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Abstract

Smartphone-based passive sensing systems have emerged as a promising tool for continuous and real-time mental health monitoring, leveraging the widespread capabilities of mobile technologies. By integrating multiple data streams, including GPS tracking, typing behavior, and app usage patterns, these systems provide a comprehensive approach to understanding individual mental well-being. Data fusion techniques allow for the synthesis of diverse behavioral signals, creating a more accurate and dynamic representation of mental health states. This chapter explores the technological foundations of smartphone-based mental health systems, focusing on the challenges and opportunities in integrating heterogeneous data sources. Key considerations, such as privacy concerns, data accuracy, and user compliance, are examined, alongside advancements in machine learning algorithms for predictive mental health analysis. The fusion of location data, typing patterns, and app engagement offers new avenues for early detection of mental health issues, allowing for personalized interventions and real-time support. Despite these advancements, issues related to data security, ethical implications, and user trust remain significant challenges that must be addressed for these systems to achieve widespread adoption. By investigating the potential of smartphone-based sensing and the methods used for data integration, this chapter provides a comprehensive overview of the future prospects of smartphone-enabled mental health tracking.

Keywords: smartphone-based sensing, mental health monitoring, data fusion, GPS tracking, typing behavior, app usage patterns.

Introduction

The intersection of technology and mental health care has witnessed significant advancements in recent years, with smartphone-based passive sensing systems emerging as a pivotal tool in revolutionizing the way mental health is monitored and managed [1]. These systems utilize a range of sensors embedded within mobile devices, allowing for continuous and unobtrusive monitoring of a user's behavior, environment, and psychological state [2]. By harnessing the capabilities of smartphones, these systems collect data from various sources, such as GPS location, typing behavior, and app usage patterns, creating an integrated approach to mental health assessment that is both real-time and highly personalized [3]. As the global prevalence of mental health conditions

continues to rise, the need for accessible, scalable, and efficient methods of monitoring mental well-being has never been more urgent [4]. Smartphone-based sensing offers a promising solution by providing a platform that is both widespread and familiar to users, breaking down barriers related to cost, accessibility, and stigma often associated with traditional mental health interventions [5].

One of the key advantages of smartphone-based mental health systems is the ability to collect data passively and continuously, without requiring active engagement from the user [6]. This contrasts with traditional mental health assessments, which often rely on periodic clinical visits or self-reported data, both of which can be limited by biases or inaccuracies [7]. Passive sensing through smartphones enables a more objective and comprehensive collection of behavioral data, allowing for the detection of subtle changes in an individual's mood, social interactions, and activity levels over time [8]. GPS data, for example, can reveal shifts in mobility patterns, such as reduced movement or social withdrawal, which are often indicative of conditions like depression or anxiety [9]. Similarly, typing behavior, including keystroke dynamics and error rates, has been shown to correlate with cognitive changes, providing valuable insights into an individual's mental state [10]. This continuous, unobtrusive data collection opens new possibilities for early detection, enabling timely interventions before mental health conditions worsen [11].

The integration of multiple data sources, such as GPS, typing behavior, and app usage, is at the core of these smartphone-based systems, creating a more holistic understanding of an individual's mental health [12]. While each data type offers valuable insights on its own, it is the fusion of these data streams that enhances the accuracy and reliability of mental health predictions [13]. Machine learning algorithms and data fusion techniques are employed to combine these heterogeneous data sources, enabling the system to detect patterns and anomalies that may not be immediately apparent from any single data stream [14]. This integration allows for a more nuanced and dynamic view of mental health, accounting for both internal states (such as cognitive and emotional changes) and external factors (such as environmental influences and social behaviors) [15]. As a result, smartphone-based systems are better equipped to provide personalized mental health assessments, tailored interventions, and real-time support [16].