Ambient Environment and Sleep Time Monitoring System

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Abstract

A sleep time monitoring system integrated into wearable technology offers a non-invasive, convenient way to track and analyze sleep in real-time. The primary goal of this system is to provide users with accurate insights into sleep cycles, duration, and quality. The system can detect sleep stages and disturbances using sensors such as accelerometer for movement, heart rate sensor for relaxation levels, and ambient sensors for environmental factors like light. Designed to be comfortable and discreet, wearable sleep monitors collect data that can be synced with mobile apps, providing detailed reports and personalized recommendations for better sleep quality. This project aims to develop an advanced sleep monitoring system using cutting-edge sensors and data analytics to help users optimize their sleep, leading to better health, productivity, and overall quality of life.

Keywords: sleep monitor, sensors, environment, Arduino Uno

1 Introduction

An adult typically sleeps 8-10 hours daily, about a third of their lifetime. Sleep is crucial for maintaining physical health, and numerous scientific studies have analyzed sleeping patterns and sleep quality. Individuals with health conditions like dementia often struggle with sleep problems, experience changes in their wake-rest routines, and endure emotional disturbances due to sleep disorders.

To solve the sleep quality problem, we propose a low-cost device to improve public health using software like Arduino IDE and hardware. Our project utilizes diverse resources such as the micro-controller Arduino and various sensors, including a 6DOF accelerometer, HC-05 Bluetooth module, heart rate pulse sensor, light-dependent sensor, and other electrical components to make a device on Ambient Environment and Sleep Time Monitoring System.

2 Related Work

Several existing works have addressed creating sleep monitoring devices. Hu et al. [1] present an IoT enabled wearable sleep body position monitoring device that focuses on wireless data collection and device control. Paglinawan et al. [2] conduct a study with the primary objective of designing an Arduino-based electrooculogram (EOG) sleep monitoring system, which includes an application for thermal environment control. Rajguru et al. [3] create a Sleep Quality Meter that evaluates sleep quality through heart rate, breathing rate, and movement measurements. The device has two main components: a base station and a glove. The glove includes various sensors such as a cardiac sensor, a gyroscope, an accelerometer for movement detection, a conductive stretchy cord for breathing rate measurement, and a wireless transceiver for data transmission to the base station.

Gathering knowledge from the related works, we propose an Arduino-based sleep monitoring device to analyze sleep quality and the environment's influence using different sensors.

3 Methodology

3.1 Selection of hardware and sensors

We select the Arduino Uno R3 as the microcontroller for our device. Our sensor suite includes a 6DOF Accelerometer, a Light-Dependent Sensor, and a Heart Rate Pulse Sensor. The HC-05 Bluetooth Module facilitates data collection from the hardware. For power, we select a rechargeable and long-time durable LiPo battery. The entire system is conveniently mounted on a wristband.

3.2 Software

We use the Arduino IDE as our software platform to develop and upload the code that controls our hardware. The Arduino IDE provides an integrated development environment for writing, compiling, and uploading code to the Arduino Uno R3 microcontroller. By using the IDE, we ensure efficient communication and data processing between the microcontroller and the connected sensors, ultimately enabling the functionality of our Ambient Environment and Sleep Time Monitoring System.

Python and Matplotlib are used for data analysis and visualization. Python's powerful data manipulation capabilities make it ideal for processing sensor data, while Matplotlib allows us to create detailed graphs and charts. This combination effectively enables us to analyze sleep patterns and environmental conditions, providing explicit visual representations of the collected data.

3.3 Assemble of the components

To assemble the sleep monitoring system, we integrate several vital components. After coding the instructions on the Arduino IDE, the Arduino Uno R3 serves as the central microcontroller, coordinating data collection and processing. We use a 6DOF accelerometer to measure movement and orientation, a light-dependent sensor to detect ambient light levels, and a heart rate pulse sensor to monitor the user's heart rate. We employ the HC-05 Bluetooth module for wireless data transmission, which sends the collected sensor data to a smartphone. A rechargeable and durable LiPo battery supplies power. All components are connected using jumper wires, ensuring secure and stable connections. Finally, the entire system is mounted on a wristband, allowing continuous, non-intrusive monitoring. The assembly process involves careful wiring to ensure all connections are correct and to prevent data transmission errors.

