Chapter 5
Affordable Internet of Things Sleep Monitor System

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ABSTRACT

Sleep monitoring offers significant benefits in understanding and optimizing a person's sleep experience by identifying problems, optimizing sleep routines, and evaluating the effectiveness of interventions. This raises the question of what factors affect the average person during sleep and what constitutes restful sleep. To cover a wide range of factors that influence the quality of sleep and to collect both the vital data, and the disturbing factors that may appear during sleep, the system presented in this work uses sensors that measure and detect the temperature, humidity, light level, air quality, room noise. The person's pulse and movements will also be monitored. To verify possible correlations between the measured data and sleep quality, the sleeping person is recorded in video and audio, so that the person's state can be checked by the data detected by the sensors at a certain moment. Long-term storage of accumulated information is necessary to evaluate the evolution of sleep quality.

INTRODUCTION

Sleep is an essential part of human life that significantly impacts our well-being and health. It plays a crucial role in the recovery and regeneration of our body, cognitive function, physical health, and emotional regulation. During sleep, our body undergoes a cellular-level process that repairs damaged cells and tissues caused by physical and mental exertion during the day. If our sleep is disrupted or of low quality, these processes do not run efficiently, negatively affecting our health and performance. Sleep also helps our brain consolidate information and experiences from the day, enhancing memory, concentration, and thought processes. Quality sleep enables the brain to optimize its functioning, preparing it for optimal mental performance during the day. However, poor sleep or poor-quality sleep can affect mental clarity, decision-making, and overall performance in cognitive and learning tasks. Research

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has shown that sleep deprivation can significantly impact different neuro-cognitive stages of spatial information processing during a virtual driving task. Young adults experience a considerable reduction in alertness and orientation functions, while the elderly experience a slowdown in decision-making processes and a decrease in working memory. In both cases, there is a latency in the actions of the test subjects. Over time, poor-quality sleep can lead to physical and mental health issues, including anxiety disorders and depression. In extreme cases, people may even be at an increased risk of psychosis (Pan et al, 2023; U.S. Dept., 2011). Restful sleep has multiple benefits, including restoring energy and supporting mental health and the immune system. In contrast, fatigue and restless sleep can lead to decreased cognitive performance, increased risk of accidents, and physical health problems such as high blood pressure and obesity. Therefore, paying adequate attention to sleep and adopting healthy habits following the assessment of sleep quality is essential to reap the benefits of restful sleep and avoid the disadvantages associated with fatigue (Zhang et al, 2023), (Izullah et al, 2022). To help individuals monitor their sleep quality and identify any issues that may affect their overall health and performance, affordable Internet of Things (IoT) sleep monitoring systems can be introduced. This paper aims to use IoT (Internet of Things) technology and smart devices to monitor sleep in an accessible, efficient, and non-invasive way. By integrating the system driven by the Raspberry Pi 4 microprocessor, sensors, and the Gear S3 smartwatch, the proposed system provides a holistic approach to sleep monitoring. By combining IoT technology, smart devices, and sleep data analysis, this project brings an innovative and more accessible approach to sleep monitoring. Accurate monitoring of various sleep-related aspects such as motor activity, environmental temperature, air quality, and heart rate is achieved. This system aims to provide information about sleep quality and help users better understand their sleep habits. Sleep monitoring via IoT has the potential to be used in medical and research applications. The collected data can assess health status, identify sleep disorders, and provide personalized interventions to improve sleep. The main technologies and methods used in sleep monitoring focus on electroencephalography (EEG), accelerometry, photoplethysmography (PPG), and actigraphy (LaGoy et al, 2022), (Ibáñez et al., 2018), (Moraes & Jermana, 2018). Each technology brings specific advantages and limitations, providing valuable information about sleep architecture and characteristics. The integration and combination of these technologies can contribute to a more comprehensive and accurate sleep assessment. Electroencephalography is a technology that records the electrical activity of the brain during sleep. By placing electrodes on the scalp, the EEG can detect and record brain waves specific to each stage of sleep, including non-REM and REM stages. This method provides a detailed assessment of sleep quality, identifying periods of wakefulness, light sleep, and deep sleep. However, EEG requires specialized equipment and trained experts to interpret the data, can be invasive in terms of electrode application, and is expensive. Commercially, institutions and private laboratories offer electroencephalography monitoring services, such as Neuroaxis or Sanador. Compared to this project, EEG monitoring can provide more detailed information about brain activity and sleep stages (Kwon et al, 2021), (Kwon et al, 2021). Still, it does not detect other external factors, is inconvenient, subjects the monitored person to stress, requires expensive equipment or specialized research spaces, and is not a suitable long-term monitoring method. Actigraphy and accelerometry can be grouped because they are often used simultaneously or individually to collect the same information. Accelerometry is a non-invasive and affordable sleep monitoring method that uses acceleration sensors to record body movements during the night. Actigraphy involves the use of a wrist or body-worn device that records movements and activity levels during sleep. These methods are useful in assessing circadian rhythms and sleep disorders, such as insomnia or REM sleep behavior disorder, sleep efficiency, and wake patterns, based on the detection of body movements (Bui