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Development of Smart Gloves Prototype for Cyclists

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ABSTRACT

Smart technologies have set their own standards and made their way into the current period. In that way, smart gloves have their own reputation for various purposes, such as gaming, boxing, power lifting, etc. However, there are not many smart gloves exclusively for cyclists in the market. Smart gloves for cyclists would be beneficial for monitoring their vitals during the athletic training or tracking their activity. There are few highly expensive wearable activity monitors that results in detecting the abnormal health status before it affects the athlete, during cycling and resistance exercise. In this paper, a smart glove prototype for cyclists is developed using Arduino software with affordable price, accurate reading of the heart rate, and oxygen-saturated level in the blood using MAX30100 sensor. The GPS enables locating and detecting the location of the user during the cycling activities. The determined data will be displayed on the Android smart phone of the user with the support of Bluetooth connection. The values can be monitored in real time, benefiting the user to act accordingly to the values in case of any significant abnormalities seen during the cycling activity. MIT app inventor had contributed a great part in accomplishing the mobile application for monitoring. As a result, in this study the developed prototype compensates the limitations of the existing smart glove and in cooperated it for serving its purpose at an affordable price.

INTRODUCTION

In the 20 centuries, it can be seen that a growing interest in the smart technologies that help, encourage and support people with regard to the regular practice of physical activity in general and fitness activity in particular. Implementing smart technologies to interface fitness routines has played a role in this modern generation. When it comes to wearable technologies, smart cycling gloves can't be left out of the conversation. When combined with recent advances in personalized diagnosis and treatment technology, advancements in postoperative tracking technology and the goal are illness prevention at an early stage, these kinds of bio-multifunctional smart wearable sensors are at a turning point in realizing widespread applications and have significant potential social benefits (Wang et al., 2019).

Severe health disorders, like cardiovascular events, respiratory disorders and musculoskeletal injuries, etc., may happen during a long cycling distance competition, due to long period exercise and sometimes-environmental conditions. Health disorders are very common among the young athletes and particularly at the beginning of the training season. The sport discipline is highly demanding and often leads to dehydration that can be followed by hypotension; decreased coordination; fatigue; and, in some scenarios, Vasovagal syncope leads to fainting episodes. Besides that, there are many severe situations attributed to cycling include arrhythmias, hypoxia, hypoglycemia, hyperventilation, and inappropriate dyspnea Having a health monitoring technology is helpful during competition for determining the athlete's performance to the load of the exercise to reduce the risk of injuries, heart problems, and other health disorders (Iliadis et al., 2021).

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Global Positioning System (GPS) provides real-time access to positioning and navigation information. Furthermore, with the widespread adoption of smartphones, we can access GPS-based positioning and navigation tools even more easily. Even if GPS-based tools help users find destinations efficiently, it is still important to examine the implications of a transition from relying on our cognitive map (or traditional analog tools) to an always-available mapping system that simultaneously shows our position and the surrounding geography (Jung and Bell, 2015). Cycling GPS such as Garmin Edge 130 Plus, Bryton 420T Intelligent GPS Bike are being sold at high prices, costing more than an individual can afford. Although the amazing aspects of these gears can inspire athletes to exercise in their daily lives, the problem is not affordable for everyone to get these units for themselves. The additional parts & maintenance cost needs to be considered if the technology can be fix. There are brands with cheaper prices but cannot be paired with smartphones.

People who do not monitor their health (SpO_2 and heart rate) during cycling may face some severe health problems such as Hypoxia if their SpO_2 level is low, and if the heart rate is abnormal, they may get cardiovascular diseases. Because there are no cycling gloves that can detect heart rate and SpO2 level and display them in the markets/shops (Ahmed et al., 2018; Boudreaux et al., 2018). After purchasing smart technologies such as wearable health monitoring, cyclists discard them for a variety of reasons, one of them the data collecting is ineffective. According to reports, the tracker does not always display the readings of heartbeats and SpO_2 displayed during exercise. In addition, the accuracy of the detecting of the heartbeats and oxygen level during cycling did not satisfy the expectations of the user. This leads the cyclists to rely on the old practice over the new technological assistance and this results in abundant use of the technologies. The utmost reason why the people are abounding the technologies is the complexity of the technologies (Lazar et al., 2015).

Hence, the objective of this study includes are to develop gloves that can be connected to GPS and smartphones with affordable prices, to innovate gloves that can check the heart rate and saturated Oxygen (SpO2) level in the blood and to determine the accuracy output of the innovative gloves.

