IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

SLEEP APNEA DETECTION USING ADAPTIVE THRESHOLD

[1]Dr. Jagadeesha S [2] Lasya Priya [3] Kaliki Harshitha [4] Vignesh [5] Jayant.C

Professor,Dept of ECE,AMCEC

Assoc Professor, Dept of ECE, AMCEC

Dept of ECE

6th Sem Department of ECE, AMC Engineering College, Bannerughatta, Bangalore

Abstract: In the recent years, sleep Apnea has become a significant concern due to their impact on overall wellbeing. Sleep Apnea is a serious sleep disorder in which breathing repeatedly stops and starts during sleep, affecting oxygen level and overall health. Sleep Apnea is important to address because it often goes undiagnosed and can lead to serious health issues such as heart d, Fatigue and reduced quality of life. This project presents a system for the detection of sleep Apnea embedded systems, IOT and machine learning techniques. With the advancement of embedded systems and IOT technologies, real time monitoring has become more efficient and accessible. This paper aims to develop a cost effective and real time monitoring system for detection sleep Apnea by integrating embedded systems, IOT and machine learning techniques. The system uses SpO_2 drop (3–4%), apnea duration (≥10 s), heart rate variation (±10–15 bpm), and airflow reduction (30–50%) with adaptive thresholds. It achieves 92.3% accuracy, 90.1% sensitivity, 93.8% specificity, and reduces false alarms by ~18%.

Keywords: Sleep Apnea Detection, Embedded system, IOT, Machine learning, health monitoring system, oxygen saturation, respiratory monitoring

I.INTRODUCTION

Rapid advancement of embedded systems, (internet of things) IoT and machine learning technologies, modern healthcare solution are becoming more intelligent and accessible. Sleep apnea is a common yet serious sleep disorder characterized by repeated interruptions in breathing during sleep. Despite its severity, a large number of cases remain undiagnosed due to lack of accessible, affordable and continuous monitoring system. Traditional diagnostic method, such as polysomnography, are very expensive, complex and require clinical supervision, making them unsuitable for regular home-based monitoring

Sleep apnea is important to understand because it is a common yet often undiagnosed condition that can significantly affect overall health and daily functioning. It causes repeated interruption in breathing during sleep, which reduces oxygen supply to the body and disrupt normal sleep cycle. Over time, this can lead to serious complication such as high blood pressure, heart disease, stroke, diabetes and extreme daytime

fatigue. The condition also impacts concentration, memory and productivity, increasing the risk of accidents and lowering quality of life

II. LITERATURE REVIEW AND RELATED WORK

B. Vijayalakshmi, S. Anusha, S. Padmapriya, C. Pamkumar, S. Prashant Bharadwaaj, and R. Priyanka (2020)

It is developed a basic IoT-based system to detect sleep apnea early. They used a sensor (MAX30100) to measure heart rate and oxygen levels from the body. The data is sent using a NodeMCU to the cloud and then shown on a mobile app.

. A. Ramachandran and A. Karuppiah (2021) It is on a machine learning-based approach for detecting sleep apnea. Instead of just collecting data, they processed it step by step—like cleaning the signals, extracting useful features, and then using a trained model to identify apnea events.

This method performs better but needs good-quality data, more processing power, and larger datasets, which makes it a bit more complex to implement.

Dongjin Yang, Eishaan Bhargava, Heather Elphick ,Lyudmila S. Mihaylova This work explains a method to detect sleep apnea using basic signals like pulse rate and oxygen level (SpO_2). It uses an adaptive CUSUM algorithm that tracks small changes in these signals to find abnormal patterns. The system adjusts its limits automatically, which helps improve accuracy. It is mainly designed for home use, making it cheaper and easier compared to hospital tests, but its performance depends on good-quality data.

R. Dhanasekar, L. Vijayaraja, A. Divya, P. Keerthana, S. Thalapathiraj, V. Venkatesh This paper focuses on using IoT devices along with machine learning to detect sleep apnea early. It collects signals like ECG and oxygen levels, processes them, and then uses trained models to classify whether a person has apnea or normal breathing. The system supports continuous monitoring and reduces manual effort, but it may require strong hardware and can be affected by noisy signals.

A. Rajasekar, V. Hema, R. Deepthikha This paper introduces a system that uses a webcam and machine learning (YOLO model) to observe sleep behavior like eye movement and yawning. If apnea is detected, the system alerts the user using a buzzer or vibration. It is portable and works in real time, but it performs best in controlled environments and cannot fully replace medical diagnosis.

