SMART SLEEP QUALITY MONITORING AND ANALYSIS SYSTEM USING IOT

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Abstract
Sleep is one of the most important factors that influences human health and daily performance. However, many people experience poor sleep due to environmental disturbances such as noise, light, temperature variation, and poor air quality. This paper proposes a Smart Sleep Quality Monitoring and Analysis System using IoT to monitor and analyze different environmental conditions that affect sleep quality. The proposed system uses an ESP32 microcontroller integrated with multiple sensors such as a PIR sensor for motion detection, DHT11 sensor for temperature and humidity monitoring, MQ135 sensor for air quality detection, sound sensor for noise level measurement, and LDR sensor for light intensity detection. The collected sensor data is transmitted to the cloud platform using Wi-Fi and stored in the ThingSpeak cloud platform for real-time monitoring and analysis through a web dashboard. When the PIR sensor detects body movement during sleep, a voice module activates and plays pleasant music through a speaker to help the user relax. The proposed system provides a cost-effective and efficient solution for monitoring sleep conditions and improving sleep quality through IoT-based analysis.

Keywords: IoT, ESP32, Sleep Monitoring, PIR Sensor, ThingSpeak, Smart Health Monitoring.

1. Introduction
Sleep plays a vital role in maintaining human health, mental stability, and overall productivity. Poor sleep quality may lead to several health problems such as stress, fatigue, decreased concentration, and other long-term health issues. In many cases, sleep disturbances are caused by environmental factors including temperature fluctuations, excessive noise, poor air quality, and improper lighting conditions. Therefore, monitoring these parameters during sleep is essential for understanding and improving sleep quality.

With the advancement of Internet of Things (IoT) technology, it has become possible to continuously monitor environmental conditions using sensors and transmit the collected data to cloud platforms for analysis. IoT-based monitoring systems integrate sensors, microcontrollers, wireless communication modules, and cloud platforms to provide real-time monitoring and remote access to data.

The proposed system presents a Smart Sleep Quality Monitoring and Analysis System using IoT, which monitors various environmental and human activity parameters that influence sleep quality. The system uses an ESP32 microcontroller connected with different sensors such as PIR sensor for motion detection, DHT11 sensor for temperature and humidity measurement, MQ135 gas sensor for air quality monitoring, sound sensor for noise detection, and LDR sensor for light intensity monitoring. These sensors continuously collect data from the surrounding environment and transmit the information to the ThingSpeak cloud platform using Wi-Fi communication.

Additionally, when the PIR sensor detects body movement during sleep, the system activates a voice module that plays soothing music through a speaker to create a comfortable sleeping environment. The collected data can be viewed through a web dashboard, allowing users to analyze sleep conditions and make necessary adjustments to improve sleep quality.

The proposed system provides an efficient, low-cost, and smart solution for monitoring sleep conditions and supporting healthy lifestyle management through IoT-based technology.

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2. LITERATURE SURVEY

1. IoT-Based Sleep Monitoring Systems.

Sleep monitoring systems using Internet of Things (IoT) technology have gained significant attention in recent years due to the increasing need for continuous health monitoring. IoT-based systems allow sensors to collect environmental and physiological data and transmit it to cloud platforms for real-time monitoring and analysis. Research by Gubbi et al. (2013) highlighted that IoT technologies enable smart health monitoring systems by integrating sensors, wireless communication, and cloud computing. These systems provide real-time data visualization and remote access, helping users understand and improve their sleep patterns. IoT platforms such as ThingSpeak are widely used for collecting, storing, and analyzing sensor data in smart monitoring applications.

2. Environmental Factors Affecting Sleep Quality.

Environmental conditions such as temperature, humidity, light intensity, and noise levels play an important role in determining sleep quality. Several studies have shown that uncomfortable room temperature and excessive noise can significantly disturb sleep cycles. According to research by Patel et al. (2012), environmental monitoring using sensors can help identify disturbances that negatively affect sleep quality. Temperature and humidity sensors are commonly used in smart monitoring systems to maintain comfortable sleeping conditions. Light sensors are also used to detect room brightness levels since exposure to light during sleep can disrupt the natural circadian rhythm.

3. Motion Detection in Sleep Monitoring

Body movement during sleep is an important indicator used to analyze sleep patterns. Motion detection sensors such as Passive Infrared (PIR) sensors are widely used in non-contact sleep monitoring systems. These sensors detect changes in infrared radiation caused by human movement. Research studies have shown that motion detection can help determine sleep disturbances and restlessness during sleep. Non-invasive motion monitoring systems are preferred because they do not require the user to wear any devices, making them more comfortable for long-term monitoring.

4. Cloud-Based Data Monitoring and Analysis

Cloud computing plays a major role in IoT-based monitoring systems by providing storage, processing, and visualization of collected data. Sensor data collected from IoT devices can be uploaded to cloud platforms for analysis and graphical representation. Platforms such as ThingSpeak allow users to view sensor readings through dashboards and graphs in real time. Research by Zanella et al. (2014) emphasized that cloud-based IoT platforms enable efficient data analysis and remote monitoring, which is highly useful in smart health monitoring applications.

3. Implementation:

The proposed Smart Sleep Quality Monitoring and Analysis System using IoT is designed to monitor environmental conditions that affect sleep quality. The system consists of multiple sensors connected to an ESP32 microcontroller, which collects and processes the sensor data.

The sensors used in the system include a PIR sensor for motion detection, DHT11 sensor for temperature and humidity measurement, MQ135 sensor for air quality monitoring, sound sensor for noise detection, and LDR sensor for light intensity measurement. These sensors continuously monitor the surrounding environment of the sleeping area.