MATERIALS AND METHOD

Based on Figure 1, smart glove was built with smart sensors and modules. In this project, the electronic components that are used are MAX30100 sensor, Bluetooth HC-05 and Arduino Nano. The MAX30100 is an integrated pulse oximetry and heart rate monitor sensor solution. It combines two LEDs, a photo detector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. It operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

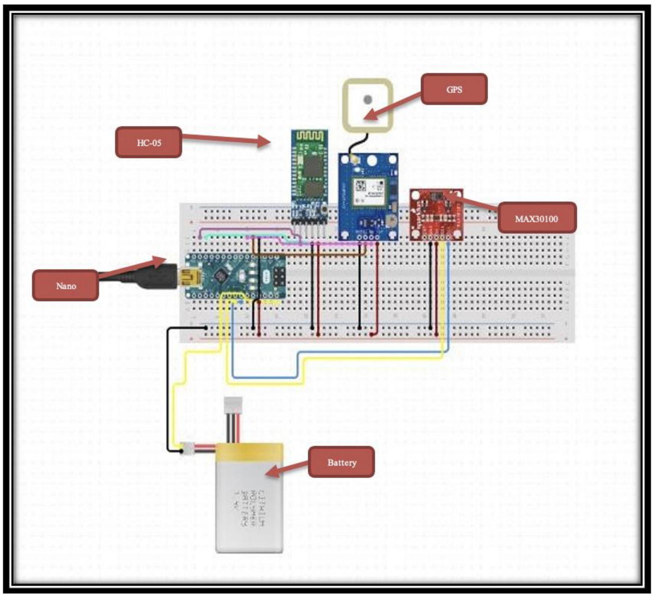

Fig. 1 Electronic circuit for the cycling gloves.

It is a little, completed, and breadboard-friendly board that runs on the ATmega328 microcontroller (Arduino Nano 3.x.). Its functionality is nearly identical to the Arduino Uno, except it comes in a different package. It is crucial to use stable current to produce a clock with correct recurrence. The lone limitation is that it cannot be supplied with any external source of force, such as a battery. Because there is no DC power jack.

Bluetooth used for enabling wireless connection for data transferring between smart devices, without any cords or cables. HC-05 Bluetooth Module specifically designed for wireless communication purposes. This module can be in a master or slave mode. HC-05 Bluetooth module. The HC-05 can conduct this research by transmitting and receiving data from the microcontroller in the smart gloves to the user's smartphone, which can then show the results on the phone. GY-NEO6MV2 board features the u-blox NEO-6M GPS module with antenna and built-in EEPROM. This is compatible with various flight controller boards designed to work with a GPS module. The accuracy of the cycling glove is determined by testing with different existing devices and the results of each device were compared. The percentage of error is given by the formula below:

Formula

$$\delta = \left| \frac{v_A - v_E}{v_E} \right| \cdot 100\%$$

δ = percent error

v_A = actual value observed

v_E = expected value

RESULT AND DISCUSSION

The complete prototype is a combination of the electronic components and the cycling glove. The prototype of the cycling glove was fabricated using medium size of breadboard, whereby the electronic sensor was attached to the cycling glove as shown in Figure 2 and Figure 3.

Fig. 2 The prototype before installing the electronic components.

The red light in Figure 2 indicates the components work as the Bluetooth, it was blinking which means it has connected to the smart phone and ready to send the data once the finger is placed upon the sensor.

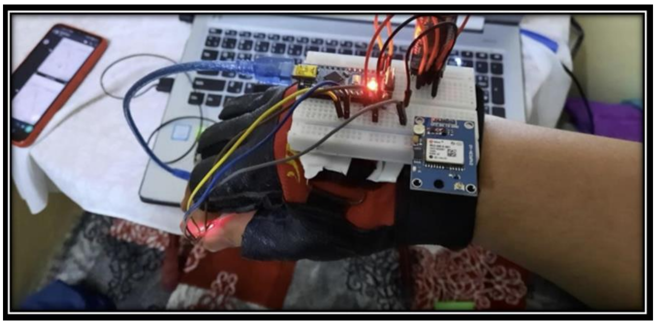

Fig. 3 The prototype after installing the electronic components.

The electronic circuits were attached to cycling glove by using a double tape, there was a strong glue in-between to make it stable as well as to prevent the sweat reaching the electronic components as shown in Figure 3 The electronic components of the prototype design were functioning well as the combination of the electronic components and the cycling glove were wrapped by double tape filled with a glue for more solid structure. The wiring of the heart sensors was long enough to reach the index finger. The cycling glove helps in preventing the shocking hazard by absorbing the sweat. The prototype can be powered by 3.7v battery as well as power bank when the battery percentage is low.

The data from the sensor MAX30100 [BPM & SpO_2 percentage] and location readings were displayed on the smart phone application. The connection between the smart phone and the smart glove has been established as the smart phone started to receive the data of heart rate, SpO_2 level and user's location after clicking locate me button. The connection status will be changed to connected. The readings of MAX30100 sensor were accurate for normal and fast cycling session when comparing the results with the normal range. However, there was a slightly different when comparing with the existing devices.

