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A Smart Bicycle BackView System Using IoT

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Abstract: A culture of finding pleasure through the pursuit of personal hobbies has been trending in recent years. One of such hobbies is cycling. Due to a rise in interest in casual cycling in the form of a hobby rather than the pursuit of professional aspirations, cases of related accidents have also been on the rise. Contact accidents are one of the most common types of such accidents. On the other hand, a number of new Internet of Things (IoT) products that combine objects with the internet have been introduced. In line with these trends, this study aims to design and realize a bike backview capable of allowing cyclists to view blindspots in real time. An Arduino was used and a Raspberry Pi was used for the purpose of providing a real-time streaming display. Due to the fact that a bike backview provides to cyclists visual and audible means of checking blindspots in real-time that are otherwise difficult to visually check, it is expected to prevent the occurrence of contact accidents associated with bikes.

Key words: IoT, Arduino, Raspberry Pi, sensor, RTSP (Real Time Streaming Protocol), blind spot

INTRODUCTION

In recent years, terms and phrases such as YOLO (You Only Live Once) and Hygge Life have begun to trend. Such newly trending terms commonly suggest a greater interest in the happiness of the self. Although, in the past it was common for people to exercise restraint for the things they desire for a better future current life styles involve putting greater emphasis on individual happiness. This has led to a rise in the number of people pursuing hobbies that they desire during free time. One of such hobbies is cycling. In South Korea, the cycling population has risen to over 12 million. With an increase in the number of cycle enthusiasts, the number of cases of related accidents has also been on the rise. Contact accidents account for the most common accidents of all cases of accidents that occur during cycling (Chang-Kyu, 2013). Due to the nature of bikes when a cyclist is facing forward, a cyclist loses awareness of what happens behind them. Even if a cyclist turns around to look behind at that moment, a cyclist is still exposed to the risk of accidents that may occur due to not being able to see what is happening in front of them while also not being able to be fully aware of the situations that may be present in blindspots. In addition by not being capable of recognizing cars approaching from behind, cyclists are often exposed to the risk of accidents due to loss of balance caused by cars passing by and failing to secure safe distance. More often than not, cycling accidents lead to serious injuries or even death. Such accidents have been on the rise by 9.4% each year. To solve such problems, this study proposes the development of a bike backview.

This study uses Arduinos. This is because they have relatively low prices are light-weight and are appropriate for installation on bikes. Due to the fact that the Bike backview provides both visual and audible indicators, users of the system can pursue active and smooth cycling without being affected by the time of the day or their locations. Through this, users can reduce the risk of accidents due to cycling and continue to enjoy their hobby.

Literature review

Bicycle accidents: Due to the fact that cyclists are exposed to the elements, there is a high possibility that bike accidents will result in injury. In actuality, an increase in the number of bike users has led to a trend in which the

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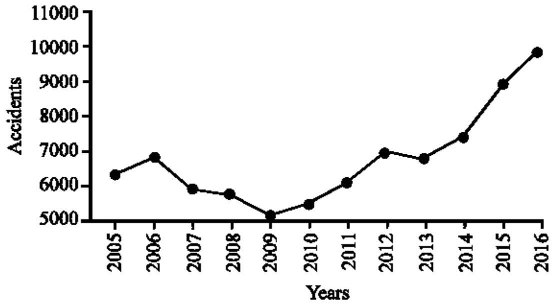

Fig. 1: Bicycle accident per year

number of bike accidents has increased. In line with this, the number of injured cyclists per bike accident has also been on the rise. Data regarding these trends are presented in Fig. 1 (Hong and Kim, 2010).

Arduino: Arduinos receive input values from various switches or sensors to control the output of electronic devices such as motors or neo-pixels. Because of such interactive functions with their environments, Arduinos are currently being used across various fields. Due to, the fact that the circuitry of Arduinos is open source, Arduinos have a low entry barrier and allow people even with no basic knowledge to easily design boards. Currently, the PCB of Arduino has been kept public and a number of different products including the Uno, Duemilanove, Nano, Bluetooth and Lilypad have been introduced for sale (Kyung-Ho, 2013). The most representative Arduino model is the Arduino Uno which has 14 digital ports, 6 analog ports and 5 and 3.3 V output pins. Writing programs for Arduinos is very simple and can be done by members of the general public without knowledge of C languages. If any errors in the code occur, the programming tool provides in-depth explanations that help program writers find exactly what the problem is resulting in the easy solving of problems (Mi-Sen, 2016).

