Introduction

- Many studies have shown that patients with psychiatric disorders are at risk for suicidal behavior.

- Mental disorders have been identified as one of the major causes of death worldwide.

- Electrodermal Activity (EDA) indicates eccrine sweat gland activity which is partly caused by psychological events including different emotions.
A Probabilistic Physiological Prior Based Sparse Deconvolution Scheme for Identifying Autonomic Nervous System Activation from Electrodermal Activity

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Goal & Existing Challenges

EDA
Deconvolution Algorithm
Sparse Neural Stimuli from Brain [input $u(t)$]
System $h_\theta$ [Parameters $\theta$]

Challenges in Existing Deconvolution Schemes:
- Sparsity level of $u(t) = \sum_{j=1}^n u_j \delta(t - \Delta_j)$
- Smoothness level of tonic component
- Presence of Noise

Methods

- Skin conductance signal can be modelled as the summation of two components.

  $h_\theta = \sigma_j = 1 u_j \delta(t - \Delta_j)$

- The fast varying component is called the phasic component which can be modelled as convolved result of SNS activity.

- Phasic impulse response $h_\theta(t)$ can be written as Bateman function,

  $$h_\theta = \begin{cases} 
  \frac{1}{\tau_r - \tau_d} \left( e^{-\frac{t}{\tau_r}} - e^{-\frac{t}{\tau_d}} \right) & ; t \geq 0 \\
  0 & ; \text{otherwise}
  \end{cases}$$

  where $\theta = [\tau_r \ \tau_d]^T$.

- The slow varying component is called the tonic component. We can model the tonic components with cubic spline basis functions.
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Discrete Model:

\[ y_{sc} = F_\theta x_{d_0} + D_\theta u + Cq \]

Optimization Formulation:

\[
\min_{\theta, u, q} J_\lambda(\theta, u) = \frac{1}{2} \left\| y_{sc} - F_\theta x_{d_0} - D_\theta u - Cq \right\|^2 + \lambda_1 \left\| u \right\|_1 + \lambda_2 \left\| q \right\|^2 + \lambda_3 \left\| r_r \right\|^2 + \lambda_4 \left\| r_d - \mu_d \right\|^2
\]

Methods (cont’d.)

- Initialization \( l = 0 \)
- Estimate \( \theta^{(l+1)} \) with \( u^{(l)} \) and \( q^{(l)} \)
- Estimate \( u^{(l+1)} \) with \( \theta^{(l+1)} \), \( q^{(l)} \), and \( \lambda_1 \)
- Estimate \( q^{(l+1)} \) with \( u^{(l+1)} \), \( \theta^{(l+1)} \), and \( \lambda_2 \)
- \( l \leftarrow l + 1 \)
- Until Convergence

GCV for \( \lambda_1 \)

GCV for \( \lambda_2 \)

Generalized-cross-validation (GCV) for identification of regularizers

Gaussian Prior (\( l_2 \)-norm)

Laplacian Prior (\( l_1 \)-norm)
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Results

• We also show its ability of discriminating between event related and non-event related responses on auditory stimulation dataset [1].

Future Work

• We plan to extend the approach to multi-channel recordings with a convex problem formulation.

• One of the future goals is to achieve fast implementation for wearable devices in cognitive stress tracking.

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Reference