An Open-Source Non-Contact Automatic Alcohol Gel Dispenser by using Embedded Real-Time Systems

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Research Article

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Abstract

This paper is intended to solve a detail in the precautions to avoid the spreading of the coronavirus. Indeed, spreading by contact could lead to a new outbreak of the epidemic and a return of coronavirus. Two applied means to avoid the spread of COVID-19 are wearing masks and using an alcohol gel dispenser. In this paper, a non-contact automatic alcohol gel dispensed (AAGD) is proposed. This device is based on microcontroller device “Arduino Nano”, Ultrasonic sensor “HC-SR05” and servo-motor of 1 Nm. It can be used and integrated in the schools, markets, and different companies. In this focus, the AAGD works without touching by hand that could have touched the nose and not cleaned 100%. This property is important in this crisis period, especially since the appearance of coronavirus delta variant. This real-time device is nice to operate, and could be produced using quite common control devices, a too high or complicated technology level would reduce its application.

1 Introduction

COVID-19 is the infectious disease caused by the last coronavirus that was discovered [1, 2]. This new virus and disease was unknown before the outbreak occurred in Wuhan, China in December 2019 [3, 4]. It is now a pandemic and affects many countries around the world [5]. Indeed, on 30 March 2020, more than 693,282 cases of COVID-19 have been reported in the world by more than 202 countries [6]. The numbers of these infections cases are increasing rapidly in all countries of the European Union and United Kingdom [7, 8]. Around this pandemic, an overview of Covid-19 infection is discussed in [9, 10]. Thus, it is researched 5194210 cases on May, 2020 with 334621 deaths.

The most common symptoms of COVID-19 are fever, dry cough, and tired [11]. Other less common symptoms may also appear gradually in people infected, such as body aches and increase body temperature [12]. Some fraction of people, do not show symptoms although they had infected by COVID-19. These people may have immunity to the COVID-19 virus, but still can spread the virus without knowing [13]. The disease is frequently spread from person to person through respiratory drops expelled from the nose or mouth when the infected person coughs, sneezes, or talks [14, 15]. These drops are relatively heavy and can’t transmit on large distances and fall quickly to the ground. People can be infected by COVID-19 if these drops are inhaled [16]. Therefore, it is important to stay at least a meter away from other people [17]. In addition, these drops can be found on objects or surfaces around the sick person such as, tables, door handles and buttons [18]. In this state, people become infected with the virus when they touch these surfaces or objects with the hand, and then touch parts of the face like the nose or mouths. Therefore, it is necessary to wash the hands regularly with soap and water or with an alcoholic gel dispenser [19, 20]. But what happens if an infected person touches first his nose, then the push button, and someone after him touches the button also and does not disinfect well that specific touched place? After the alcohol dried, it can still spread.

The main contribution of the paper is helping to fight the spread of coronavirus infections. For this purpose, an AAGD will be achieved, by using microcontroller device, ultrasonic sensor, and a servomotor. Indeed, the servo-motor of 1 Nm is used to control the push-pull button of alcohol dispenser, by using a mechanism combined between the metal gear of servo-motor and the button of dispenser. This mechanism can be changed depending on the design of AAGD. On the other hand, the Ultrasonic sensor is integrated to detect the distance between the hands and the dispenser. This measurement is based on ultrasonic sound waves, which is transmitted and received by transducer. In addition, the microcontroller device “Arduino Nano” is used to process the signal waves of Ultrasonic sensor, and to control the direction of servo-motor device.

The present paper is organized as follows; in the beginning some models of AAGD in the world markets are mentioned. The benefits and negative points are discussed, and our solution is proposed in the end of the section. Moreover, the process of distance measurement between the hand and alcohol dispenser is presented. For this purpose, the code source of measurement is explained, and the result obtained in this measurement is discussed. In the next step, the development process of AAGD is detailed, and the global circuit of automatic dispenser is showed. Finally, the benefits of AAGD are mentioned, and the future challenge of this development is proposed.

2 Models Of Aagd

A variety of AAGD can be found in the markets and companies. However, each having its advantages and disadvantages and the impact on simplicity and efficiency. Among the models which exist in reality can be cited as follows:

- Hands Free Dispenser Stand, this type of AAGD can be operated by foot, and it’s based completely on the mechanics in the process of working, as shown in Fig. 1. This device has a good efficiency in normal life because it is not needed to power supply. However, in this pandemic, has an opposite effect because the COVID-19 virus can be carried by the shoes, and is quite large to transport and to store.
- AAGD based on an infrared circuit (Levchenko et al. 2009). The disadvantage of this dispenser can be influenced by the intensity of light, and they are often used outdoor, on the street and in buses.
- AAGD based on a laser sensor. Indeed, the laser sensor makes measurement in any place or any situation and has a good performance. Despite the advantage of laser sensor, but it is very expensive.

