Psykiatri Rigshospitalet DTU

novo nordisk fonden

Multimodal Signal Modelling for Intervening and Managing Mental Disorders

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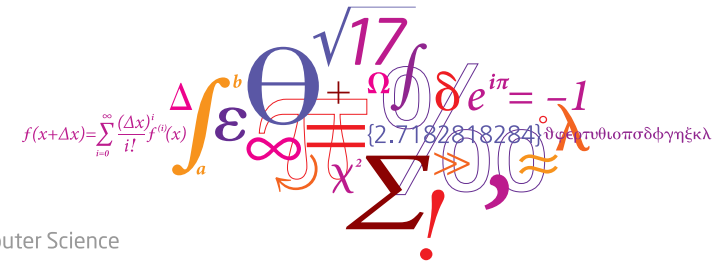


DTU Compute
Department of Applied Mathematics and Computer Science

Outline

- Motivation
- General introduction
- Audio
- Biosignals
- Conclusions

Mental Health and Mental Disorders

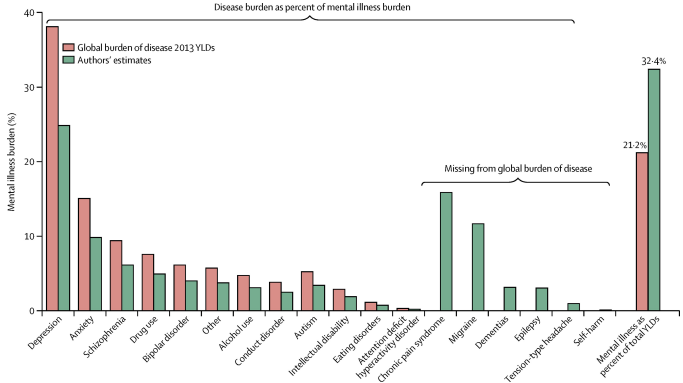


Figure: Original image from Vigo et al., 2016

- Mental illness is one of the leading causes of global disease burden (Prince et al., 2007; Vigo et al., 2016).
- In Denmark, 15% of youth will be diagnosed with a psychiatric disorder before their 18th birthday (Dalsgaard et al., 2020).

WristAngel: Intervention and Research for OCD Treatment I

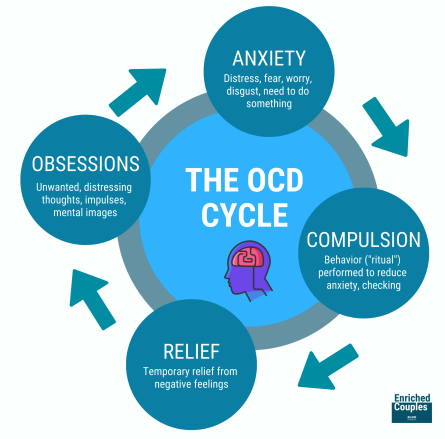


Figure: Obsessions and compulsions behave cyclically. Original image from `https://medium.com/amalgam/ocd-is-not-what-you-think-it-is-ee818028e79c`

- Mental disorder wherein "People are caught in a cycle of obsession and compulsions".
- Obsessions $\rightarrow$ intrusive and disruptive urges, thoughts, images, etc.
- Compulsions $\rightarrow$ behavior to overcome obsessions, distress.
- In 2010, anxiety disorders - including obsessive-compulsive disorders -alone cost Europe over €74 billion (Gustavsson et al., 2011).

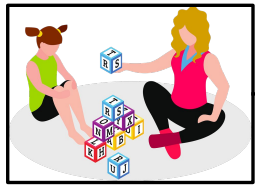
WristAngel: Intervention and Research for OCD Treatment II

Identify and predict impending OCD events and provide useful interventions → progression and severity of disorder.
Aid in delivering cognitive behavioral therapy to patients.

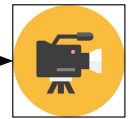
WristAngel

- Sneha Das — DTU Compute
- Line H. Clemmensen — DTU Compute
- Nicole Nadine Lønfeldt — Child and Adolescent Mental Health Center, KU Hospital
- Anne Katrine Pagsberg — Faculty of Health, Department of Clinical Medicine, KU
- Nicklas Leander Lund — DTU Compute

