Analysis of Sleep Hygiene in an IoT Sensor Network

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Objectives

The primary objective of the project is to monitor the correlation of sleep quality and environmental factors (Sleep Hygiene) via data collected from air quality, light, temperature and humidity sensors. This forms an Internet of Things sensor network hosted on a Raspberry Pi server. By analysing the data thus obtained, meaningful results are hoped to be derived. This can be extended to applications in:

- Sleep tracking devices
- Sleep quality analysers
- Smart alarms

Motivation

Analysis of Sleep Quality Getting enough quality sleep at the right times is essential in protecting one's mental health, physical health, quality of life, and safety.[1]. An estimated 70 million American people suffer from sleep disorders, like Sleep Apnea, without their knowledge, which amounts to $15.9 Billion in the national health care bill.[1] Hence, a meaningful analysis of Sleep Hygiene is likely to improve sleep quality, which will improve the overall health, mental and physical awareness, and productivity of human life, and the **low cost of the setup** will make it affordable for the general populace.

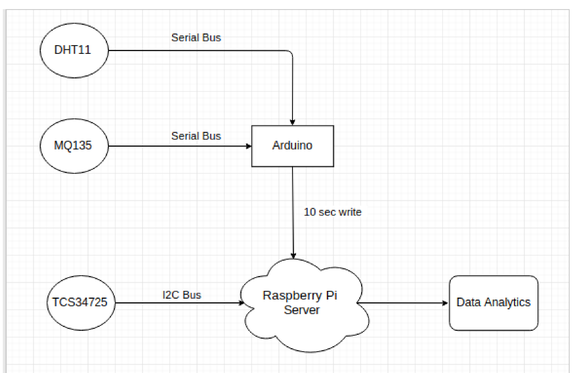

Figure 1: Block Diagram of Sensor Network

Medical Relevance

Sleep Analysis Different variables exist for monitoring sleep, such as movement throughout the night, tosses, and turns. Movement is a personal metric and comparing absolute values between people is not significant. However, a comparative analysis with respect to an individual's data from previous nights will be useful, as a conclusion can be made on the correlation between the person's movement and sleep.

Sleep Apnea is a common sleep disorder where one's breathing is briefly interrupted during sleep. The Alaskan Sleep Clinic estimates a number of 20 million Americans suffering from Sleep Apnea, 80% of which are unaware of their condition [2]. This interruption usually occurs during the REM cycle of sleep. So this means that if a person is experiencing sleep apnea, he is subjected to breathlessness and movements in the bed which gets reflected in the readings of the sleep app by an abrupt change from deep sleep to normal/light sleep. Breathlessness might also lead to snoring which gets monitored as a sound parameter. This project aims to detect and alleviate this condition through careful analysis.

Sensor Network Topology

Raspberry PI zero is setup in headless mode (with server control functionality) with the sensors mentioned below to observe the changes in environmental variables during the sleep time. The subject's sleep quality is captured by the **Sleep Cycle App** [3] which uses the mobile phone's inbuilt accelerometer and microphone to identify sleep states by tracking nightly motion in bed. This information is recorded throughout the duration of sleep and saved into a CSV file daily. Readings obtained from the sensors are correlated with the sleep quality through cluster analysis.

MQ135- Used to detect ppm of CO_2 in an indoor environment. This sensor was used to test the correlation of air quality with sleep quality, if any.

DHT11- Used to detect the temperature (Celsius) and Relative humidity (Percent) levels in the indoor environment

TCS34725- This light sensor was used to obtain both RGB color values, and the intensity of incident light. Through our analysis, we hope to obtain the optimal color and intensity in various spatial contexts to facilitate the highest level of sleep quality.

Important Result

The use of **light therapy** as suggested is critical in treatment of patients suffering from **Seasonal Affective Psychosis**. This is an onset of a mental psychotic state brought upon by a drastic change in sleep hygiene, especially prevalent in countries located far in Northern regions (Scandinavia).

Components

The main components required are:

1. Arduino Uno
2. Raspberry Pi Zero
3. MQ-135 Air Quality Sensor
4. DHT11 Temperature and Humidity Sensor
5. TCS34725 Light Sensor

Process

The data gathering process was done over a two week period, from 12:30 A.M. - 7:20 A.M. each night. The data collected from the sensors and the app was plotted via cluster analysis to detect optimum conditions for correlation with sleep quality. This data was plotted in a scatter plot for visualisation.

Data Analytics

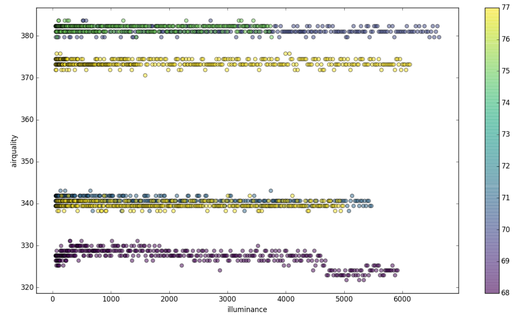

Figure 2: Scatter Plot of Air Quality, Light Illuminance, Sleep Quality

References and Resources

1. The National Center on Sleep Disorders Research
`https://www.nhlbi.nih.gov/about/org/ncsdr`
2. Alaskan Sleep Clinic Research
`http://www.alaskasleep.com`
3. Sleep Cycle Mobile App by NorthCube
`http://www.northcube.com/`

Conclusion and Results

The following optimal conditions were observed throughout the course of analysis:

1. **Light Intensity:** Red 581, Blue 593, Green 589, Illuminance 307 lux
2. **Air Quality**: 359.67 ppm CO_2
3. **Temperature** = 28.65°C
4. **Humidity** = 56%
5. **Cardiovascular Activity** = 10,252 steps ≈ 8 kilometers
6. **Future Scope:** for much clearer convergence, a vast increase in data points is required, which is planned for the upcoming academic semester.