Infrared ray: When dispersing sunlight through a prism, the electromagnetic waves found beyond the edges of the red color lines are known as infrared light. Depending on the wave lengths, infrared light is further classified as near-infrared for wavelengths between 0.75~3 μm as infrared light for wavelengths between 3~25 μm and as far-infrared for wave lengths of 25 μm or greater. Compared to UV or visible light, infrared is known to produce strong heat interactions and because of this, it is also called a heat ray. Radiant heat conducted through space from a heat source or the sun is typically due to infrared. Infrared loses little intensity while it passes through the air compared to visible light. Sensors used to detect infrared are capable of detecting small temperature differences on ground surfaces and because of this, it is possible to observe ground surfaces during dark nights with no light or through cloudy weather (Jin-Sang, 2005).

Raspberry Pi: The Raspberry Pi is a low-cost mini PC of the size of a credit card which was created by the Raspberry Pi Foundation in the UK for the purpose of basic computer science education in schools. Unlike the Arduino, the Raspberry Pi can become a PC by connecting a keyboard, mouse and monitor to the device. The Raspberry Pi has video processing capabilities strong enough to support full HD resolution images. Its GPIO (General Purpose Input Output) is also capable of supporting connections to a number of control devices. Currently, the Raspberry Pi has been introduced up to the Raspberry Pi 3 Model (Dong-Hyuk, 2016). The Raspberry Pi was considered appropriate for use in this study since it is capable of displaying HD quality real-time image streams for its users.

MATERIALS AND MATHODS

A bicycle BackView system using Arduino

System design: This study designed and developed a bike backview using Arduino and Raspberry Pi. Through, the development of the bike backview, a means of conveying information regarding blindspots to its users during cycling was proposed for the purpose of dramatically reducing the occurrence of contact accidents and promoting the safety of its users. The design drawings of the system were presented in Fig. 2.

The design drawings specify the installation of the Arduino and sensor (infrared distance measurement sensor, neo-pixel and speaker) as well as the Raspberry Pi camera module to a bike. Due to the nature of bikes which make them largely affected by wind resistance, the size of the modules was kept as small as possible and bands were proposed as a means of fastening the devices to the bikes for the purpose of reducing the possibility of misplacing the devices during cycling. By installing an infrared distance measurement sensor at the rear of a bike, a method of informing users of detected individuals according to their distances was proposed. Using NeoPixels, the system makes it possible to visually convey information to its users. In addition, the system makes it possible to audibly convey information to its users using speakers. A means of streaming the rear-view of a bike, otherwise not visible to mobile phones in real-time was made possible by installing the camera module using a Raspberry Pi at the rear of the bike. This function is expected to not only provide the ability to stream the rear-view in real-time but also serve as a recording function similar to that of black box units of cars.

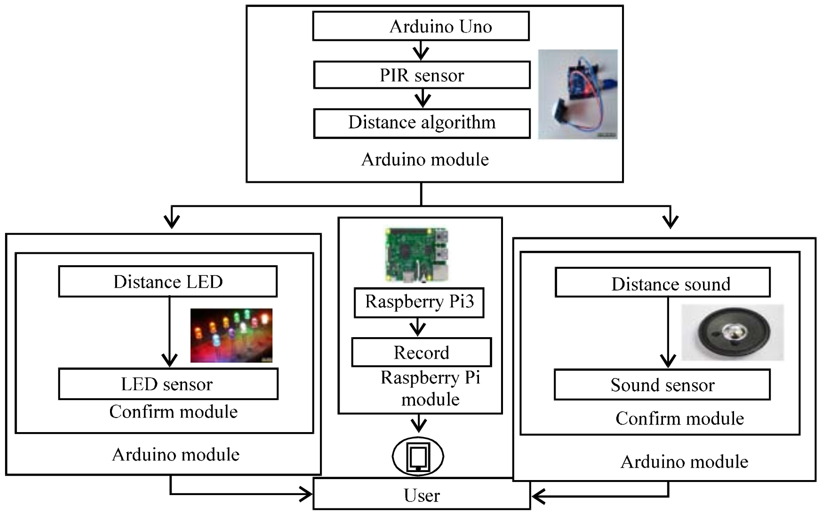

Fig. 2: System architecture

System implementation: This system of this study was developed on Microsoft Windows 8.1 K 64 bit. Raspberry Pi 3 ARM Coretex-A53 was used as the operating system of the Raspberry Pi. AT mega 168 was used as the operating system for the Arduino Nano and AT mega 328 was used as the operating system for the Arduino Uno. Communication was set up to be undertaken via Bluetooth modules using two Arduinos in order to make the NeoPixel and speaker respond to distance measurements taken by the infrared distance measuring sensors while accounting for the distance between the devices installed on the bike.

