

Detection of human stress using short-term ECG and HRV signals

Abstract

This paper introduces a method for resolving the problem of human stress detection through short-term (less than 5 min) electrocardiogram (ECG) and heart rate variability (HRV) signals. The explored methodology helps to improve the stress detection rate and reliability through multiple evidences originated in same sensor. In this work, stress-inducing protocol, data acquisition, preprocessing, feature extraction and classification are the major steps involved to detect the stress. In total, 60 subjects (30 males and 30 females) participated in the Stroop color word-based stress-inducing task and ECG signal was acquired simultaneously. The wavelet denoising algorithm was applied to remove high frequency, baseline wander and power line noises. Discrete wavelet transform (DWT)-based heart rate (HR) detection algorithm is used for deriving HRV signal from the preprocessed ECG signal. The ectopic beat removal method is employed to eliminate the ectopic beat and noise peaks in the HRV signal. In order to detect the stress, the issue of uneven sampling with the HRV signal has been successfully rectified using the Lomb-Scargle periodogram (LSP). The application of LSP in short-term HRV signals (32 s), uneven sampling issue, and power spectral information issue has been rectified and the trustworthiness of the short-term HRV signal has been proved by hypothesis as well as experimental results. Theoretical analysis suggested that a minimum 25 s of online or offline ECG data is required to analyze the autonomous nervous system (ANS) activity related to stress. In addition to the HRV signal, ECG-based stress assessment has been proposed to detect the stress through optimum features using fast Fourier transform (FFT). Various features extracted from the ECG and HRV signal have been classified into normal and stress using PNN and kNN classifiers with different smoothing factor and k values. The experimental results indicate that the proposed methodology for short-term ECG and HRV signal can achieve the overall average classification accuracy of 91.66% and 94.66% in the subject-independent mode.

Keywords

Electrocardiogram (ECG); Heart rate variability (HRV); Human stress detection; Stroop color word test