SLEEP MONITORING SYSTEM

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*Abstract*—In the realm of personal health and medical diagnostics, sleep monitoring systems have emerged as pivotal tools. This review provides a comprehensive examination of contemporary sleep monitoring technologies, delineating their evolution, functionalities, and applications. It commences with a brief overview of the importance of sleep monitoring in healthcare and personal wellness, followed by a detailed analysis of various types of sleep monitoring systems, including wearable devices, non-wearable technologies, and mobile applications. The report delves into the comparative effectiveness and accuracy of these systems, highlighting technological advancements and user experiences. A critical evaluation of the strengths, limitations, and user feedback of current systems reveals significant insights into their practicality and reliability. Additionally, the review explores the burgeoning developments in this field, particularly the integration of artificial intelligence and machine learning, which promises enhanced precision and user engagement. This report not only serves as a valuable resource for understanding current trends and challenges in sleep monitoring but also provides a vision for future research directions. It aims to assist healthcare professionals, researchers, and technology developers in comprehending the potential and limitations of existing systems, thereby fostering innovation in the development of more sophisticated and user-friendly sleep monitoring solutions.

Keywords—

# **Introduction**

In recent years, the importance of sleep in maintaining overall health and well-being has gained substantial recognition, prompting a surge in the development and utilization of sleep monitoring systems. Sleep, a vital physiological process, plays a critical role in cognitive function, emotional regulation, and physical health. Disruptions in sleep patterns have been linked to a wide array of health issues, ranging from chronic diseases to impaired cognitive functions. Consequently, the accurate monitoring of sleep patterns has become a critical component in both clinical settings and personal health management.

The advent of sleep monitoring systems signifies a remarkable evolution in healthcare technology, offering individuals and healthcare professionals unprecedented insights into sleep patterns and quality. These systems, varying from sophisticated wearable devices to non-invasive home-based setups, leverage an array of sensors and algorithms to track various sleep parameters such as duration, stages, and quality of sleep. With the escalating prevalence of sleep disorders and growing public interest in health and wellness, these systems have become more than mere gadgets; they are now essential tools in preventive healthcare and personalized medicine.

This review report aims to provide an in-depth analysis of the current landscape of sleep monitoring systems. It encompasses a detailed examination of the technologies employed, their effectiveness, user experiences, and their applications in both clinical and personal contexts. By scrutinizing the latest advancements and identifying existing gaps in technology and application, the report seeks to offer a comprehensive perspective on the state of sleep monitoring technologies. It also aims to shed light on the future potential of these systems, considering the ongoing technological innovations and the increasing awareness of the importance of sleep health.

In navigating through the realms of technology, health, and personal wellness, this review stands as a testament to the intricate relationship between technological advancement and healthcare, and its profound impact on improving the quality of life.

The contribution of this review paper is summarized as follows:

I. Summarize all the available technology in the sleep monitoring field.

II. To make aware of the limitations of the current available technologies.

III. To allow the future researchers for the further scope.

# **RELATED WORK**

There are four categories, in which we can classify modern sleep monitoring technologies, currently under study.

A diagram of sleep monitoring

Description automatically generated

*Fig. 1. Categories of Modern Sleep Monitoring Technologies*

Modern sleep monitoring tools practice diverse sensing technologies. These sensors can also be used for sleep staging. We do not cover sleep stages in the proposed system. PSG (polysomnography) is a type of sleep observing technology, which measures physiological factors such as breathing, temperature, muscle fluctuation, and oxygen saturation (SPO2). With the help of this technology, researchers can classify sleep-onset and wake-up time. A device has been attached to the wrist of the patient during his sleep to analyze the physical parameters or changes. It is investigated that there is a solid relationship between wrist movement and the sleep status of the user. In another method, there is the use of audio-video recording together with a Passive Infrared (PIR) sensor to detect the patient’s sleep status.

The current study shows an ambient sleep observation method using sensors that are installed in homes. This study comprises of PIR sensors for motion detection, interaction sensors, which are connected to windows and doors, environment temperature monitors to measure the temperature of a room, and some other devices, which can detect heat and energy.

# **EXISTING WORK**

Several devices are also available which are currently used for sleep evaluation at home as shown in Table. Many of these are accessible in the market for purchase. The following table shows the comparison between various sleep monitoring devices where REM (rapid eye movement) and NREM (nonrapid eye movement) are sleep stages.

Table 1. Various Sleep Monitoring System Accuracy.

A table with a list of information

Description automatically generated with medium confidence

The iBrain encompasses the headband, which registers solo front lead EEG signals. Zeo is another device that comprises the headband of plastic and cloth material placed on the forehead, which measures electroencephalogram (EEG), electromyography muscle electromyogram (EMG), and electrooculogram (EOG) signals, where these signals are transferred to mobile phone through Wi-Fi or bluetooth. The Heally system encloses embedded sensors within a shirt, which are used to calculate the respiratory and cardiac movement of the patient. The SleepTracker is another device fixed to a watch. This wristwatch captures human activity during sleep. WakeMate consists of a band, which is worn on the wrist of the patient. This band sends actigraphy information to a mobile phone. This information consists of total sleep duration, how many times the patient is awake during sleep and “sleep quality” information based on physical activity. Air cushion consists of an air-filled beanbag, which can calculate several ambient and physical parameters. Emfit Bed Sensor consists of Emfit foil electrodes, which locates under a mattress to calculate parameters like respiration, heart rate, and body movement.

Nowadays, mobile devices are commonly used in everyday routine, which also provides several apps to monitor the sleep of patients. A system called ubiquitous architecture uses heart rate signals, sound signals, and accelerometer data for sleep monitoring. This idea works combining with the monitoring system through a smartwatch or smartphone. It also suggests an innovative and intelligent algorithm for the signal organization.

Even though, the abovementioned methods and tools have their benefits for analyzing patient’s sleep. There are many drawbacks as well. Most of them are not grounded on the IoT and machine learning. The IoT model consists of many sensing devices, data transfer protocols, and cloud computing tools, which is trending and emerging nowadays. Data processing is performed on devices like mobile devices, which requires a lot of energy that is why such models can only be feasible for a little time.