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Sleep Pattern Monitoring Pillow Using KNN & Smart Band

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ABSTRACT: People who have sleep apnea experience shallow breath or even stop breathing during their sleep. When OSA occurs, the upper airway is blocked during sleep and people may not be aware that they have difficulty to breathe. Monitoring of respiratory, sleep and cardiac parameters are used to diagnose OSA. In this project, a research to develop an unobtrusive sleep monitoring system, Sleep Smart that is made of smart textile pressure sensors connected to a wireless embedded system with IoT functions, is pursued. The aim of Sleep Smart is to develop a fabric pillow topper, which is embedded with textile pressure sensors, which can track sleeping habits and respiration rate to monitor the probability of OSA. Sleep Smart topper consists of a fabric sensor grid, resistor networks, and an embedded system with IoT and wireless capabilities. Embedded algorithms will be developed to detect the episodes of OSA during sleep and also monitor the sleep quality. IoT framework will be established to offer person-centred visualization of the sleep quality and OSA data on a tablet app.

KEYWORDS: Obstructive Sleep Apnea (OSA) ,textile pressure sensors,fabric pillow topper, sleep monitoring . machine learning, Internet of Things, Machine Learning

I. INTRODUCTION

Designing Textile Pressure Sensors Embedded into a pillow Topper-Cushion Cover Design A 4x3 textile pressure sensor grid (equal to 12 sensors) was designed to perform initial testing. The textile pressure sensors were designed with piezoelectric conductive materials responsive to subtle pressure changes such as respiration cycle or changes in sleeping posture. To monitor the pressure changes, the sensor grid was connected to embedded computing unit, node MCU. While each sensor row was connected to digital pins to power up the sensors; each sensor column was connected to analog pins to collect analog pressure data. An embedded computing code was written with Arduino IDE to drive the sensors and to collect pressure data. Then the sensor grid was expanded to be built on a cushion cover. The pressure sensors were connected to each other with conductive tape. A conductive thread was used to make connections between sensor array and analog/digital pins. The size of each pressure sensor was 1 sq. inch. As the next step, the conductive tape was changed with the conductive thread and the topper was placed on top of a cushion foam, covered with a bed sheet to simulate the bed. Monitoring the Pressure Changes and Sensor Location. To monitor the pressure changes, the data coming from sensors were stored into a .csv file and was plotted from that .csv file on python. The pressure was applied using bare fingers tapping on to the sensors. The system was also programmed with Processing IDE to show the sensor location on graphical user interface (GUI) Bluetooth Communication. The data collected from the sensors was sent to the controller in the pillow via Bluetooth. The sensor grid was connected to Arduino Nano. BLE Sense board and its built-in BLE communication protocol was used. The data coming from the sensors were analyzed in the server.

II. RELATED WORK

Title :Sleep Monitoring System

Author: Takuji Suzuki, Kazushige Ouchi and Ken-ichi Kameyama and Masaya Takahashi. This paper describes a new sleep monitoring system for home use. The basic system consists of a wearable physiological sensor and PC software

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for analyzing sleep quality from user's wrist motion and heart rate variability. Different from a conventional sleep monitoring device used in a hospital, the sensor is so small and easy-to-use that a normal person can use it at home. This means that the system is useful for a sleep specialist who wants to check a patient's daily sleep pattern. The system can also be used for self-care.

Title: Insomnia Diagnosis and Treatment

Author: Sana Tmar-Ben Hamida and Beena Ahmed. An efficient insomnia diagnosis and treatment requires the analysis of sleep stages and patterns in the vital signals and clinical face-to-face consultations. The measured signals are collected from different locations on the head and the body and used to evaluate the sleep quality and quantity. Generally, these measurements require spending several days of monitoring at sleep centers.

Title: Sleep Evaluation

Author: Zhangjie Chena, Ya Wang. Recently, sleep evaluation has attracted lots of attention as sleep disorders have become a public health problem that causes cumulative effect on physical and mental health. Poor sleep qualities can lead to adverse effects on performance of basic activities in normal life such as memorization, concertation and learning especially among elderlies. Sleep posture is one of the keys factors that evaluates sleep qualities to prevent medical conditions such as pressure ulcer formation. In this paper, a sleep monitoring system is developed based on an infrared array sensor to detect different sleep postures.

III. PROPOSED ALGORITHM

A. *Design Considerations:*

- Textile Pressure Sensors Embedded into a pillow Topper-Cushion Cover Design A 4x3 textile pressure sensor grid (equal to 12 sensors)
- The textile pressure sensors were designed with piezoelectric conductive materials responsive to subtle pressure changes such as respiration cycle or changes in sleeping posture.
- To monitor the pressure changes, the sensor grid was connected to embedded computing unit, node MCU.
- the conductive tape was changed with the conductive thread and the topper was placed on top of a cushion foam, covered with a bed sheet to simulate the bed. Monitoring the Pressure Changes and Sensor Location
- To monitor the pressure changes, the data coming from sensors were stored into a .csv file and was plotted from that .csv file on python.