Vedhashree S K, Pargadeswaran S, Menakadevi Nanjundan, Gokul Chandrasekaran, Gokulkrishna S, Hemalatha G This research proposes a real-time system that uses multiple sensors like SpO_2, GSR, and accelerometer to monitor sleep apnea at home. It provides continuous tracking and is comfortable for users since it is non-invasive. The system is cost-effective and power-efficient, but it may sometimes give false alarms and depends on threshold settings.

H. B. Kwon, K. H. Jun, H. Yoon, E. Y. Joo, S. H. Choi This work uses an advanced deep learning model (Conv-ViT) with LoRa tuning to provide personalized sleep apnea detection. It collects data using a PVDF sensor and adapts the model for each individual, improving accuracy. The system supports home monitoring and severity classification, but it still needs further real-world testing and better sensor reliability.

Chi Fung, Joshua Lopez, Samuel Hurtado, Ernesto Garcia This study presents a smart lighting system that turns off lights automatically when a person falls asleep. It uses wearable and IoT data to understand the user's sleep state. The idea improves energy saving and user comfort. However, the accuracy depends on sensor quality and the system may not always detect sleep instantly.

III IMPLEMENTATION

HARDWARE IMPLEMENTATION

BLOCK DIAGRAM

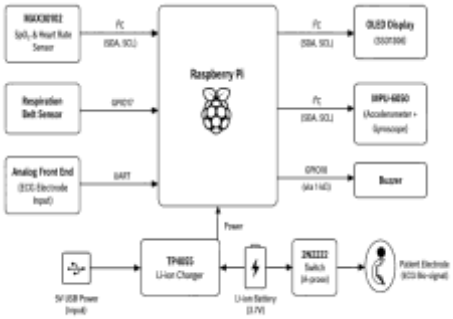

Fig.1 Sleep Apnea detection using Threshold

This diagram represents a low-cost system designed to monitor and detect sleep apnea using multiple sensors connected to a central processor. The Raspberry Pi acts as the main controller, collecting and analyzing data from various inputs. On the input side, a MAX30102 sensor measures blood oxygen levels and heart rate through an I²C interface. A respiration belt tracks breathing patterns via a GPIO pin, while ECG electrodes connected through an analog front-end capture heart signals using UART communication.

On the output side, an OLED display shows real-time data such as oxygen levels and pulse rate. An MPU-6050 sensor provides motion and orientation data, helping detect body movement during sleep. A buzzer is included to alert the user if abnormal conditions are detected. The system is powered by a rechargeable lithium-ion battery, charged through a TP4055 module.

SOFTWARE IMPLEMENTATION

The software part of this project is responsible for collecting data, processing it, and detecting sleep apnea events automatically.

First, the system uses Arduino IDE with Embedded C programming to communicate with sensors like the MAX30102 and respiration sensor. These sensors continuously send data such as heart rate and blood oxygen (SpO_2) to the Raspberry Pi or controller.

Once the data is received, the software performs basic signal processing. This means it cleans the data by removing noise and unwanted disturbances so that the readings become more accurate and reliable.

After cleaning the data, the system applies an algorithm called Adaptive CUSUM (Cumulative Sum). This algorithm checks for sudden changes or abnormal patterns in the signals. Since human body signals change over time, a fixed limit may not work properly. So, the system uses adaptive thresholding, which automatically adjusts the limit based on current signal conditions.

Then, the software analyzes both pulse rate and SpO_2 values separately and together. If it detects unusual drops in oxygen level or irregular heart rate patterns that match sleep apnea conditions, it identifies it as an apnea event.

Finally, the system gives an output or alert. This can be displayed on an OLED screen or indicated through a buzzer, informing that an abnormal condition has been detected.

FLOW CHART

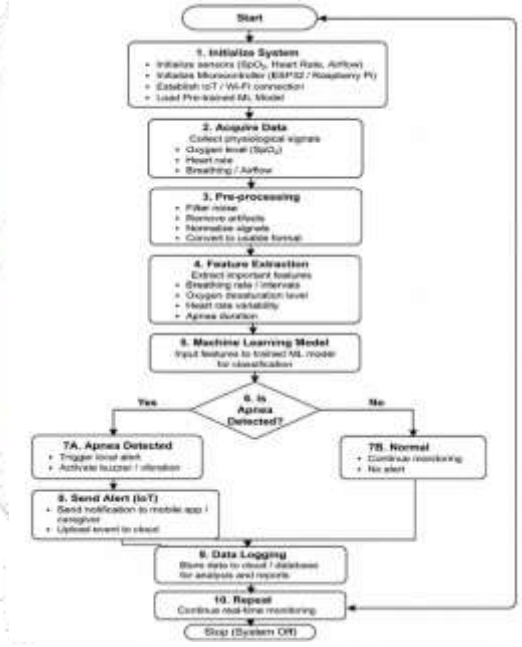

Fig.2 Sleep Apnea detection using Threshold

IV. EXPECTED RESULTS

This project presents a simple and affordable system for detecting sleep apnea using pulse rate and blood oxygen (SpO_2) signals. Instead of relying on expensive hospital-based tests, the system allows continuous monitoring at home, making diagnosis more accessible. It uses sensors to collect physiological data and applies an adaptive algorithm (ACUSUM) that adjusts its threshold based on signal variations, improving accuracy even when the data changes over time. By analyzing pulse and oxygen levels both separately and together, the system can

