

Physical Distancing Alarm System Based on Proximity Sensor and Microcontroller

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ABSTRACT

Keeping an interaction distance between 1 to 2 m is one of the health protocols during the COVID-19 pandemic. This attempt was made to reduce the spread of the Coronavirus. On the other hand, this health protocol activity is often overlooked, whether intentionally or not. According to the mechanism of the Coronavirus spreading in the form of droplets that comes out during communication, sneezing, or coughing, maintaining distance can be the best effort to minimize the transmission of this virus. Therefore, the availability of a simple, accurate and user-friendly physical distancing alarm system could be a solution in the implementation of this health protocol. In this study, a prototype of a physical distancing alarm based on a distance sensor and a microcontroller in the form of an identity card was developed. Several steps are conducted in developing of this system, namely designing the instrumentation system and testing the performance of the system. System performance is tested through variations in the distance and angle of the objects. The measurement results show that the system can detect objects in front of the sensor up to a distance of 2.8m and an angle of $0^{\circ} - 20^{\circ}$ for a distance of 1m. The measurement using different angles of objects was performed for objects on the left and right sides of the sensor. In addition, a warning alarm will be on when the distance of the object exceeds the allowed distance.

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Introduction

The Coronavirus outbreak that began to spread in late 2019 in Wuhan, China, has changed people's perception around the world about health, social interactions, etc [1-5]. The pattern and speed of spread, the effects, and virus's ability to mutate are some of the considerations that cause a high level of vigilance in the face of the spread of this virus [1,4]. As the global health authority, World Health Organization (WHO) has announced the status of a pandemic against this type of virus, including

the various efforts for dealing with the situation amid this pandemic [1,4]. To reduce the spread of Coronavirus Diseases (Covid-19), the health protocols such as using masks, diligently washing hands, maintaining distance, avoiding crowds, and reduce mobility must be implemented [6-9]. Implementing these protocols related to the mechanism of virus spreads using droplets possibly come out during the sufferer coughs, sneezes, or communication. Therefore, maintaining distance during physical interactions is the main effort to reduce the spread of Covid-19.

In general, the results study obtained a safety distance for social interaction to prevent the spread of the Coronavirus, which is between 1 and 2 m [8,10]. The determination of this distance is related to the droplet's characteristics which is the main media for transmission of the Coronavirus. On the other hand, humans as social creatures have their challenges in applying safety distance during social interaction activities. Therefore, the availability of automatic alarms for measures the safety distance can facilitate the humans for interaction, especially in public facilities, and prevent Coronavirus transmission. Various systems could be utilized to develop distance detection systems such as GPS, artificial intelligence, sensor systems, and others [1,3,5,11-13]. However, the growth of instrumentation, automation, and sensor systems have enabled the development of accurate, user-friendly, and low-cost automatic alarm systems. In this research, the automatic alarm system for physical distancing based on proximity sensor and microcontroller was developed. Moreover, the measurement systems were carried out through two main variations: the variations in the distance and the object's angle to the sensor.

Method

A physical distancing automatic alarm system has been developed using a type of proximity sensor ultrasonic HC-SR04 and a microcontroller Arduino Nano types. An ultrasonic sensor consisting of receiver and transmitter was used as a proximity sensor. The transmitter will emit high-frequency sound waves that travel at a speed of around 340 m / s. When the wave hits an object, the waves will be reflected and received by the receiver. The distance between the sensor and the object is calculated according to the required time of wave to travel between the transmission and received by the receiver as shown in Equation (1).

$$s = \frac{v \times t}{2} \quad (1)$$

According to Eq. (1), s is distance of the object, v is the velocity of the sound wave and t is the wave time required for propagation. The sensor's ability to measure this distance is used in the manufacture of an automatic alarm system. To control and process the results of sensor responses, and also for automation system, a microcontroller system was used.

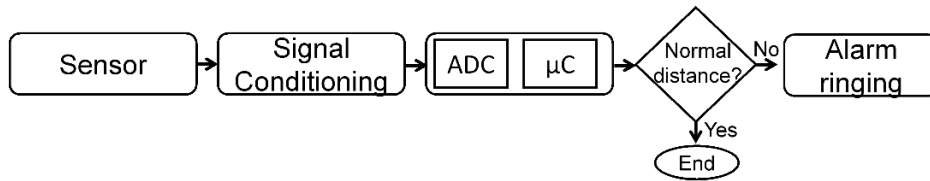


Figure 1. Block Diagram of Instrumentation System

In general, this system consists of an ultrasonic sensor HC-SR04, a buzzer, an Arduino Nano, and a battery. The block diagram of the entire system is shown in **Figure 1**. This system is equipped with a buzzer as an alarm. The alarm will sound automatic when the distance to the object is less than the allowed distance. The system is equipped with a portable battery that can be charged like a charge of a cell phone battery. Moreover, the system can be upgraded using an audible notification, but it is limited by the system’s size.

Design of Measurement System

In this study, the measurement mechanism was designed to obtain the system’s sensitivity and accuracy in detecting distances of objects with different positions. The variation position is for the object in front of the sensor, and for the object in the right and the left sides of the sensor as shown in **Figure 2**.

