Wearable Social Distancing Detection System

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***Abstract* — The conventional method of keeping people at a safe distance in the Covid-19 Standard Operating System could not ensure everyone obeys the rule. An automatic social distancing system needs to be created to assist and train individuals to stay at a safe distance of at least 1 m. This paper proposes a wearable social distancing detector that uses a microcontroller with an ultrasonic sensor to detect the distance between two persons and provides a warning if the person fails to obey the rule. The system could perform social distancing detection accurately and can assist in the movement of people in an area.**

Index Terms — ultrasonic sensor, Covid-19, physical distancing, ARM microcontroller.

I. Introduction

The occurrence of Covid-19 has led to the exploration of various techniques to reduce the spread of the disease. These include the detection of the region at risk, tracking the location of workers, tracing contacts, identification of spreaders, tracking Covid-19 symptoms and others [1-4]. Alsaeedy et al. [1] used a cellular network to detect a region at risk for spreading Covid-19. In another study, contact tracing devices were used to selectively isolate any employees with exposure to Covid-19, allowing the rest of the company to keep working [2]. Despite raises privacy concerns, the device nonetheless could also make employees feel safer about going to work [2].

World Health Organization (WHO) has recommended the physical social distancing be obeyed to prevent the spread of Covid-19. Malaysia practices physical distancing of at least 1 metre between each other in both outdoor and indoor to stay safe from the virus. As of today, a mark of 1m distance is used to keep people at a safe distance from each other in various places as part of the Covid-19 standard operating procedure (SOP) for opened businesses. On June 28th 2020, the government announced that schools and kindergartens will be reopened as well, to catch up with the syllabi that have been unattended to. This has caused concerned reactions from people on social media since kids are considered a high-risk group due to their still-developing immune system [5]. The difficulty of controlling them for the teachers adds to the concern despite the strict SOP that has been put which restricted any activities that involved contact and only allowing pupils to stay in their designated seat.

The existence of a device that can automatically detect the distancing of one to another to remind surrounding people to obey the rule will complement the current SOP very well, to an even better extent. This device does not only benefit the kids in school, in fact, those who are part of the high-risk group including the elders and those with illnesses as well, giving them more assurance that they are safe to step outside when it is needed. To the best of our knowledge, there is no report describing the social distancing detector, let alone detailing the design of the system.

The distance between objects can be measured using various types of sensors and the most popular sensor is an ultrasonic sensor. Zhengdong et al. utilized an ultrasonic sensor in the distance alarm system of a car [6] while Abdulqader et al investigated the use of ultrasonic sensor in remote sensing applications [7].

This paper describes the development of the wearable social distancing detection system for assisting and training everyone to obey the recommended distance stated in the SOP. The process of detecting social distancing with emphasize on the functions used in the work is detailed out.

II. Method

The development of the system was carried out in three main phases which are hardware development, software development and testing. In the hardware development phase, the circuit was first designed and simulated. Once it was confirmed that it produced the required output correctly, the circuit was constructed. The software development phase was performed simultaneously with the hardware development phase and modular approach was implemented where the program was divided into several modules and each module was tested separately before they were combined to form a working program.

A. Hardware Development

The system consists of an ultrasonic sensor, a microcontroller, a buzzer and an LCD Module as shown in Fig. 1. In this work, the HC-SR04 ultrasonic sensor was used to detect the distance of any obstacle behind the person wearing the device. The function of the microcontroller is to read the value from the sensor, calculate the distance between

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the subject and a person behind him and remind the person if the distance is less than a metre. Here, the STM32F446 microcontroller was employed due to its compatibility with most external devices and capability to operate at high speed.

The buzzer was included to produce a sound whenever a person behind is closer than 1 metre hence disobeying the safe physical distance. The function of the LCD module is to display the distance between the subject and the person behind him.

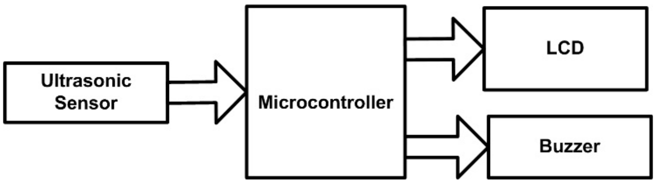

Fig. 1. Block diagram of the system.

