IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

IoT-Based Smart Sleep Tracker with Personalized Recommendations

Mrs. Gowthami S[1], Manoj M[2], Cibiraj P[3]
Assistant Professor, Department of Computer Science and Engineering[1]
Students, Department of Information Technology [2, 3,]
Dhanalakshmi Srinivasan University, Trichy, Tamil Nadu, India

Abstract: *In today's fast-paced world, sleep quality plays a crucial role in maintaining overall health and well-being. This paper presents the design and development of an IoT-based smart sleep tracker system integrated with personalized recommendations. The proposed system monitors various physiological parameters such as body movement, heart rate, and ambient room conditions to evaluate sleep patterns. The collected data is processed through an AI-driven analytics layer to provide actionable recommendations tailored to individual users. The system architecture encompasses hardware sensors, data acquisition modules, cloud-based data storage, and a user-friendly mobile interface. The results demonstrate the effectiveness of the system in identifying sleep disturbances and offering insightful guidance to enhance sleep quality.*

Keywords: IoT, Sleep Tracking, Personalized Recommendations, AI Analytics, Smart Health, Wearable Devices

I. INTRODUCTION

Sleep disorders and poor sleep quality are increasingly common due to modern lifestyle factors. Traditional sleep monitoring methods, such as polysomnography, are often intrusive and expensive. Therefore, there is a growing demand for non-intrusive, cost-effective, and continuous sleep tracking solutions. This paper introduces an IoT-enabled smart sleep tracker that offers real-time monitoring and personalized recommendations, aiming to improve users' sleep health and overall wellness.

II. SYSTEM OVERVIEW

The proposed system integrates multiple layers to deliver seamless sleep tracking and recommendation functionalities. Each layer is responsible for a specific set of tasks that collectively contribute to the overall performance of the system.

2.1 System Architecture

The architecture comprises five layers: Presentation Layer, Application Layer, Data Layer, AI & Analytics Layer, and Integration Layer. These layers interact with hardware components and external services to provide a cohesive user experience.

2.2 Presentation Layer (User Interface)

This layer involves a mobile application that displays real-time and historical sleep data. Users can view personalized recommendations, trends, and alerts. The UI is designed for ease of use, with intuitive graphs, statistics, and user feedback features.

2.3 Application Layer (Backend Logic)

The backend handles data processing, user authentication, session management, and communication between the user interface and other layers. It acts as a middleware that ensures secure and efficient data exchange.

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2.4 Data Layer (Database and Storage)

This layer includes cloud-based storage solutions to store raw and processed data. The database is designed to handle time-series data, user profiles, and recommendation logs securely and efficiently.

2.5 AI & Analytics Layer

Machine learning algorithms are applied to analyze sleep patterns, detect anomalies, and generate personalized recommendations. This layer adapts to user habits over time, enhancing the accuracy of insights and suggestions.

2.6 Integration Layer

This layer connects the IoT devices (wearables, environmental sensors) with the system through standard communication protocols like MQTT or HTTP. It ensures reliable data transmission from sensors to the cloud.

III. HARDWARE COMPONENTS

The system utilizes a set of sensors and microcontrollers to capture relevant sleep-related data. These components are selected for their accuracy, energy efficiency, and ease of integration.

IV. SYSTEM OPERATION

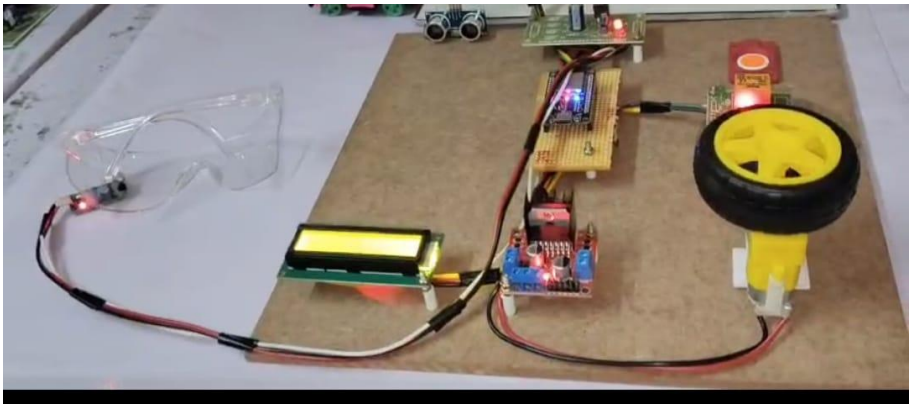
The system operates by continuously collecting data from sensors, which is transmitted to the cloud for storage and processing. The AI & Analytics layer processes this data to evaluate sleep quality and identify irregularities. Recommendations are generated based on user-specific patterns and are displayed via the mobile app. Alerts for significant issues, such as prolonged restlessness or abnormal heart rate, are also provided.

Table 1: Hardware Components Used

Component	Description
ESP32 Microcontroller	Central processing and communication unit
Heart Rate Sensor	Measures pulse rate
Accelerometer (MPU6050)	Detects body movements during sleep
Temperature Sensor	Monitors ambient temperature
Humidity Sensor	Monitors room humidity levels
Wi-Fi Module (built-in)	Provides internet connectivity

V. RESULTS

Initial testing with a small group of users demonstrated the system's capability to accurately monitor sleep phases, detect disturbances, and provide relevant recommendations. User feedback indicated improved sleep quality and better awareness of sleep hygiene practices.



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VI. CONCLUSION

The IoT-based smart sleep tracker offers a non-invasive, efficient, and personalized solution for sleep monitoring. By integrating hardware sensors with AI-driven analytics and a user-friendly interface, the system provides actionable insights that promote better sleep health. Future enhancements may include integration with smart home systems and expansion to support additional health metrics.

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