Development of a Heart Rate Monitoring System (Part II)

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Abstract—The respective Heart Rate Monitoring System is engineered to detect fear and anxiety levels in students undergoing engineering related activities. Dr. Pi-Sui Hsu is a staff member of Northern Illinois University’s College of Education Program. Because anxiety toward math and science courses is prevalent, Dr. Hsu is conducting a study that will track these anxiety levels. The Heart Rate Monitoring System was carefully designed following each need and constraint from the client. This device uses a photodiode and LEDs to send a pulse signal to an Arduino. The signal is converted to a beats per minute (BPM) value and that data is sent wirelessly to an external computer in an excel file.

I. INTRODUCTION (HEADING 1)

School related anxiety is a growing pandemic for many young students. It is even more common when it comes to math and science related courses. Stress and anxiety are physical reactions that can be measured by a spike in one’s heart rate. There are thousands of heart rate monitors on the market that can track heart rate, but most are extremely expensive or do not have the ability to transfer data to a computer for the sake of observing it. The main objective of this project was to design a heart rate monitoring device that was inexpensive and also capable of transferring its data in the form of an excel file to an external device. This data shows the user’s beats per minute (BPM) value in 15 second intervals. This data format is suitable for this setting because any spike in the data would be indicative of feelings of stress in the user.

The client of this project is Dr. Pi-Sui Hsu who is an associate professor for Northern Illinois University’s College of Education. Dr. Hsu conducts an after-school program for middle school students that focuses on science and engineering. With years of experience, Hsu is well aware of the widespread anxiety students face when undergoing science and engineering related activities in school. As a result, she has been monitoring her student’s heart rate during class with a product called Biodot. This product, which is worn around the user’s wrist, is designed to measure the stress level of the wearer. Although inexpensive, this device gives feedback in the form of 3 different colors where the darker the color, the more stress the user is experiencing. It may give a general idea however; this is not a measurable amount and is therefore not appropriate for research. A better solution would be a heart rate monitor that gave numerical data which could also be transferred to a computer such that the data can be stored and analyzed. Additionally, having the ability to observe the user’s heart rates as the activities are being held would be of importance because Dr. Hsu would be notified of a student’s anxiety as it is happening.

With thousands of heart rate monitors on the market, there are many similar products to this one. The T31C Heart Rate Sensor created by Polar is relatively inexpensive and can transfer its data wirelessly [1]. Unfortunately, this data is sent to a very specific smartphone application and cannot be transferred or edited. One product that does transfer universal data to a computer is the Scosche Rythym24. This product, which uses the same sensors as the proposed design, has the same functions and even more [2]. Unfortunately, it is 3 times the cost as our design. The market offers many variations of heart rate monitors, but none that give live and editable data at a low cost.

II. METHODS AND MATERIALS

Mainly, there are 4 methods to measure heartbeat rate which are, electrocardiogram, photoelectric pulse wave, blood pressure measurement, and phonocardiography [4]. The photoelectric pulse wave method is used for this project where infrared light (LED) emits through the skin, and the photodiode sense the reflected light from the body. The photodiode, then, sends the data to the Arduino to analyze the change in the blood volume based on the reflected light, measured by the photodiode, to determine the pulse rate and then it calculates the heartbeat rate per minute.

Below in Figure 1, is the schematic showing all the components and how they are connected. As shown, the heart rate monitoring device contains an Arduino Nano, IR LEDs, a Photodiode, a BTBEE Bluetooth Transmitter, and a Rechargeable Battery.

![Heart Rate Monitoring Device Schematic](image)
III. RESULTS AND DISCUSSION

Below in Figure 2, a waveform is shown. This wave was a result of the LEDs and photodiode working together to gain a signal from the user’s pulse. By dividing the Samples by 100Hz, the duration in seconds is obtained. This is converted into duration in minutes by simply dividing by 60. From here, the beat count can be divided by the duration in minutes to obtain a beats per minute (BPM) value.

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As shown above, the user’s heart rate is around a steady 81 BPM. When anxiety is induced, values will spike to around 140-180 BPM which will be obvious for the conductor to visualize [3].

IV. CONCLUSION

Although the heart rate monitoring device wasn’t able to be completed and tested through trials, the electronic circuit and programming have proven to have made appropriately so the device can record information through LED lights and transfer the given data to a computer via Bluetooth successfully. There have always been students who have struggled with staying calm and being patient in order to understand complicated courses like science and engineering.

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References