B. Process of Detecting Social Distancing

In order to automatically detect social distancing, an ARM C language program was developed using STM32 Cube Mx firmware. The process of detecting social distancing is shown in Fig. 2. When the device is switched on, the program will read the value of the sensor output and measure the distance between the subject and the person behind him. Sensor reading was obtained by first sending a 10 µs trigger pulse to the sensor and then read the duration of the received pulse.

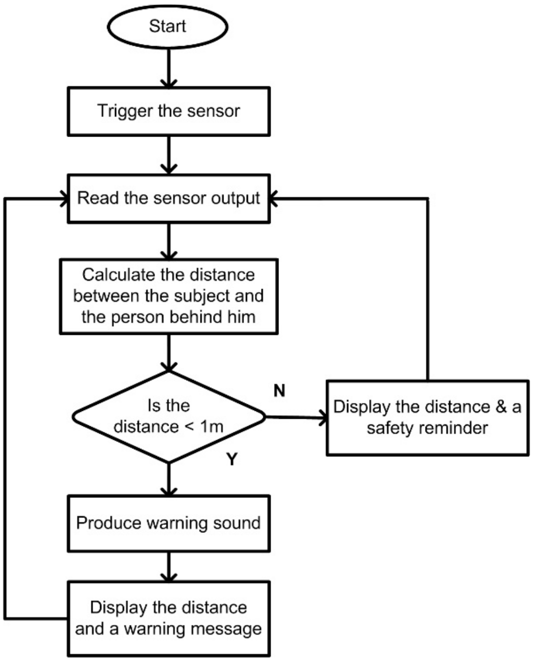

Fig. 2. Process of detecting social distancing.

The distance was calculated using (1). Then the device will check whether the person is less than a metre from the wearer or otherwise. If the distance is less than a metre, a warning sound will be produced and the distance and a warning message will be displayed on the LCD. However, if the person is in a safe distance, which is more than one metre, the system will display the distance and a safety reminder. Monitoring the distance will be continuously carried out if the system is in the operating mode.

$$Distance = t_d v \tag{1}$$

where t_d is the duration of the received pulse and v is the speed of sound.

The program was built from several subroutines. Some of the built-in subroutines provided by Cube MX firmware were also used to ease the port configurations and initialisations. All the input and output ports were first initialized using static void MX_GPIO_Init function before they were used as shown in Fig. 3. The function starts with the setting of the clock of port A and B.

```
static void MX_GPIO_Init(void)
{
GPIO_InitTypeDef GPIO_InitStruct = {0};
/* GPIO Ports Clock Enable */
__HAL_RCC_GPIOA_CLK_ENABLE();
__HAL_RCC_GPIOB_CLK_ENABLE();
:
:
}
```

Fig. 3. Initialisation function used in the work.

Fig. 4 shows the function that triggers the sensor and reads the sensor value. Here, the HAL_GPIO_WritePin() function was used to send a pulse to the TRIG pin of the sensor and the HAL_GPIO_ReadPin() function was used to get the values from the output of the ultrasonic sensor.

```
/* HCSR04 measure routine */
//1. Output 10 µsec to TRIG
HAL_GPIO_WritePin(TRIG_GPIO_Port,TRIG_Pin,GPIO_PIN_SET);
usDelay(10);
HAL_GPIO_WritePin(TRIG_GPIO_Port, TRIG_Pin,
GPIO_PIN_RESET);

//2. Wait for ECHO pin rising edge
while(HAL_GPIO_ReadPin(ECHO_GPIO_Port, ECHO_Pin) ==
GPIO_PIN_RESET);
:
:

}
```

Fig. 4. Functions for triggering the sensor and read its value.

C. System Testing

As mentioned previously, the software and hardware modules were first tested separately. A modular testing approach was employed to test the functionality of the software module. Once it was confirmed that both hardware and software modules were working successfully, they were combined together and the overall system testing was carried out. The distance measured was displayed on a computer screen using a software called RealTerm Serial Capture Program. A probe is connected to the port PB7 where the data for the message was produced (see Fig. 5). A human subject moved at various distances (0.1m to 1.6m) while the measured distances were recorded.