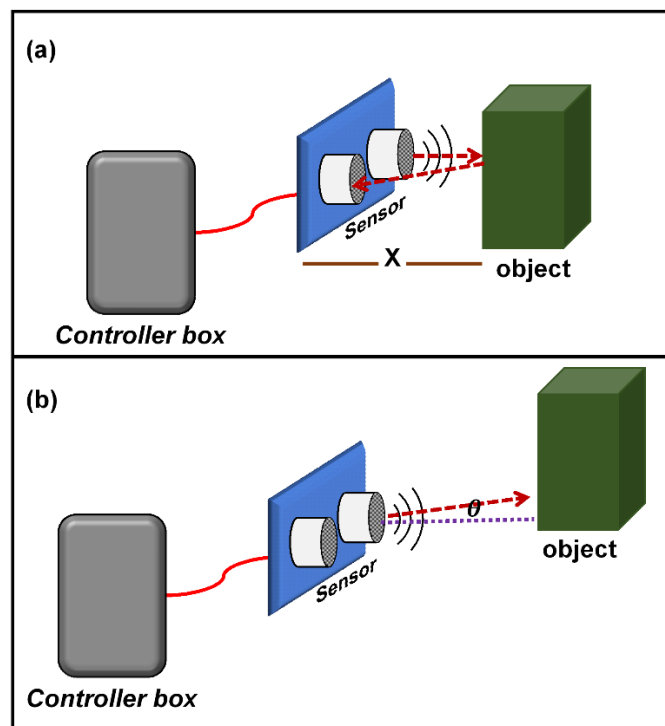


Figure 2. The System Testing Mechanism (a) in front of the sensor, (b) making an angle with sensor

The variation of distance and angle consider the characteristics of the sensor used [14,15]. Furthermore, the object used in this measurement is a box which is a solid material. The first measurement was performed by placing the object directly in front of the sensor. In this test, the distance between sensor and object was varied. The second measurement was conducted for objects located on the right and left sides of the sensor. This measurement was performed by varying the angle of the object to the sensor. According to **Figure 2**, the controller box contains an Arduino nano, a buzzer and a battery.

Result and Discussion

In general, the physical distancing alarm system has been developed in the form of an ID card which can be hung in a pocket or a bag. This prototype is made in two types, the single type, and the dual type, as shown in **Figure 3**. The single system consists of a system of sensors, while the dual system consists of two sensors that can be hung in two different places simultaneously. For the dual system, system's control and empowerment are done through a single command, which requires more complicated wiring than a single system. However, the dual system's advantage is the capability to detect objects in two opposite directions simultaneously. Besides, the system is equipped with a user friendly on-off push button system.

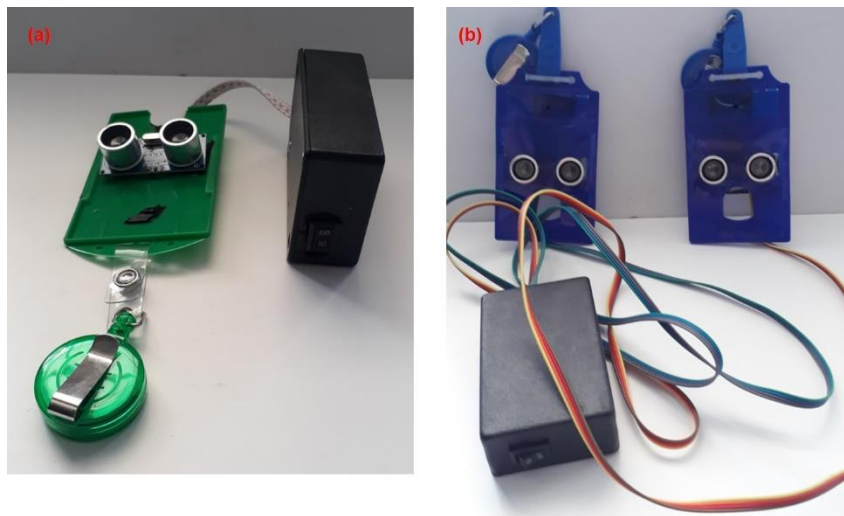


Figure 3. Prototype of Physical Distancing Alarm (a) Single System, (b) Dual System

The ability of these two systems to measure the distance of the object was performed by using the mechanism as shown in **Figure 2**. The measurement result for the first variation was displayed in **Figure 4**. This figure shows the response of the sensor to variations in distance from the object. According to the sensor datasheet, the ultrasonic sensor used has a working area between 2 and 400 cm [15]. Therefore, the measurement was conducted using distance variations from 0 cm until 400cm with

intervals of 10cm. These measurements were repeated five times for each interval. The measurement results show that the sensor can work well up to a distance of 280cm. There is a significant difference between the distance read by the sensor and the actual distance for longer distances. Based on these results, the sensors used were not able to correctly detect the objects for distances longer than 280 cm even though was conducted in the sensor's operating range. These may occur due to interference or other disturbance of the waves emitted by the transmitter. Furthermore, based on the working mechanism of this sensor, the greater the distance between the transmitter and the receiver, the wider the wave range, which makes them vulnerable to interference/disturbance. However, the performance of this system is still relevant for use as a physical distance alarm in the pandemic of Covid-19.

