# Personalized Graph Attention Network for Multivariate Time-series Change Analysis: A Case Study on Long-term Maternal Monitoring

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## ABSTRACT

Internet-of-Things-based systems have recently emerged, enabling long-term health monitoring systems for the daily activities of individuals. The data collected from such systems are multivariate and longitudinal, which call for tailored analysis techniques to extract the trends and abnormalities in the monitoring. Different methods in the literature have been proposed to identify trends in data. However, they do not include the time dependency and cannot distinguish changes in long-term health data. Moreover, their evaluations are limited to lab settings or short-term analysis. Long-term health monitoring applications require a modeling technique to merge the multisensory data into a meaningful indicator. In this paper, we propose a personalized neural network method to track changes and abnormalities in multivariate health data. Our proposed method leverages convolutional and graph attention layers to produce personalized scores indicating the abnormality level (i.e., deviations from the baseline) of users' data throughout the monitoring. We implement and evaluate the proposed method via a case study on long-term maternal health monitoring. Sleep and stress of pregnant women are remotely monitored using a smartwatch and a mobile application during pregnancy and 3-months postpartum. Our analysis includes 46 women. We build personalized sleep and stress models for each individual using the data from the beginning of the monitoring. Then, we compare the two groups by measuring the data variations. The abnormality scores produced by the proposed method are compared with the findings from the self-report questionnaire data collected in the monitoring and abnormality scores generated by an autoencoder method. The proposed method outperforms the baseline methods in exploring the changes between high-risk and low-risk pregnancy groups. The proposed method's scores also show correlations with the self-report data. Consequently, the results indicate that the proposed method effectively detects the abnormality in multivariate long-term health monitoring.



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## CCS CONCEPTS

• **Applied computing** → **Health informatics**;

## KEYWORDS

Multivariate Time-series, Graph Attention Network, Change Analysis, Maternal Health, Long-term Monitoring

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## 1 INTRODUCTION

Internet-of-Things (IoT) technology is fundamentally transforming traditional and hospital-based healthcare into ubiquitous health monitoring, by which individuals are remotely monitored while they engage in their daily activities [9]. Such monitoring systems exploit a distinct set of paradigms – such as smart devices (including smartwatches and smartphones), communication infrastructure, and computing resources – to track users' health and physical activity over months or years. Recent studies show a growing demand for such systems in home-based healthcare applications, for example, to track sleep [18] and different physiological signs [8].

Ubiquitous health monitoring systems produce a large volume of data, which accumulates over time. The collected data in such systems are often time-series with temporal dependencies and correlations. The longitudinal data enable the investigation and detection of certain diseases [25]. Moreover, IoT-based systems include multi-sensory and -modal data collection, where various health parameters are captured simultaneously. Such multimodal data might represent different aspects of an event or situation. For example, various heart rate variability (HRV) parameters in time and frequency domains can be exploited to evaluate the individual's stress level [10].

Multivariate and longitudinal data call for novel analysis techniques to extract the *trends* and *abnormalities (e.g., deviations or*