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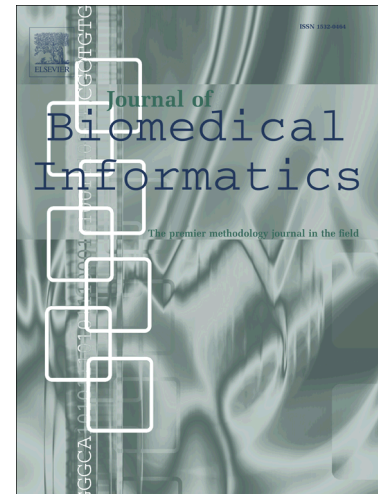
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How Are You Feeling?: A Personalized Methodology for Predicting Mental States from Temporally Observable Physical and Behavioral Information

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Abstract

It is believed that anomalous mental states such as stress and anxiety not only cause suffering for the individuals, but also lead to tragedies in some extreme cases. The ability to predict the mental state of an individual at both current and future time periods could prove critical to healthcare practitioners. Currently, the practical way to predict an individual's mental state is through mental examinations that involve psychological experts performing the evaluations. However, such methods can be time and resource consuming, mitigating their broad applicability to a wide population. Furthermore, some individuals may also be unaware of their mental states or may feel uncomfortable to express themselves during the evaluations. Hence, their anomalous mental states could remain undetected for a prolonged period of time. The objective of this work is to demonstrate the ability of using advanced machine learning based approaches to generate mathematical models that predict current and future mental states of an individual. The problem of mental state prediction is transformed into the time series forecasting problem, where an individual is represented as a multivariate time series stream of monitored physical and behavioral attributes. A personalized mathematical model is then automatically generated to capture the dependencies among these attributes, which is used for prediction of mental states for each individual. In particular, we first illustrate the drawbacks of traditional multivariate time series forecasting methodologies such as vector autoregression. Then, we show that such issues could be mitigated by using machine learning regression techniques which are modified for capturing temporal dependencies in time series data. A case study using the data from 150 human participants illustrates that the proposed machine learning based forecasting methods are more suitable for high-dimensional psychological data than the traditional vector autoregressive model in terms of both magnitude of error and directional accuracy. These results not only present a successful usage of machine learning techniques in psychological studies, but also serve as a building block for multiple medical applications that could rely on an automated system to gauge individuals' mental states.

Keywords: Mental State Prediction, Machine Learning, Multivariate Time Series

1. Introduction

Major mental illnesses such as schizophrenia, bipolar disorder, and chronic diseases do not just appear unexpectedly, but often gradually emit symptoms that can be externally observed in early stages [1]. Such illnesses might be prevented or managed more effectively if anomalous mental states are detected during the early stages of the disease, where special care and treatment could be provided. For example, intervention and careful observation could be provided by medical specialists to individuals who have high risk of mental health problems. Given that assessment of individuals' mental states from their appearance or behavior is still advanced psychological science that has not yet been automated, most mental diagnosis solutions involve active participation of patients and medical ex-

perts [2, 3]. Although solutions that involve screening tests exist, such solutions would not be feasible for large populations due to financial and time constraints. Furthermore, diagnosis-based methods sometimes end up discouraging sick individuals from participating [4]. As a result, psychological disruptions often remain undetected, or under-treated.

Oftentimes, an individual's mental state has direct impact on his/her behavioral outcomes, and vice versa. For example, a person may experience intense stress after losing a job, which may later cause him/her to consume extraordinary amounts of alcohol. Similarly, positive interactions with friends may decrease the level of one's stress. It is our conjecture that an individual's mental state can be inferred from his/her physical behaviors that can be objectively observed. A trivial, illustrative example would be the ability to predict whether someone is satisfied with life from his/her alcohol intake, hours of sleep, and social interactions. The ability to model the interplay between behavioral and emotional attributes could also shed light

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