A Probabilistic Physiological Prior Based Sparse Deconvolution Scheme for Identifying Autonomic Nervous System Activation from Electrodermal Activity by Md. Rafiul Amin

Abstract: Skin conductance (SC) signals are the skin's conductance fluctuations owing to the sweat discharge from the sweat glands in response to the neural stimulation from the autonomic nervous system (ANS). SC recordings are very popular in psychological studies as it contains information about emotional arousal. In most of the recent studies, SC is regarded as the summation of two different components. The relatively fast variation of SC, called the phasic component, reflects sympathetic nervous system activity. The slow variation related to thermoregulation and general arousal is known as the tonic component. Deciphering the encoded neural information related to emotional arousal by decomposing the SC signal into its constituents is a challenging task.

In this research, we present an SC decomposition algorithm for the inference of the ANS activations. We model the phasic variations with a two-dimensional state-space formulation representing the diffusion and evaporation processes of sweating. In this model, we assume a sparse impulsive neural signal originated from ANS is stimulating the sweat glands for sweat production. Further, we model the tonic changes with multiple weighted and time-shifted cubic B-spline functions. We formulate an optimization problem with Gaussian priors on system parameters, a sparsity prior for the neural stimuli, and a smoothness prior for the tonic component. Finally, we incorporated a generalized-cross-validation-based coordinate descent approach to balance among the smoothness of the tonic component, the sparsity of the neural stimuli, and the residual. We illustrate that we can successfully recover the unknowns and separate both tonic and phasic components from both experimental and simulated data. We further demonstrate our ability to automatically identify the sparsity level for the neural stimuli and smoothness level for the tonic component. Also, we evaluate its performance in discrimination between the SC responses due to auditory stimulation and spontaneous ones. Our generalized-cross-validation-based novel method for SC signal decomposition successfully addresses previous challenges and retrieves a physiologically plausible solution. Accurate decomposition of SC could potentially improve cognitive stress tracking in patients with mental disorders.