3], we have modified the detection algorithm to reflect a more robust QRS detection.
- ➢ Based on QRS detection, 10 features were extracted include RR interval, standard deviation of RR intervals, QR to QS ratio , RS to QS ratio and others.



Electrodermal Activity (EDA):

- ➢ A Gaussian low-pass filter have been recommended and used for the filtering process of EDA [4].
- ➢ Skin conductance response (SCR) was detected by performing differentiation and subsequent convolution with a 20-point Bartlett window [5].
- ➢ Features including SCR duration, SCR amplitude, SCR rise-time, and number of SCRs were extracted.

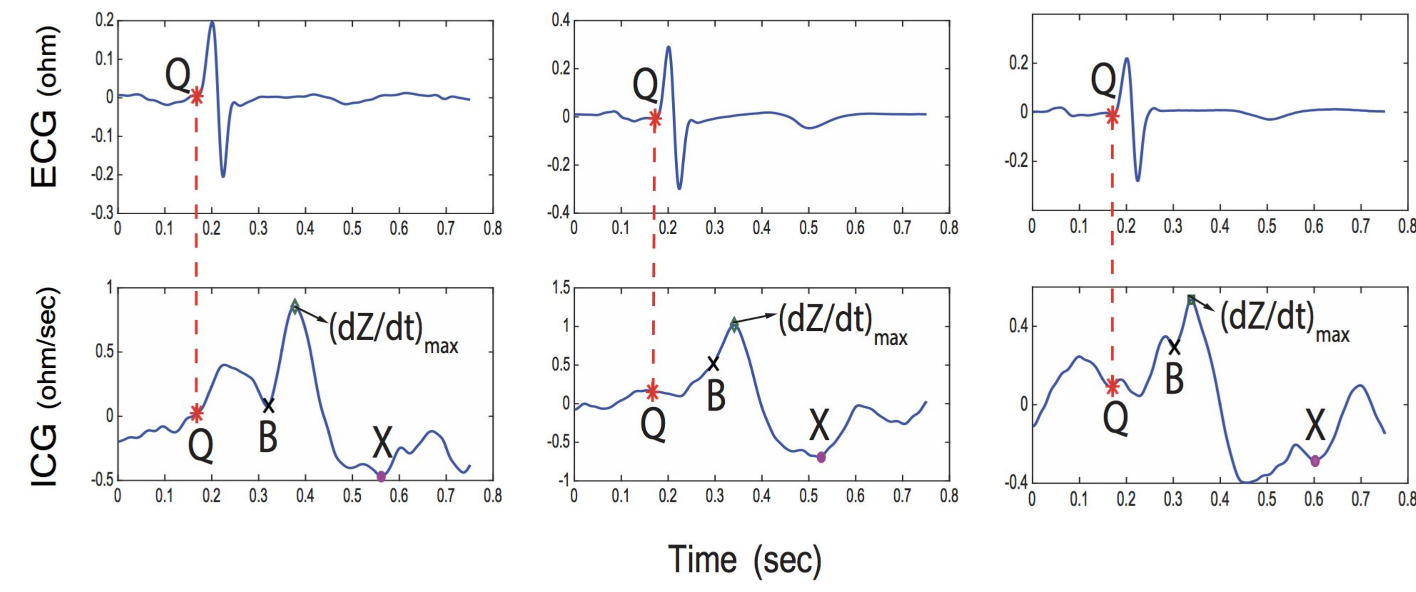


Electromyography (EMG):

- ➢ An Elliptic bandpass filter with the cutoff frequency of 10-300Hz was recommended for the EMG filter.
- ➢ Feature options for EMG was selected based on D. Tkach's work [19], including EMG mean absolute value, EMG zero crossing count, Slope Sign Change, Waveform Length, and Log Detector of EMG signals.