The ESP32 microcontroller processes the sensor data and transmits it to the ThingSpeak cloud platform using Wi-Fi communication. The uploaded data can be visualized through a web dashboard, allowing users to observe environmental conditions in real time.

Additionally, when the PIR sensor detects body movement, a voice module connected to a speaker plays pleasant and relaxing music to help the user return to sleep. This feature helps in reducing sleep disturbances and improving overall sleep comfort.

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The block diagram of the proposed system includes sensors, ESP32 controller, cloud platform, and a speaker module for audio output.

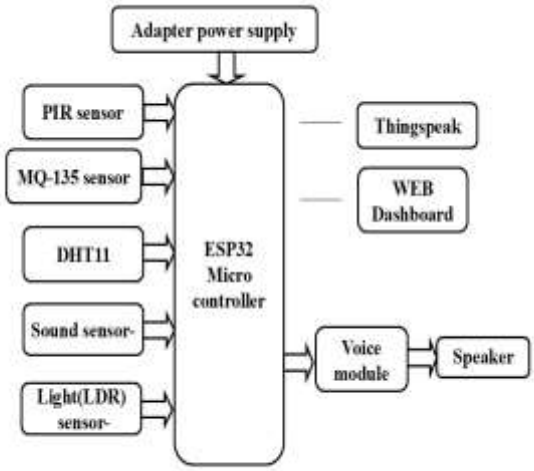

Fig1: Block diagram

4.Related Work: The brief introduction of different modules used in this project is discussed below:

4.1 PIR sensor:

Fig2: PIR sensor

The Passive Infrared (PIR) sensor is used to detect motion or movement in the sleeping area. It works by detecting changes in infrared radiation emitted by the human body. When movement is detected during sleep, the PIR sensor sends a signal to the ESP32 controller, which activates the voice module to play relaxing music through the speaker.

4.2 DHT11 SENSOR

Fig3: DHT11 sensor

The DHT11 sensor is used to measure temperature and humidity levels in the sleeping environment. Maintaining a comfortable temperature and humidity level is essential for good sleep quality. The sensor sends environmental data to the ESP32 microcontroller for monitoring and cloud storage.

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4.3 MQ135 AIR QUALITY SENSOR

Fig4: Air quality sensor

The MQ135 sensor is used to monitor air quality by detecting harmful gases such as carbon dioxide and ammonia. Poor air quality can affect breathing and disturb sleep. The sensor continuously measures air quality levels and sends the data to the ESP32 for analysis.

4.4 SOUND SENSOR:

Fig5: Air quality sensor

The sound sensor detects noise levels in the surrounding environment. Excessive noise can interrupt sleep patterns. By monitoring sound levels, the system helps identify environmental disturbances that may affect sleep quality.

4.5 LDR SENSOR:

Fig6: LDR sensor

The Light Dependent Resistor (LDR) sensor measures light intensity in the room. Proper lighting conditions are important for maintaining healthy sleep patterns. The sensor detects changes in light levels and sends the data to the microcontroller for monitoring.

4.6 ESP32 Microcontroller

Fig7: ESP32 microcontroller

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The ESP32 microcontroller acts as the central processing unit of the system. It collects data from all sensors, processes the information, and transmits the data to the cloud platform via Wi-Fi. It also controls the voice module and speaker when motion is detected.

ESP32 Peripherals Features

- 18 Analog-to-Digital Converter (ADC) channels
- 10 Capacitive sensing GPIOs
- 3 UART interfaces
- 3 SPI interfaces
- 2 I2C interfaces
- 16 PWM output channels
- 2 Digital-to-Analog Converters (DAC)
- 2 I2S interfaces

4.5 Voice module:

Fig8: Voice Module

The voice module is used to play pre-recorded audio messages or pleasant music in the proposed sleep monitoring system. It acts as an output device that helps create a relaxing environment when sleep disturbances are detected. The voice module is connected to the microcontroller and controlled through digital signals.

In this system, when the PIR sensor detects body movement during sleep, the microcontroller sends a signal to the voice module to activate the speaker and play calming music. This helps the user relax and return to sleep comfortably. The module can store multiple audio files and play them when triggered by the controller.

5. Results:

The proposed system successfully monitors environmental parameters affecting sleep quality such as temperature, humidity, air quality, noise level, light intensity, and body movement. The collected data is transmitted to the ThingSpeak cloud platform and displayed through a web dashboard.

The graphical representation of sensor data helps users analyze sleep environment conditions in real time. When motion is detected by the PIR sensor, the system activates the voice module and plays soothing music through the speaker, which helps in reducing sleep disturbances.

The system demonstrates efficient monitoring of sleep-related environmental factors and provides useful insights for improving sleep quality.

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Fig9: Smart Sleep Quality Monitoring and Analysis System using IoT

6. ACKNOWLEDGEMENT

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7. CONCLUSION:

In this proposed system, an IoT-based solution is developed for monitoring and analyzing sleep quality. Multiple sensors are used to monitor environmental conditions such as temperature, humidity, air quality, noise levels, and light intensity. The ESP32 microcontroller collects sensor data and transmits it to the cloud platform for real-time monitoring.

The integration of motion detection with a voice module that plays relaxing music provides additional comfort to the user during sleep disturbances. The system offers a cost-effective and efficient method for monitoring sleep conditions and improving overall sleep quality.

The proposed system can be used in smart homes and healthcare applications for maintaining a healthy sleeping environment.

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