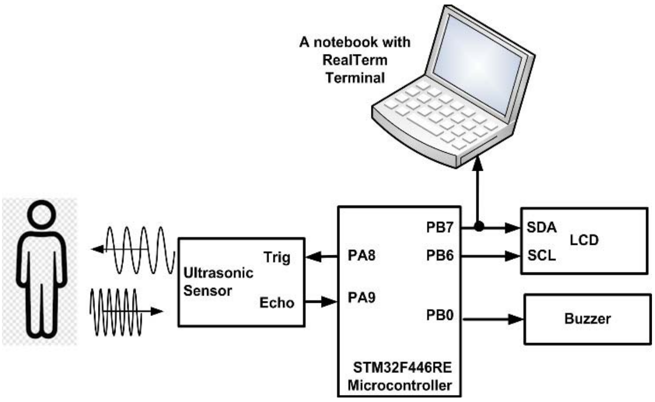

Fig. 5. Experimental setup for testing the system using RealTerm Terminal program on a notebook.

The accuracy of detecting the distances, A_d was measured by dividing the difference between the actual distance, D_a and the measured distance, D_m by the actual distance and multiplying the result with 100 per cent using (2).

$$A_d = \frac{D_m - D_a}{D_a} \text{ x } 100\% \qquad (2)$$

III. Results

Fig. 6 shows the distance measured by the system which is displayed on the computer screen using RealTerm Serial Capture Program during overall system testing where real time measurement is carried out. Note that the distances 0.03m to 0.1m displayed on the screen show that there is an obstacle near the sensor whereas the reading of 2.45 m indicates the subject is away from the sensor and in the safe distance.

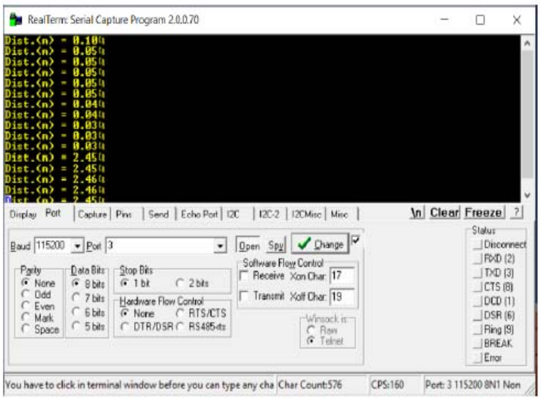

Fig. 6. The detected distances displayed on the screen using RealTerm.

Fig. 7 shows the voltage at PB0 which is connected to the buzzer. The voltage is 2.8 volts when the distance is below 1 m. When the distance is more than 1 metre, there is no sound and the voltage is 0V. When there is a person within the distance of less than 1 metre, the buzzer produces a warning sound while the LCD displays the distance and also a warning message "WARNING! STEP BACK" (see Fig 8). When the obstacle is over a metre from the wearer, the LCD displays the distance and message, "SAFE DISTANCE", to notify the person is in a secure distance as shown in Fig 9.

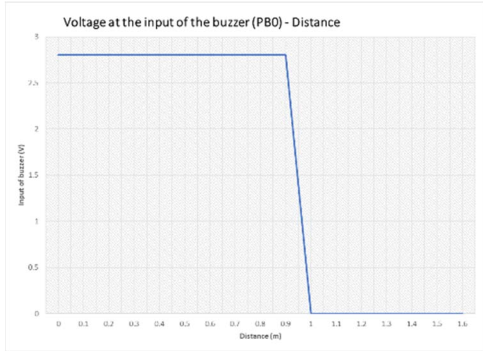

Fig. 7. Voltage at the busser input for various distances.

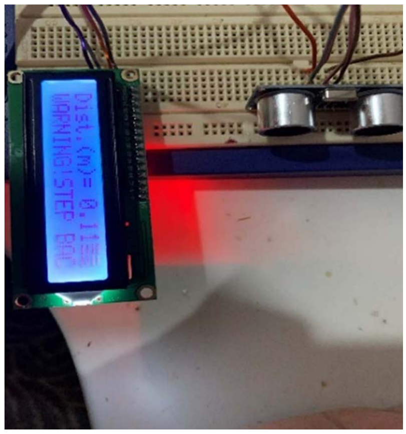

Fig. 8. The warning message displayed on the LCD when the subject is at a distance of less than 1 metre.

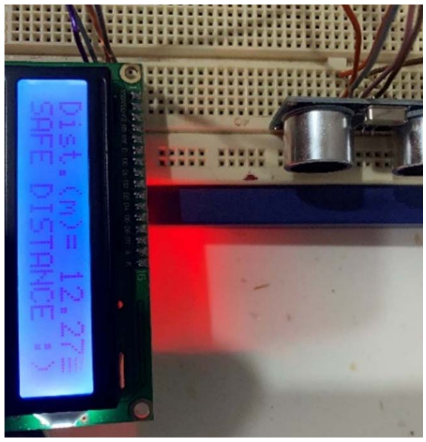

Fig. 9. The message displayed on the LCD when the subject is at a distance more than 1 metre

Fig. 10 shows the accuracy of detecting the distance between 0.1 to 1.6m provided by the system. It was found that the system could measure the distances below 1.4m accurately. There is a discrepancy of 0.62% to 0.72% in measuring the distance between 1.4m to 1.6m. The average accuracy of detecting the distance is 98.87%. Note that the distance is measured from the width of the received pulse (time duration) when the pulse at the Trig port is high using (1), not from the amplitude of the received signal.