Impedance Cardiography (ICG):

- ➢ The preprocessing of ICG includes noise removal using a second order elliptic band-pass filter, segmentation and ensemble averaging [2,7].
- ➢ Robust algorithms [7] were developed to find the characteristic points Q, B, (dz/dt)max and X on the ICG signal.



- ➢ Then, these characteristic points are used to calculate the physiological features including PEP, LEVT, SV, CO and TPR [7] .

$$PEP = T_B - T_Q \qquad CO = SV \times heartrate/1000$$

$$LVET = T_X - T_B \qquad TPR = (BP/CO) \times 80$$

$$SV = \rho \times (L/Z_0)^2 \times LVET \times (\mathrm{d}Z/\mathrm{d}t)_{max}$$

Graphical User Interface (GUI)

We embedded all the algorithms explained earlier for the preprocessing and feature extraction of the ECG, EMG, EDA and ICG biosignals, all in one easy-to-use,MATLAB based toolbox. This toolbox is accessible via MathWorks File Exchange site [8]. The two main pages in the GUI are demonstrated in the following figures.

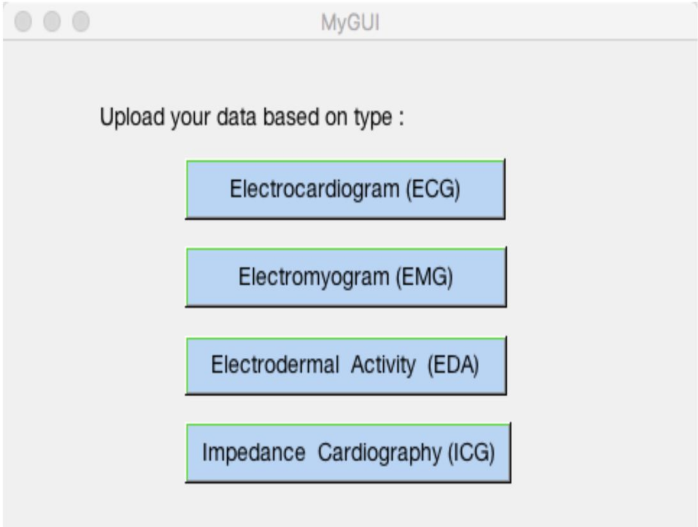


Figure 1. Loading the corresponding signals.

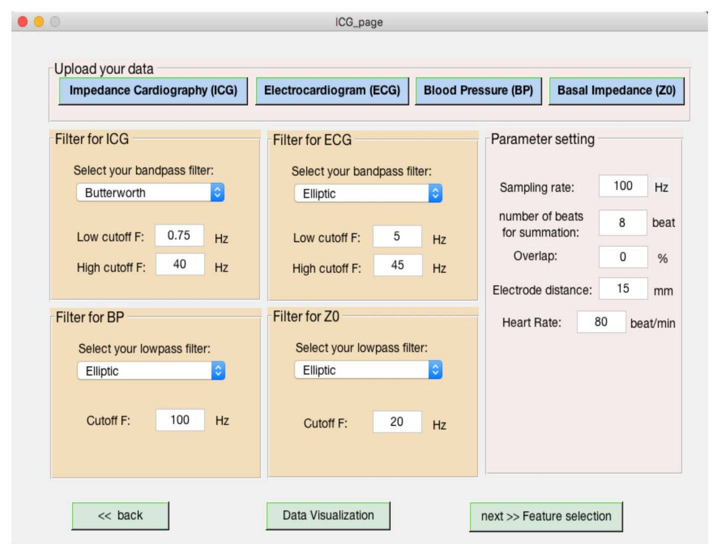


Figure 2. Setting the filtering type and parameters

Conclusions

In this work, we have created a biosignal-specific processing and feature extraction software in MATLAB based on the state-of-the-art algorithms provided in scientific literature for each type of biosignals. The software computes the corresponding feature matrix of biosignals, which can be further used as input feature matrix for variety of machine learning and pattern recognition algorithms. This open-source tool could be useful in facilitating research in machine learning, affective computing, and psychology.

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