PPG Signal Morphology-Based Stress Assessment

Mantas Rinkevičius, Spyridon Kontaxis, Eduardo Gil, Raquel Bailón, Jesús Lázaro, Pablo Laguna, and Vaidotas Marozas

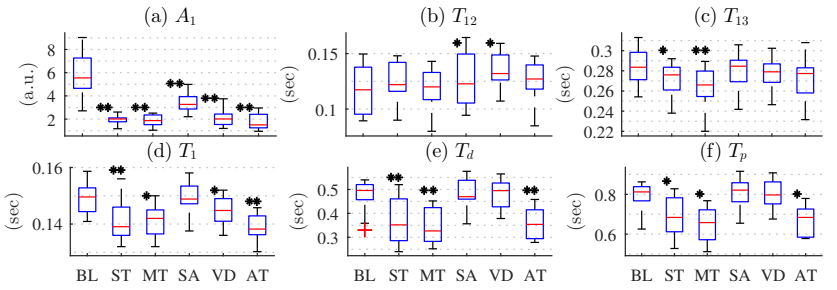
Kaunas University of Technology
Kaunas, Lithuania

Aim. Stress is a healthy natural response to a perceived or actual threat. However, when stress is persistent, it decreases work productivity, increases the risk of diseases, and affects the quality of life. Stress is reflected in physiological variables such as blood pressure, velocity of forward and reflected pulse waves related to vessel stiffness, and heart rate, among others. This study analyses parameters derived from PPG signal morphology for mental stress assessment.

Methods. A low-complexity algorithm is designed using the filtered second derivative of the PPG signal for estimation of three wave amplitudes A_1, A_2, and A_3 (located at T_1, T_2, and T_3, respectively), related to the forward pulse P_1 and the reflections P_2 and P_3 from the *renal* and *iliac* sites in the central arteries, respectively. The time delay T_{12} between P_1 and P_2, and T_{13} between P_1 and P_3 are analyzed as surrogates of instantaneous vessel stiffness. Additional parameters are studied including the amplitude A_1 and delay T_1 related to systole, the diastolic interval T_d estimated from dicrotic notch until the end of the pulse, and the pulse duration T_p. The data (11 subjects) contain a baseline (BL) and five different stages with induced stress: storytelling (ST), memory task (MT), stress anticipation (SA), a video display (VD), and arithmetic task (AT).

Results. The most significant differences between BL and the stress stages are found for A_1 and T_1, where lower values are related to sympathetic activation, while T_d shows better performance than T_{12}, T_{13}, and T_p.

Conclusion. The analyzed PPG signal morphological parameters are related to stress-induced sympathetic activation, thus offering the potential to be used in wearable devices for unobtrusive monitoring and management of occupational stress, and prevention of cardiovascular diseases.



Boxplots of the parameters: (a) amplitude A_1 of P_1, (b) time delay between P_1 and P_2, (c) time delay between P_1 and P_3, (d) time delay T_1 of P_1, (e) duration of diastole T_d, (f) pulse-to-pulse interval T_p. Significant differences relative to BL are marked with * ($p < 0.05$) and ** ($p < 0.001$).