Figure 3 presents the Arduino Bluetooth communications algorithm. Distance values can be shared through the following algorithm. The two Arduinos were used in this study: an Arduino sketch open library as shown in Fig. 4 where one Arduino is responsible for measuring distance values using an infrared distance measurement sensor and the other Arduino responsible for receiving this information via Bluetooth communication and determining the appropriate levels used to control the output of the NeoPixels and speaker. Figure 4 presents the window that realizes the output of measured values found through the infrared distance detecting sensor via serial communication. The range of measurements was set from 20-150 cm in which measurements that fell out of this were set to trigger output of the message: 'Out of Range'.

Implementation results: Each of the devices was installed on a bike using handle bands. The infrared distance measurement sensor was installed behind the saddle of the bike and was used to check for the existence of objects behind the bike and measure the distance to the

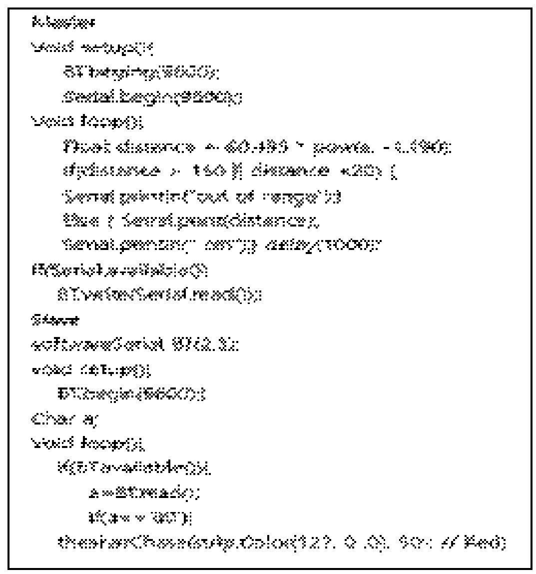

Fig. 3: Arduino Bluetooth commnuication algorithm

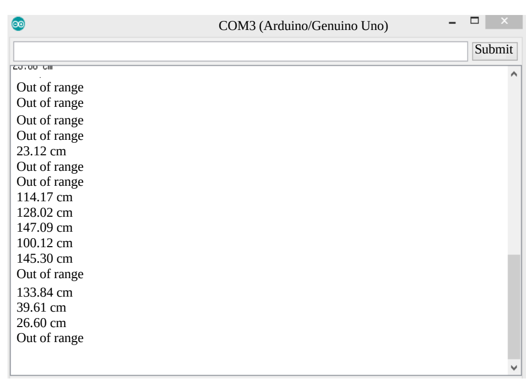

Fig. 4: System implementation results

Fig. 5: Infrared sensor attached to bicycle

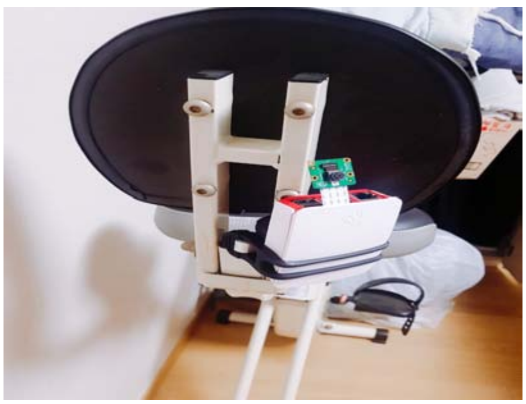

Fig. 6: NeoPixel attached to bicycle

object if it was present. The measured distance values were then transmitted to the NeoPixel installed on the bike handles via. Bluetooth. Figure 5 presents a bike installed with the infrared distance measurement sensor on its saddle.

Due to the NeoPixels being installed on the handles of the bike, users are capable of predicting situations behind them while facing forward through the lights that turn on according to the distance values obtained from the infrared distance measurement sensor. Figure 6 presents a picture of the above process. The Raspberry Pi camera module was installed on the back of the bike saddle and served the purpose of streaming the rear-view situation of the bike to a smart phone and also recording the images to function as a black box for a bike. Figure 7 presents a picture of the above process.