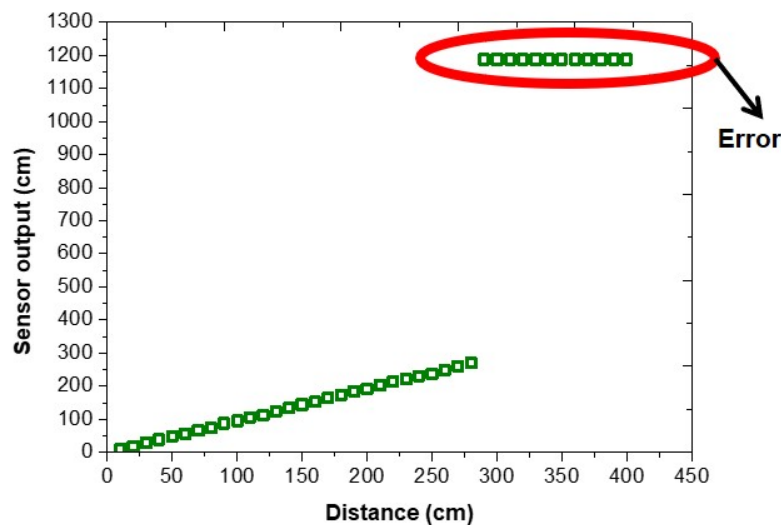


Figure 4. Sensor Performance for Distance Variation

In the second evaluation, the measurement was performed for objects located in the right or left of the sensor. In this mechanism, the object was placed at the same distance, which is 100 cm, while the variation is the angle between the object and the sensor. There are several variations of the angle used, as shown in **Figure 5**. The measurement results show that the sensor system performs well for angles $0^{\circ} - 20^{\circ}$. The resulting angular range is greater than the effectual angle of the sensor, as indicated on the datasheet ($> 15^{\circ}$)[15]. This difference could be occurred due to selecting a reasonably close distance between the transmitter and receiver.

In general, the measurement results on these two mechanisms have shown good performance from a physical distancing alarm system based on a proximity sensor. The system can detect objects in front of the sensor correctly up to a distance of 280 cm. While for objects located in the right or left sensor, this system detects accurately for angle below 20° . The performance of the system for detecting the objects related to the working principle of the ultrasonic sensor. The sensor detecting the distance of

the objects by calculating the time required for the waves emitted by the transmitter and received back by the receiver. The characteristics of the environment and other disturbances that occur during a wave transmitted from the transmitter until it is received back by the receiver affects the performance of the system. Furthermore, based on the performance of the system, as illustrated in **Figure 4**, it is possible to select a safety distance in the system to generate an alarm. According to the research about the mutation of Coronavirus, the safety distance for the interaction was also increased to 2 m. Therefore, this system is still relevant to use. Besides, this system can also be upgraded using a sound module to produce an alarm in the desired warning sound. Furthermore, this system can also be used by blind people to discover the existence of objects in front of them. However, this system not capable of distinguishing the objects in front of it, humans or inanimate objects. Therefore, if there is a barrier and it exceeds the safety limit, the alarm system will sound.

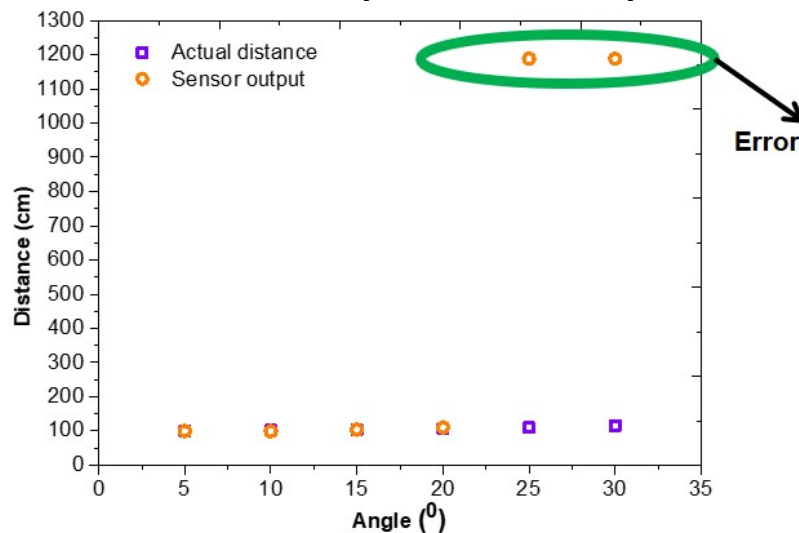


Figure 5. Sensor Performance for Angle Variation

Conclusion

The physical distance alarm system based on an ultrasonic sensor was developed. This system provides good response in detecting objects up to 2.8m in front of the system. While, for objects located 1 m in the right or left sensor, the systems only be detected if the tilt angle of the system is $\leq 20^\circ$. In addition, for a normal distance of 1 m, the system can warn if the position of the object is less than this distance.

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