The data of the heart rate for the fast-cycling session, as the smart glove was the highest among the other devices, which was 106 beats per minute, compared to the other devices. Although, the difference among the data from all four devices were not that big. It was due to the placement of the sensors in the smart glove prototype as well it being griped strongly alongside the handling bar while accelerating. In addition, the design of the smart glove prototype was not solid stable as it results in the movement of the wire while moving fast caused some data may not be sent. However, the reading of the heart rate did not exceed the danger zone.

The outputs of the heart rate were also observed for normal cycling as Apple watch 6S was the highest among the others, which was 85 beats per minute, compared to the other devices. Honor band 4-7cc and Amazfit GTS 2 fitness smart watch both of them were 84 beats per minute as for smart glove prototype it was 83 beats per minutes. The reason why the reading of the smart glove was the lowest even though the difference among the data were not that big because of the design of the smart glove as it was not solid stable and this affected the reading as some data may not being received. However, the reading was considered acceptable as it was within the normal range.

The outputs of the SpO_2 were extracted from the fast-cycling session as Apple watch 6S was the highest as compared to the other devices which was 95%, the smart glove prototype was 94% and the Amazfit GTS 2 fitness smart watch was 93%. While Honor band 4-7CC did not support the reading of SpO_2 percentage, as the difference among the three devices outputs were not that big. Since the heart rate sensor in the smart glove prototype was not stable but it was being held alongside the handling bar the reading of the oxygen level was considered below the normal level, which was 94% as consuming more oxygen when accelerating the speed. Hence, it was considered as normal for the oxygen level to drop a little bit during doing activities but, in case if the blood oxygen level drops below the normal range, immediate medical assistance is required (Coughlin et al., 2016).

The extracted data of SpO_2 level from the normal cycling session also showed that the similarity in the outputs between the smart glove prototype and apple watch S6 as both of them 96% compared to Amazfit GTS 2 fitness smart watch was 97%. While Honor band 4-7CC did not support the reading of SpO_2 level. Since the normal cycling did not require a lot of physical energy to be applied during the cycling as compared to the fast cycling. Moreover, the design of the smart glove prototype was not very solid but the reading of its sensor was still accurate. Hence, all the outputs from the three different technologies were within the normal range (Fraser, 2013).

Table 1 displays the data from the smart glove, Amazfit GTS 2 Fitness Smart watch and Honor band 4-7CC during the normal cycling. They were compared with apple watch S6 to check the error percentage for each device. The error percentage of the smart glove were 2.3% for BPM and 0% for SpO_2 level. While the error percentage for Amazfit GTS 2 Fitness Smart watch was 1.1% for BPM and SpO_2 level respectively.

Table 1 Error percentage (%) for normal cycling

Apple watch S6	Heart rate (BPM)	SpO_2 (%)
Smart glove	2.3	0
Amazfit GTS 2 Fitness Smart watch	1.1	1.03
Honor band 4-7CC	1.1	

Table 2 compares the percentage of error from the smart glove, Amazfit GTS 2 Fitness Smart watch, and Honor band 4-7CC during fast cycling to the percentage of error from the apple watch S6. The error percentage of the smart glove prototype was below than 2 percent for BPM and SpO_2 level. However, the inaccuracy percentages for the Amazfit GTS 2 Fitness Smart watch were greater than 2 percent for BPM and SpO_2 level.

Table 2 Error percentage (%) for fast cycling

Apple watch S6	Heart rate (BPM)	SpO_2 (%)
Smart glove	1.0	1.1
Amazfit GTS 2 Fitness Smart watch	3.0	2.2
Honor band 4-7CC	6.0	

The obtained results of BPM and SpO_2 level during the two sessions, normal cycling and fast cycling were within the normal range of a healthy person. The error percentage from both sessions were below than 5% only the honor band had exceeded the 5%. The SpO_2 level decreased slightly due to the physical activities caused the reduction of the amount of oxygen that binds to hemoglobin, the oxygen level in the blood drops somewhat during exercising (Jain et al., 2015). The human body normally responds to variety levels of oxygenation by raising breathing rate when working exercise (Maw et al., 2016). As a result, during severe exercise, the breathing becomes heavier and quicker due to a lack of oxygen in the body (Padakis et al., 2016). The heart rate rises, and the muscles receive the oxygen they require. For muscles to function properly, enough blood oxygenation is required (Marx et al., 2018).

CONCLUSION

In conclusion, the development of the smart glove prototype for cyclist has been successfully accomplished as the connection between the smart glove and the smart phone established successfully through Bluetooth module HC-05. The heart rate and the saturated oxygen level sensor MAX30100 have been installed and run successfully. As result, the data from the cycling glove prototype could display on the smart phone and on the monitor using Arduino software. MAX30100 sensor used in many applications since its small, cheap, and easy to use comparing to the other sensor. The comparisons among the existing devices have helped in determining the output accuracy of the cycling glove prototype. The results from this study showed that smart cycling glove prototype was accurate as the error percentage were less than 5%.

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