4 Result and Discussion

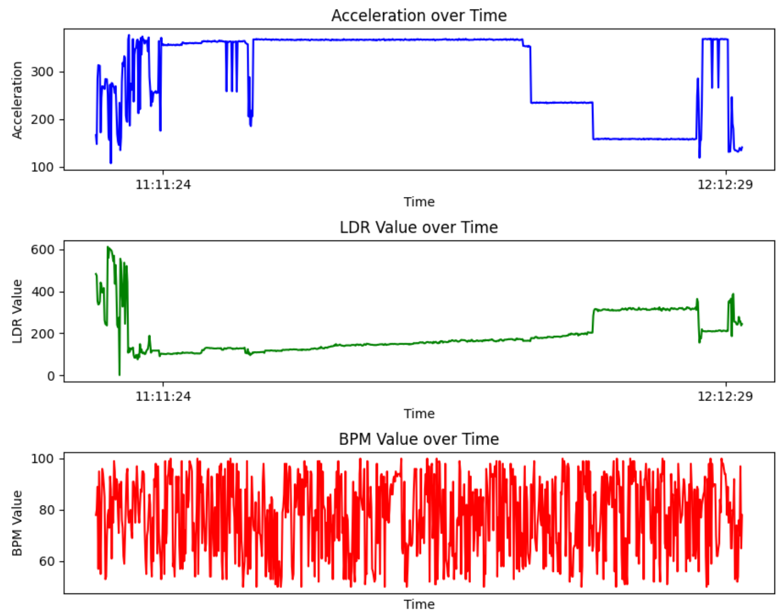

Figure 1: Line plot acceleration, LDR, pulse rate values and time

From the line plot in Figure1, acceleration and light dependent resistor(LDR) value over time shows us a trend. In the initial stage of falling asleep the value of accelerometer is fluctuating and as a result the acceleration value is oscillating, this means the person is not asleep. Around time 11:11:24 the acceleration assumes a stable value and very little fluctuation is noticed till time 12:12:29. This indicates that during this time the person wearing the wearable has low activity which means the individual has fallen asleep. It is to be noted that during the time interval the acceleration is not totally a constant value as even during sleep a person makes some changes to their position. The trend in acceleration is concistent with ideal sleep time activity represented in figure 2. For the LDR value, we can see a similar trend consistent with the accelerometer. The value of LDR assumes a stable value between time 11:11:24 and 12:12:29. This stability is achieved as there is low activity. Moreover, in the plot we also have the pulse level that fluctuates between 60 and 100 which is considered normal.