Advantages:

- Easy-to-use that a normal person can use it at home
- More robust and stable compared to previous works
- We will be able to monitor the pressure changes in real-time

Algorithm:

- Random Forest is a popular machine learning algorithm that belongs to the supervised learning technique.
- It can be used for both Classification and Regression problems in ML.
- It is based on the concept of ensemble learning, which is a process of *combining multiple classifiers to solve a complex problem and to improve the performance of the model.*
- As the name suggests, *"Random Forest is a classifier that contains a number of decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset."*
- Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, and it predicts the final output.
- The greater number of trees in the forest leads to higher accuracy and prevents the problem of overfitting.

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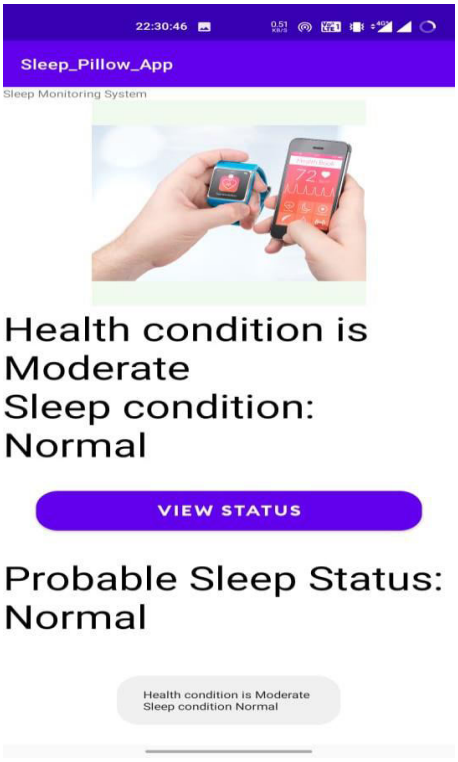
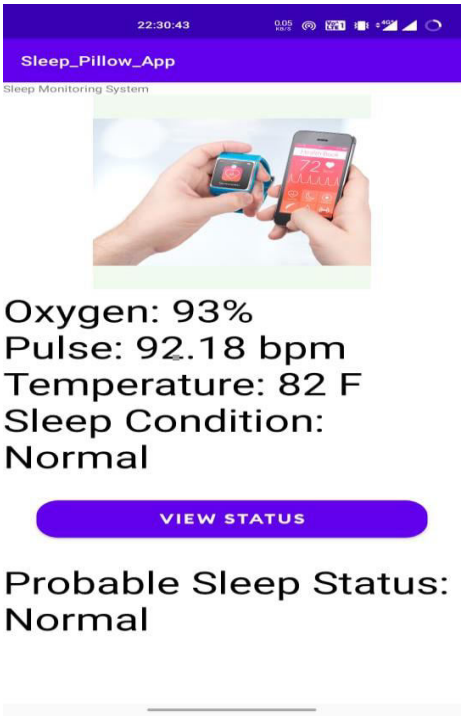
IV. PSEUDO CODE

```
#.....Arduino code for pillow .....#

int lpin = A0;
int mpin = A1;
int rpin = A2;

void setup() {
  Serial.begin(9600);


}

void loop() {

  int lpinValue = analogRead(lpin);
  int mpinValue = analogRead(mpin);
  int rpinValue = analogRead(rpin);
  Serial.println(String(lpinValue)+"#"+String(mpinValue)+"#"+String(rpinValue));
  delay(500);

}
```

V. SIMULATION RESULTS

Trackers can detect interrupted sleep, letting you know when you're tossing and turning or waking during the night. Sleep phases: Some tracking systems track the phases of your sleep and time your alarm to go off during a period when you're sleeping less deeply.





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```
Filename: Health_Test/input.txt
['97', '83.57', '84']
['97', '83.57', '84']
Health condition is Moderate


Filename: Health_Test/input.txt
['94', '79.01', '86']
['94', '79.01', '86']
Health condition is Moderate
```

VI. Conclusion and Future Work

Amid concerns regarding the limited validity of mobile sleep trackers and variation in results compared to golden standard PSG, other roles of such apps must be considered. We conclude that sleep trackers may be useful in improving user's self-management, and increasing sleep hygiene awareness, knowledge, and behaviours. Thus, apps may present valuable tools for improving sleep quality. However, continuous audits and validation trials for available apps are vital to improve their quality. It is recommended to assess behavioural changes associated with sleep trackers in different populations, such as elders, and people with sleep disorders and major illnesses.

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