In this paper, the ultrasonic sensor is used on the alcohol dispenser to avoid the downsides of precedent models. The advantage of our AAGD can work without touching, which gives to him an importance in this pandemic. Independently, such techniques are also useful in medicine practice, surgery and dental surgery, even without covid, especially in the developing world.

3 Distance Measurement Between The Hand And The Aagd

The distance between the hand and the AAGD is measured by HC-SR05 sensor. Indeed, the HC-SR05 sensor is a low cost ultrasonic sensor that used two transducers to transmit and receive the sound waves, and operates with a supply voltage of 5 volts (Jeswin et al. 2017). It has a measurement angle of

approximately 15 degrees and allows distance measurements between 2 cm and 4 meters with an accuracy of.

The process of distance measurement is entirely dependent on the speed of sound. For this purpose, a high impulsion of 10µs duration is sent to the TRIGGER pin of ultrasonic sensor. In this state, the impulsion will be generated by the microcontroller “Arduino nano”, and the TRIGGER pin of HC-SR05 sensor is linked in the pin D2 of microcontroller, as illustrated in Fig. 2. Moreover, the impulse sent to the TRIGGER pin will be split by the sensor, to produce a series of impulsions (8 pulses of 40 kHz). Then, the ultrasonic sensor will be sent these pulses outside, to detect the distance between the hand and dispenser. In the next step, the signal waves propagate through the air until contact an impediment. These sound waves will be returned on the other way to the transducer of sensor. On the other hand, the signal ECHO of ultrasonic sensor is remain high value when the sensor trying to detect the distance. It is important to note that the ECHO pin has been attached to the pin D2 of microcontroller, to confirm the reception of the transmitted signal.

3.1 Code source of distance measurement.

The Arduino Software (IDE) allows writing the program of the distance measurement, and uploads it to the microcontroller board. This program will be transmitted from computer to the microcontroller device by a mini USB cable. One of the problems encountered during the uploading of the programs, is that the serial PORT is not detected when the mini USB cable inserted in the computer device. For this purpose, an Arduino megaAVR Core is added in the IDE software, as shown in Fig. 3. Then, the computer software should be running automatically its driver installation process once the mini USB cable plugged in the computer device.

The source code of distance measurement between the hand and the alcohol dispenser is a key element in this work. Indeed, the code first specifies all the constants and variables used in the program. There are four constants; two constants for the TRIGGER and ECHO pins of the ultrasonic sensor, a constant that specifies the measurement delay (Delay_Time) and a constant to define the speed of sound. In addition, the source code is contains two variants; one is used to ensure the alcohol dispenser button is pressed once when the hand remains close to the ultrasonic sensor. Moreover, the second variable is used to control the rotation angle of servo-motor. These specific declarations are shown in declaration code.

[Declaration code]

```
#include < Servo.h> //Implementing the sevomotor library in the program.

Servo Myservo ; //Creating an object "Myservo" from the class "Servo".

const byte ECHO_PIN = 2; //Connecting the ECHO_PIN of sensor with the D2 pin.

const byte TRIGGER_PIN = 3; //Linking the TRIGGER_PIN of Ultrasonic by the D3 pin.

const byte LED = 5; //Placing the signal LED in the D5 pin of Arduino Nano.

const unsigned long Delay_Time = 25000UL; // Defining the waiting time.

const float SOUND_SPEED = 340.0 / 1000; // Defining the sound speed.

int Hand_Test, rotation_angle; //Declaring global variables of hand testing and rotation

//angle.
```

[/Declaration code]

In the next step of source code generation, the setup function initializes the baud rate of transmission data by the serial port. This communication between the microcontroller and computer is used to monitor the distance measurement between the hand and alcohol dispenser in real-time. In addition, the TRIGGER pin of the sensor is defined as output in the setup function and made it on low voltage, and sets the ECHO pin of the HC-SR05 sensor as an input pin. On the other hand, the connection of servo-motor on the microcontroller board is declared in the function. This setup function is presented in setup code.