effectively identify abnormal breathing patterns. The hardware setup includes components like a Raspberry Pi, biosensors, and display modules, while the software processes and interprets the data in real time. Overall, the project reduces cost, improves convenience, and enables early detection of sleep apnea, which can help prevent serious health complications and support better patient care through continuous and automated monitoring.

V. CONCLUSION

In conclusion, this project presents a cost-effective method for detecting sleep apnea using pulse rate and SpO_2 signals with an adaptive threshold algorithm. It improves reliability over basic methods and enables comfortable home-based monitoring. While not a replacement for clinical diagnosis, it serves as an effective tool for early screening and management.

VI. FUTURESCOPE

In the future, this project can be improved by adding more sensors to increase accuracy and detect different types of sleep apnea. Using machine learning can help the system learn better patterns and reduce errors. It can also be developed into a wearable device or connected to a mobile app for easy monitoring and alerts. Doctors could track patient data remotely through cloud integration. With further improvements, this system can become a reliable and user-friendly solution for continuous health monitoring at home.

VII. REFERENCE

[1] B. Vijayalakshmi, S. Anusha, S. Padmapriya, C. Pamkumar, S. Prashant Bharadwaaj, and R. Priyanka, “An early alert system for sleep apnea disorder using IoT,” 2020.

[2] A. Ramachandran and A. Karuppiah, “Machine learning based sleep apnea detection systems,” 2021.

[3] D. Yang, E. Bhargava, H. Elphick, and L. S. Mihaylova, “An adaptive CUSUM approach for automating sleep apnea analysis based on pulse and oximetry data,” in Proc. IEEE Int. Conf. Mechatronics and Automation (ICMA), Harbin, China, Aug. 2023, pp. 557–562.

[4] R. Dhanasekar, L. Vijayaraja, A. Divya, P. Keerthana, S. Thalapathiraj, and V. Venkatesh, “IoT-based sleep apnea monitoring for timely detection and prevention,” in Proc. Int. Conf. Self-Sustainable Artificial Intelligence Systems (ICSSAS), 2023, pp. 1363–1368.

[5] C. Fung, J. López, S. Hurtado, and E. García, “Intelligent lighting system based on sleep detection using IoT devices and wearables,” in Proc. IEEE Latin-American Conf. Communications (LATINCOM), 2023.

[6] V. S. K., P. S., M. Nanjundan, G. Chandrasekaran, G. S., and H. G., “IoT-based system for sleep apnea detection and disorder measurement,” 2025.

[7] A. Rajasekar, V. Hema, and R. Deepthikha, “Real-time sleep apnea monitoring and alert mechanism using machine learning and embedded systems,” in Proc. 9th Int. Conf. Computational Intelligence in Data Science (ICCIDS), 2026, pp. 1–6.

[8] H. B. Kwon, K. H. Jun, H. Yoon, E. Y. Joo, and S. H. Choi, “Unconstrained sleep apnea detection with Conv-ViT network: LoRa tuning for personalized monitoring,” IEEE Sensors Journal, vol. 26, no. 4, pp. 6331–6342, Feb. 2026.

[9] S. Saha, S. A. Fattah and M. Saquib, “St ApneaNet: A Deep Learning-Based Sleep Stage Adaptive Apnea Detection Network Using EEG Signal,” *IEEE Access*, vol. 12, pp. 198250–198261, 2024.

[10] L. Werthen-Brabants *et al.*, “Deep Learning-Based Event Counting for Apnea-Hypopnea Index Estimation Using Spiking Neural Networks,” *IEEE Transactions on Biomedical Engineering*, 2025.

[11] N. La Porta *et al.*, “Sleep Apnea Events Recognition Using Multi-Channel Machine Learning on Polysomnographic Data,” *IEEE Open Journal of Engineering in Medicine and Biology*, 2024.

[12] D. Peng, L. Sun, Q. Zhou and Y. Zhang, “AI-Driven Approaches for Automatic Detection of Sleep Apnea/Hypopnea Based on Physiological Signals: A Review,” *IEEE/Engineering Applications of Artificial Intelligence*, 2024.