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# A Low-Power IoT-Enabled System for Real-Time Sleep Apnea Detection Using Temporal Fusion Transformer

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## Abstract

Sleep apnea is common among elderly patients and can lead to serious health issues like heart disease and cognitive problems. Traditional diagnostic methods, such as polysomnography (PSG), are accurate but expensive and inconvenient for regular or home-based monitoring. This study introduces a simple, low-power IoT system for real-time sleep apnea detection. It uses a MAX30100 sensor to monitor $SpO_2$ and heart rate non-invasively and a Temporal Fusion Transformer (TFT) model to analyze the data.

The system processes $SpO_2$ signals sampled at 3 Hz and uses the TFT model to detect apnea events by capturing key patterns in the data. It also considers patient-specific details like age and BMI, making it reliable for different individuals. Tests on 26 elderly patients showed excellent results, with detection accuracy above 97% and sensitivity over 95%.

The system sends real-time alerts to caregivers and doctors, ensuring quick responses during emergencies. Its scalable design supports easy integration into healthcare networks for remote and continuous monitoring. By overcoming the challenges of traditional methods, this system offers a practical, non-invasive solution for managing sleep apnea in elderly patients.

*Keywords: Sleep Apnea Monitoring, IoT-based Health Monitoring, $SpO_2$ Signal Analysis, Temporal Fusion Transformer (TFT), Real-Time Apnea Detection, Elderly Patient Care*

## 1. Introduction

Monitoring elderly patients with sleep apnea presents unique challenges, particularly in households where family members are engaged in work and unable to provide constant supervision. Sleep apnea, characterized by repeated interruptions in breathing during sleep, poses significant health risks, including cardiovascular diseases, cognitive impairments, and daytime fatigue. For families balancing caregiving with professional