Monitoring the Key Parameters of Circadian Rhythm for Life Style Observations

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Abstract

The circadian rhythm is a natural rhythm in the human body that regulates several physiological functions such as sleep-wake cycles, hormone secretion, and metabolism.

The project aims to provide a quick, accurate, and user-friendly way to track a person's health. The user-friendly and wearable hardware module makes it ideal for continuously monitoring critical circadian rhythm parameters. The module could revolutionize the healthcare industry by providing personalized health recommendations and early detection of health problems.

Introduction

A 24-hour cycle that governs numerous physiological processes in living creatures, including humans, is known as the circadian rhythm. The human circadian rhythm regulates many bodily functions, including sleep-wake cycles, hormone secretion, and metabolism.

As a result, there is a rising necessity for monitoring and analyzing the essential parameters of the circadian rhythm to comprehend an individual's health state. This is where our initiative comes in. Our research aims to develop a hardware module with sensors to monitor the important parameters of the circadian rhythm. The ECG, PPG, Accelerometer, and GSR sensors regularly collect data from the subject's body. Machine learning algorithms analyze the data and develop a health index reflecting the subject's health. The accelerometer sensor data is also used to measure sleep activity, which provides extra information about the subject's sleep quality.

Motivation

Disruption of the circadian rhythm can seriously affect an individual's health and well-being. Unfortunately, circadian rhythm problems are frequently misdiagnosed and undertreated since many people are unaware of their irregular sleep habits' influence on their general health. We can better understand how this natural biological process affects an individual's health and well-being if we design a gadget that monitors the circadian rhythm's important parameters. Healthcare providers can use this gadget to detect early indicators of circadian rhythm abnormalities and give necessary therapies. Individuals may also use it to track their health and well-being and make lifestyle adjustments to optimize their circadian rhythm.

Monitoring critical parameters of this rhythm can provide valuable information about a person's health, but most currently available methods are frequently invasive, time-consuming, expensive, and unsuitable for long time monitoring. This limits their applicability in real-world settings.

The proposed project overcomes these limitations by providing a non-invasive and convenient way to monitor the critical parameters of the circadian rhythm, which are pointed out to be HRV(cr1), Sleep-Activity-Cycle(cr2), BP(cr3), CBT(cr4), and GSR(cr5).

Content

A hardware module has been developed in the initial prototypes, outfitted with ECG, PPG, Accelerometer, and GSR sensors capable of recording a subject's key Circadian Rhythm parameters. The module is designed to be worn on the left forearm, allowing for continuous monitoring of these parameters. The monitoring is done without interfering with daily activities. The form factor of the developed hardware is designed to make the device user-friendly and suitable for constant monitoring of the essential parameters even while a subject is asleep.

The raw data collected by the sensors was then processed using a microcontroller module and sent to our database for storage. The data has been further analyzed using machine learning algorithms to create a health index that reflects the subject's overall health status. Several parameters are included in the health

index, including cardiovascular health, stress level, and sleep quality.

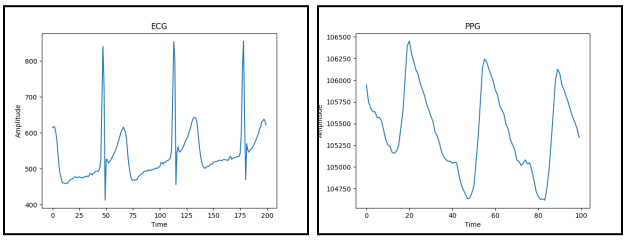

Figure 1. ECG graph and PPG graph

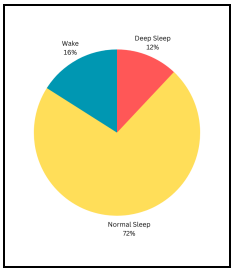

Figure 2. Sleep Activity

Initially, the proposed project considers only two Diseases/Disorders , namely Diabetes and Cardiovascular disorder. One more category will be used as the base category to formulate the final health index with reasonable accuracy. There are n subjects in each category.

The project's database has five key parameters [cr1, cr2, cr3, cr4, and cr5] , where each CR variable forms a matrix using the recorded datasets. After applying the machine learning in these five parameters on the Healthy category, the respective weights "**WH**" are generated. Similarly, for the Diabetic and Cardiovascular types, "**WD**" and "**WC**" are developed, respectively. (These weights are trained to be globally accepted and generic using a suitable set of databases).

Diabetic	**Cardiovascular**	**Healthy**
Subject 1	Subject 1	Subject 1
…..	…..	…..
Subject n	Subject n	Subject n

With these weights, the health index formulates the different dependencies of [cr1 , cr2 , cr3 , cr4, and cr5] in the following manner : f(H.I) = G(cr1, cr2, cr3, cr4, cr5) on this category to generate a generic heath index "**HI**."

With the help of generic weights ("**WH**," **WD**," **WC**") and health index("**HI**") , a specific range of a health indices for diabetic , cardiovascular, and healthy categories will be predicted.

Hardware Design

The pictures show the wearable hardware module with the required sensors interfaced with the central microcontroller unit. The module is powered up by a rechargeable 3.7 volts battery(integrated with the module). The module also includes a buzzer in its power supply segment, which triggers and alarms when the input voltage gets reduced below its minimum requirement. The sensors are compatible with recording ECG, PPG, Accelerometer, and GSR pulses, tapped suitably at a predefined spot in the body. The other image demonstrates a real-time scenario where the module was worn for the data collection. The left hand is chosen explicitly because the ECG sensor electrodes can be conveniently taken to the chest nodes for obtaining the ECG pulses as per the medical standards. There will be no direct touch to the sensors and any other components that ensures the safety of the hardware and the arm. The developed prototype can be further fine-tuned as we gradually progress and can be made commercially viable. The overall cost of the hardware is meager concerning the commercially available health monitoring devices.


Figure 3. Depicting the design and wearability of the designed hardware module.

Conclusion

Finally, this project created a hardware module outfitted with sensors capable of monitoring the critical parameters of the circadian rhythm. The module provides a non-invasive, convenient, and accurate way to watch a person's health by leveraging advanced sensors and machine learning algorithms. The data-driven health index can provide valuable insights into the subject's overall health

status, such as cardiovascular health, stress level, and sleep quality.

The module's potential applications include home monitoring of elderly or high-risk patients, athlete performance monitoring, and early detection of health problems. The module's design is user-friendly, making it suitable for continuous monitoring of the critical parameters of the circadian rhythm. This project has the potential to significantly impact the healthcare industry by providing personalized health recommendations and early detection of health problems, which can lead to improved health outcomes and lower healthcare costs.

Overall, this project demonstrates the potential of using advanced sensors and machine learning algorithms to monitor the critical parameters of the circadian rhythm, ushering in a new era of healthcare monitoring and management. With further development and testing, the hardware module has the potential to revolutionize how we monitor and maintain our health, providing more personalized and effective healthcare solutions.

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