The distances measured by the infrared distance sensor were divided into three categories that were presented through the lights of the NeoPixels. For distances of <100 cm (approximately 1 M) red color lights

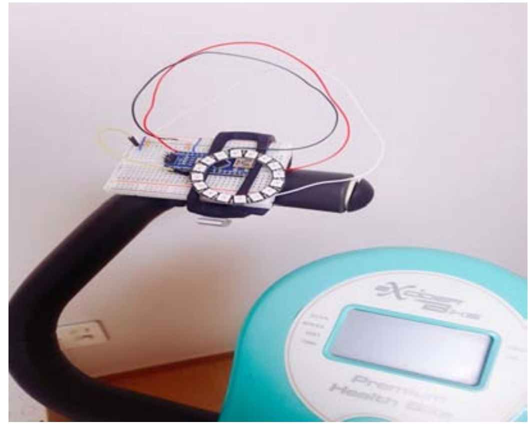

Fig. 7: Raspberry camera attached to bicycle

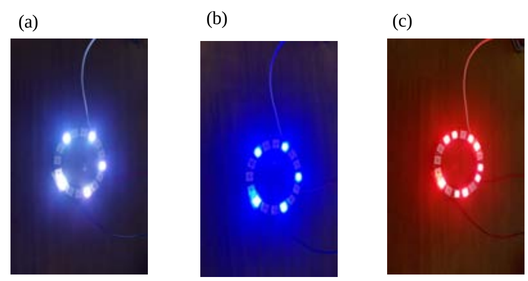

Fig. 8: Light by distance

were lit. For distances >100 and <150 cm, blue color lights were lit and for all other cases, white color lights were lit. In the case that a distance of <30 cm was detected, users were notified of this through a sound produced by the speaker. Regarding each of the lights, white colors indicated the best situation, blue colors a satisfactory situation and red colors a situation warranting caution. Figure 8 presents a picture of this process.

RESULTS AND DISCUSSION

Performance evaluation: Performance assessment of the bike backview was undertaken in an area when it was dark and also when it was brightly lit. The assessment aimed to examine whether the NeoPixel lights lit up correctly according to the distances measured by the infrared distance sensor in which the distances and angles to an object were correctly distinguished. Each of the tests was repeatedly carried out 100 times for each of the concerned distances and angles.

Table 1 presents the results of the assessment test undertaken in a brightly-lit test area. As indicated in the (Table 1) the accuracy of the measurements dropped as the angles became wider and distances became greater in

Table 1: Accuracy by distance and angle in bight

	Angle (CM)		
Distance	10° (%)	20° (%)	30° (%)
20	100	100	100
40	100	100	100
60	100	100	60
80	100	60	0
100	100	60	0
120	100	100	100
140	100	80	60
160	100	100	100

Table 2: Accuracy by distance and angle in night

	Angle (CM)		
Distance	10° (%)	20° (%)	30° (%)
20	100	100	100
40	100	100	100
60	100	60	40
80	100	10	0
100	100	40	0
120	100	100	80
140	100	60	0
160	100	100	10

Fig. 9: Raspberry Pi camera module implementation

situations warranting caution in which distances were less than 100 cm. For satisfactory situations regarding distances exceeding 100 cm but <150 cm, measurement accuracies were found to rise and again fall as distances and angles became greater. For all instances in which the measured distances were beyond the range of measurement, the measurement results indicated 100% accuracy.

Table 2 presents the results of the assessment test undertaken in a dark test area. As indicated in the table, the results showed a decrease in accuracy compared to the assessment test results taken during the day time.

This is due to the fact that infrared lights are electromagnetic waves present in the scattered light passing through a prism. Despite its lower accuracies, the ability of the system to measure the existence of and the distance from the bike to an object was considered acceptable.

Figure 9 presents a photograph displaying the bike rear-view streamed to a laptop computer through the Raspberry Pi camera module. Despite the final goal of this study being the real-time streaming of the bike rear-view to an Android device, the system was realized only to the extent possible allowed by the limits of the development environment at the time the testing took place. As a result of this, only photos were taken.

CONCLUSION

This study makes use of Arduinos and sensors as well as a Raspberry Pi camera module to detect and interpret distances to objects based on infrared detections. The system developed in this study to be installed on bikes, makes it possible for its users to accurately recognize their rear situations during cycling without looking behind anyplace anytime while being unaffected by various outdoor conditions. In addition, since it is possible for users to predict situations unlike existing alarm systems users of the system are expected to be able to more pro-actively deal with the means of preventing contact accidents. One area of the system in need of further supplementation involves the development of more appropriate means of installing each of the devices on the bike to account for less wind resistance, compared to the current installations based on handle bands on the bikes. Designs regarding this are currently under development. The remaining tasks of this project include the installation of devices using the design improvements and the realization of rear-view streaming in real time using the Raspberry Pi camera module for users.

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