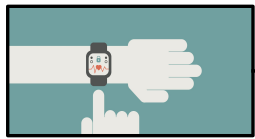
Data and Signals



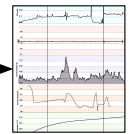
Therapy sessions



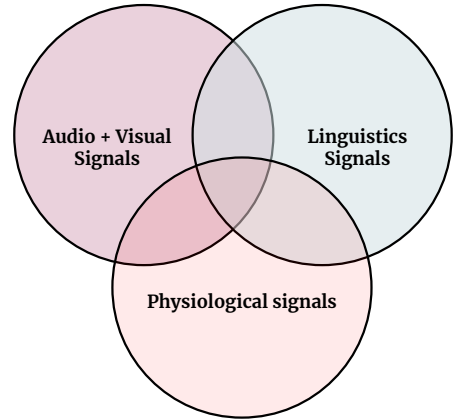
Videos



Wearable device

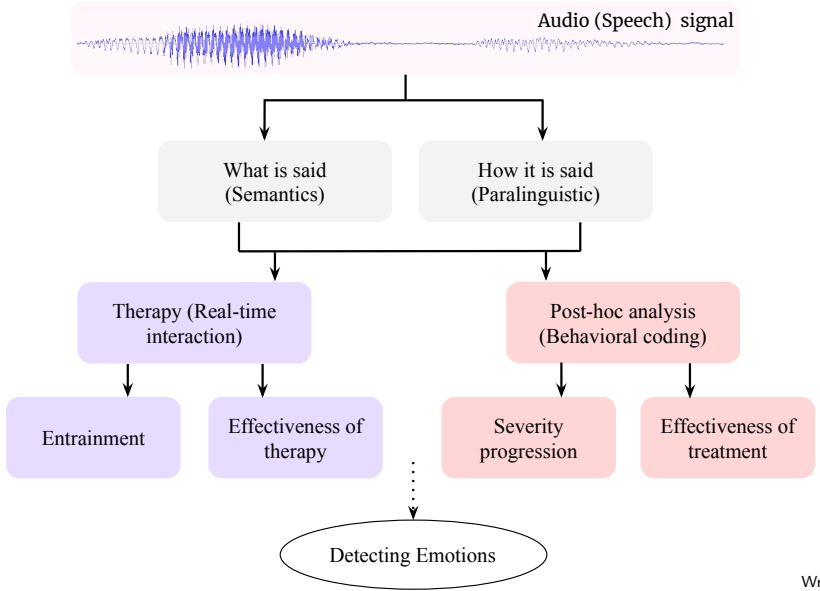


Heart-rate, EDA, Accelerometer



AUDIO SIGNALS

Role of Audio (Speech) in OCD Treatment



Speech Emotion Detection I

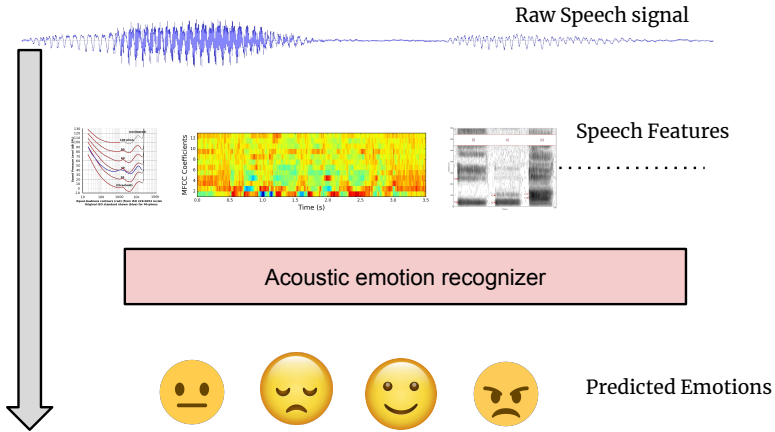


Figure: Image sources https://medium.com/prathena/the-dummys-guide-to-mfcc-aceab2450fd; https://commons.wikimedia.org/wiki/File:Lindos1.svg; https://commons.wikimedia.org/wiki/File:Spectrogram_-iua-.png

Speech Emotion Detection II

Conventional approaches

• Statistical ML and signal processing	HMM, GMM, SVM
• Deep learning (DL)	RNN, CNN, LSTM with deep architectures
• Hybrid	Eg., DL +SVM

Persistent challenges

• Generalization	corpora, languages $\rightarrow$ cultural, phonetic differences
• Low-resource corpora	Small data set and lack of labels
• Black-boxes	

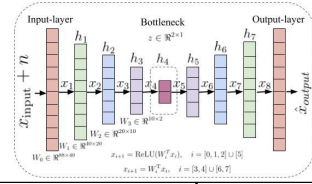
Methodology

Transferable feature embedding

Denoising autoencoder (DAE)

$\mathcal{L}_{\text{Total}} = \mathcal{L}_{\text{Rec}}$

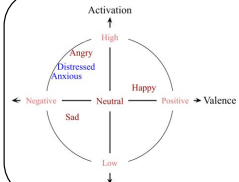
Discriminating subspace



Semi-supervision (metric learning)

$\mathcal{L}_{\text{Total}} = \mathcal{L}_{\text{Rec}} + \mathcal{L}_{\text{Met}}$

Emotion relevant embedding



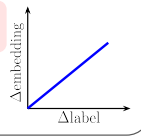
Dimensional emotion model (Activation, valence)

1. Consistent over languages, in contrast to emotion class labels
2. Allows to model emotion classes that does not exist in training dataset.

Continuous metric loss for emotion modelling

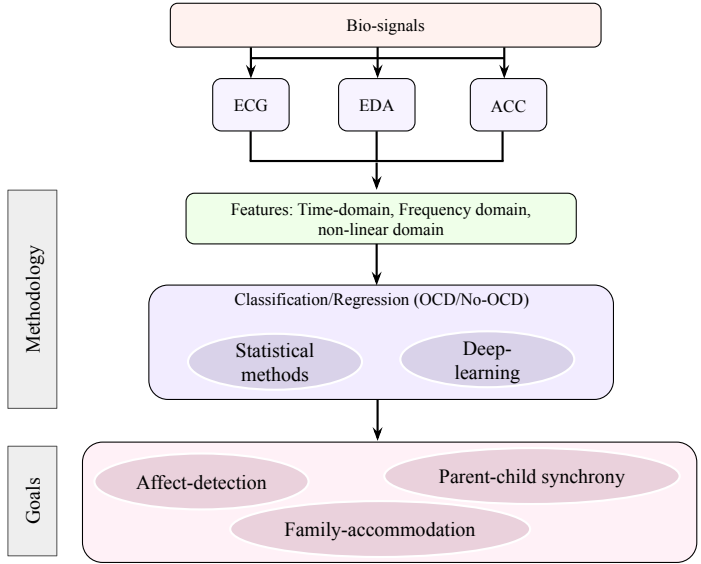
$\mathcal{L}_{\text{Met}} = \mathcal{L}_{\text{Slope}} + \mathcal{L}_{\text{Res}}$

Label: Activation, valence



BIOSIGNALS

Signals, Methods and Goals



Tying Modalities Together