From the histogram in figure 3 we can see frequencies of different values of ac-

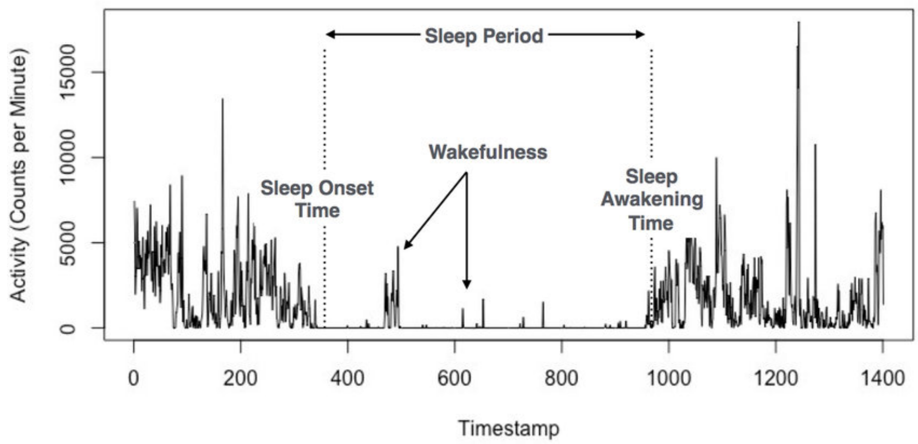

Figure 2: Acceleration data of ideal sleep time acceleration

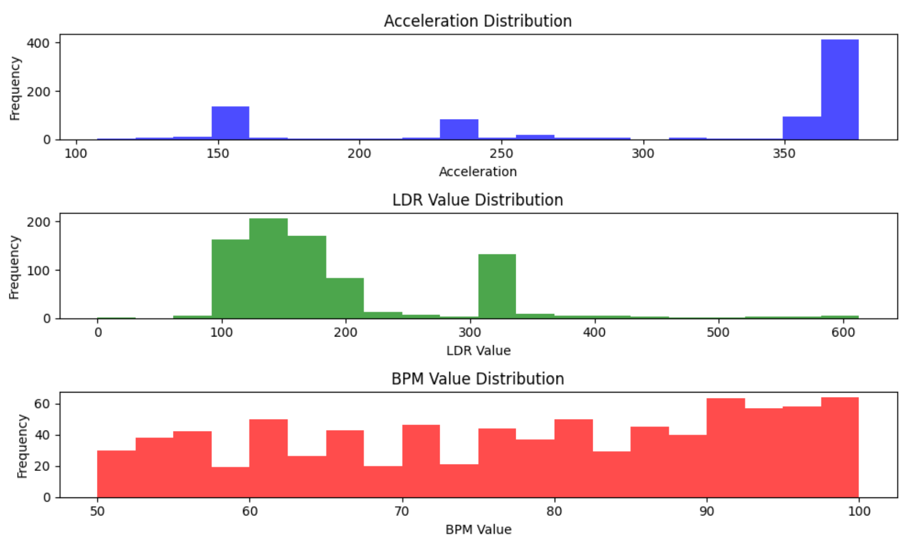

Figure 3: Histogram of acceleration, LDR, pulse rate values

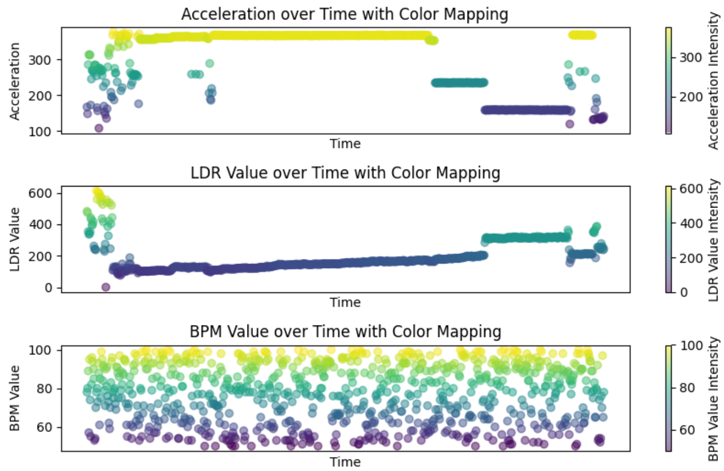

Figure 4: Scatter Color plot

celeration, LDR and pulse rate. In the heart beat plot of this histogram we see the distribution of heart beat is within 50 and 100. But in ideal good sleep conditions the heart beat should be considerably low in the range of 40-60. From this the assumption can be made that the sleep was not good.

In figure 4 we can see the coloured scatter plot of Acceleration, LDR and pulse rate. From here in the LDR scatter plot we can see the intensity of the light is rather high. For our LDR we have tested in a dark room the ideal value should be below 10 for most time. So from here the conclusion can be made that the ambient environment was not conducive for good sleep as the room was moderately well lit.

4.1 Analysis using code

We have also analyzed the collected data using code and got similar results as the plot(figure 5). To calculate the sleep duration we have compared mean acceleration of every 10 second interval with the mean of previous 10 seconds. If the current 10 second acceleration mean is larger by 30 then we have considered the current 10 second time to be awake time. We have kept on doing this for the entire data and summed all sleep times up, to get the total sleeping time. For LDR value we have taken the 0.85 quantile which means the value which is larger than or equal 85 percent of the LDR values. This value which is ideally supposed to be very low turns out to be moderately high which implies ambient light was not ideal for good sleep. Finally, we have the heartbeat which is higher than the expected value which implies the wearable user was not sleeping well.

```
Sleep Time Periods:
From: 11:04:50 To: 11:04:50
From: 11:05:00 To: 11:05:20
From: 11:05:30 To: 11:05:30
From: 11:05:40 To: 11:06:00
From: 11:06:10 To: 11:08:00
From: 11:08:10 To: 11:10:10
From: 11:10:20 To: 11:10:40
From: 11:10:50 To: 11:10:50
From: 11:11:00 To: 11:11:10
From: 11:11:20 To: 11:11:40
From: 11:11:50 To: 11:19:10
From: 11:19:20 To: 11:19:20
From: 11:19:30 To: 11:19:30
From: 11:19:40 To: 11:45:40
From: 11:45:50 To: 11:59:50
From: 12:00:00 To: 12:08:00
From: 12:08:10 To: 12:09:50
From: 12:10:00 To: 12:33:20
From: 12:33:30 To: 12:33:40
From: 12:33:50 To: 12:33:50
Total Sleep Duration: 85.83 minutes
The ambient light is not conducive for good sleep.The LDR value has been less than> 313.0 for maximum time. Ideal is less than 10.
The heart rate has been  93.0 most of the time which indicates not good sleep
```

Figure 5: Output of the program written for analysis

5 Conclusion

In conclusion the wearable we have designed is capable of monitoring sleep in a manner that is consistent with the findings of other credible sources. The wearable we have designed come with limited features but can be improved further by adding better sensors and prediction models.

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