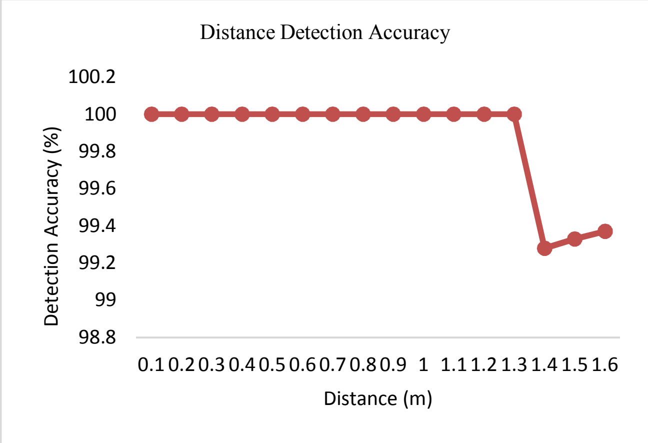

Fig. 10. Accuracy of detecting the distance provided by the system.

The prototype of the wearable social distancing detector is shown in Fig 11. All electronic components of the device such as the batteries, STM32 Nucleo board and veroboard are placed inside a pouch with a belt for the person to wear.

Fig. 11. The prototype of the wearable social distancing detector.

IV. Conclusion

The development of the wearable social distancing detection system has been described in this paper. The system employed an ARM microcontroller and an ultrasonic sensor to detect and measure the distance between a subject and a person nearby. It equipped with a LCD module which displays the distance and a message and a buzzer to notify that the physical distancing of 1-metre is not followed. The system has been tested successfully and it could perform the social distancing detection accurately.

This system can be improved to be more interactive to the user such as by sending a notification through a smartwatch to remind them of their distance or including a vibrating disc to increase the awareness to the user. Thermal or infrared sensor also can be included to detect a human's body temperature to produce more accurate results of detecting another human near the user. These measures secure physical distance between people (of at least one metre), and reduce contact with contaminated surfaces, while encouraging and sustaining virtual social connection within families and communities.

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References

[1] A. R. Alsaeedy, K. P. Chong, "Detecting Regions At Risk for Spreading COVID-19 Using Existing Cellular Wireless Network Functionalities", IEEE Open Journal of Engineering in Medicine & Biology, 2020, pp 187-189.

[2] E. Waltz, "Back to Work: Wearables Track Social Distancing and Sick Employees in the Workplace as companies re-open, employees may don wearable tech to prevent the spread of COVID-19", IEEE Spectrum, May 2020.

[3] E. Montes-orozco, R. Mora-gutiérrez, S. De-los-cobos-silva, E. Rincón-garcía, G. Torres-cockrell, J. Juárez-gómez, B. Obregón-quintana, P. Lara-velázquez, M. Gutierrez-andrade, "Identification of COVID-19 Spreaders Using Multiplex Networks Approach", IEEE Access, vol 8, 2020, pp 122874 - 122883.

[4] R. Stojanović, A. Škraba, B. Lutovac, "A Headset Like Wearable Device to Track COVID-19 Symptoms", 9th Mediterranean Conference on Embedded Computing, 2020, pp 1-4.

[5] E. S. M. Chin, "Dr Noor Hisham: Children Still Categorised High-Risk for Covid-19 Though No Child Mortality Cases Locally", Malay Mail, 9 Jun 2020.

[6] L. Zhendgong, H. Shuai, L Zhaoyang, L. W eifeng, H. Daxi, "The ultrasonic distance alarm system based on MSP430F449", Measuring Technology and Mechatronics Automation, 2013, pp1249-1251.

[7] H. A. Abdulqader, M. G. Vargese, N. A. Nabhani, "Dynamic Short Distance Estimation Using ultrasonics", IEEE Business, Engineering & Industrial Applications Colloquium, 2012, pp 70-73.