Doctoral School of Information and Biomedical Technologies Polish Academy of Sciences

Subject

Computational intelligence methods for time-ordered medical data

Supervisor, contact, place of research
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Project Description

Within this project, real-life heterogeneous dataset of high medical importance will be analysed. The primary objective is to accurately predict a phase change in bipolar disorder using data collected from various sources, namely, smartphones and psychiatric assessments. Bipolar disorder is a serious mental illness affecting more than 2% of the world's population and characterized by fluctuations between different mood phases, ranging from depression to manic episodes and mixed states. Our dataset was collected in the recent years (2017-2019) during the observational study, which was conducted in collaboration of Systems Research Institute, in the Department of Affective Disorders, Institute of Psychiatry and Neurology in Warsaw and in the centre specializing in the clinical trials – Prosen Net. During the study, a dedicated smartphone app was developed and installed on patients' smartphones. It worked in the background to record daily statistics about calls and text messages and to extract the acoustic features of the patient's voice during phone calls, such as for example loudness or pitch. Crucially, the psychiatric state of each study participant was assessed every two months. Many challenges remain open in regards to the analysis, monitoring and prediction of the mental state of a patient. The mental state was observed only indirectly using smartphone-based data and psychiatric assessment data. Problems to be solved are the following:

1. Unsupervised and semi-supervised learning algorithms for time series monitoring

Smartphone-based systems for bipolar disorder monitoring typically try to solve a classification problem of detection of the disease phase. However, even though the data collection is performed during the everyday life of a patient, the number of labeled data is reduced only to days around the clinical assessment. The intelligent combination of the unsupervised, supervised and semi-supervised techniques is a novel approach allowing for better identification and prediction of indirectly observed process, namely the mental state of a patient.

2. Prediction using an intelligent combination of Bayesian Networks with objective priors

Bayesian Networks are used in many application areas, such as bioinformatics, diagnostic systems, robotics, and are often used to support medical diagnosis owing to their interpretability and clear, visual structure. Importantly, they allow to include the domain knowledge into modeling and inference with the prior probabilities. However, the proper formulation of priors is challenging. The objective priors will be constructed using the outputs of the psychiatric assessment.

3. Linguistic summarization for human-machine communication

Linguistic summarization enables to describe large datasets with natural language, such as for example, *Most patients call less frequently in depression than in euthymia*. Summarization techniques extract hidden knowledge from large databases, and hence improve their comprehension. Efficient human-machine communication with the patient or the psychiatrist about a detected alarming situation is challenging. Informing a psychiatrist about absolute values collected from smartphone is insufficient because patients have their own usage habits. Patient-dependent linguistic summaries could support this communication.

4. Monitoring stability of indirectly observed process using intelligent combination of statistical process control and predictive modeling

The observed smartphone-based data are autocorrelated and often short (for example less than 50 observations). Many of the traditional methods for time series analysis and process monitoring inaccurately monitor such data. However, intelligent combination of statistical process control and predictive modeling may alleviate the problems of autocorrelation and small samples. Discrete autoregressive processes will be innovatively combined with the weighted model averaging approach to support the monitoring of the autocorrelated indirectly observed process, namely the mental state of a patient.

5. Prediction of indirectly observed processes using deep learning

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The aim of deep learning will be to build end-to-end trainable models that are able to use raw smartphone-based, acoustic features and psychiatric assessment data. Although deep neural networks have been successfully build for many different tasks ranging from speech recognition to computer vision, the challenge remains to build end-to-end training for the partially uncertain data coming from the bipolar disorder domain.

Bibliography

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