[Setup code]

```
void setup() { //The setup function will run for one time (In each

// start-up of the microcontroller device).

Serial.begin(9600); //Initializing the baud-rate of transmission data

//(the distance between the hand and AAGD).

pinMode(ECHO_PIN, INPUT); //Configuring the Pin D2 of Arduino Nano as input.

pinMode(TRIGGER_PIN, OUTPUT); //Configuring the Pin D3 of microcontroller as output.

digitalWrite(TRIGGER_PIN, LOW); //Initializing the state of Pin D3 by 0 Volts.

pinMode(LED, OUTPUT); //Configuring the Pin D5 of microcontroller as output.
```

```
digitalWrite(TRIGGER_PIN, HIGH);//Lighting the signal LED, to ensure that the

//program is running

Myservo.attach(4); //Linked the PWM pin of servo-motor device in the D4 pin.

Myservo.write (0); //Initializing the rotation-angle of servomotor by

//zero degree.

Hand_Test = 0; //Initializing the hand testing variable by zero value.

delay (100); //Giving a delay time before moving to the loop function.

}
```

[/Setup code]

In the last part of the source code, the loop function is used to measure the distance between the hand and dispenser. In addition, it's used to control the servo-motor rotation, as presented in loop code. For the purpose of measurement, it first generates a high-value pulse of 10µs duration, which transmitted to the TRIGGER pin of the HC-SR05 sensor. After that, it measures the time required to receive the sound waves. This time is represented the round trip of the ultrasound signal, and it can be measured by pulseIn function. Finally, the distance between the hand and the alcohol dispense will be measured and will be sent to the computer device for monitoring. This communication between the microcontroller and computer device is done under the UART protocol. On the other hand, the servo-motor angle is controlled by two angles (0 and 150 degrees).

3.2 Results of distance measurement

The source code of distance measurement between the hand and alcohol dispenser is tested. For this purpose, the distance is measured by a tap-meter and with Ultrasonic sensor. The result obtained is presented in the Fig. 4 and Fig. 5. Indeed, the error of the distance measurement is augmented when the distance between the hand and alcohol dispenser is less than 6 cm, it's reached 25% on average above 7 mm. This error will be decreased when the distance between them is greater than 5 cm. Indeed, this experiment is repeated many times when the hand is far from the sensor because the hand is representing a small impediment. However, the AAGD is required that the hand become close from Ultrasonic sensor (6 cm). Without this condition, the servo-motor stay in the initial state (0 degrees).

[Loop code]

```
void loop() { //The loop function will be executed simultaneously.

digitalWrite(TRIGGER_PIN, HIGH); //Transmitting a high impulsion to TRIGGER_Pin.

delayMicroseconds(10); //Defining the duration of the impulsion.

digitalWrite(TRIGGER_PIN, LOW); //Stop transmitting the impulsion (10 us is enough).

long measure_time = pulseIn(ECHO_PIN, HIGH, Delay_Time); //Measures the time between

//sending the sound wave and its Echo.

float distance_mm = measure_time / 2.0 * SOUND_SPEED; //The distance will be calculated.

if (distance_mm > = 60) { //This condition is implemented, to test if the hand is

//not closed to the dispenser.

Hand_Test = 0; //Giving the global variable a value equals zero.

}

if (Hand_Test = = 0) { //This condition is integrated, to confirm that

//the distance between The hand and dispenser was more

//than 6 Cm

if (distance_mm < = 60) { //This condition is implemented, to test if the hand is

//closed to the dispenser.

Myservo.write(150); //Rotating the servo-motor by angle equals to 150 degree
```

```
delay(600); //Waiting the alcohol exit ( The push-pull button is

//pressed).

Myservo.write(0); //Returning to the initial state.

delay(15); //Giving a time delay to servo-motor (for stabilization).

Hand_Test = 1; //Changing the state of global variable, to test

//if the hand is still closed to the dispenser.

}

}

Serial.print(distance_mm); //Monitoring the distance measurement, by using UART

//protocol.

}
```

[/Loop code]

4. Development Of Aagd

Covid-19 is a disease that can be spread quickly between persons, by touching the others infections bodies or by contacting the things that in it are the virus. Indeed, the World Health Organization is announced that the vaccines or a specific antiviral treatment for COVID-19 virus are not available in the laboratories. For this purpose, the protection tools from the Covid-19 virus should be developed, to avoid the spread of coronavirus infections. For this purpose, an AAGD is developed, to use it in different sectors such as, hospitals, transportation tools, and in the companies. This development is achieved by the mounting of servo-motor and ultrasonic sensor in the microcontroller device “Arduino Nano”, as shown in Fig. 6. In addition, a signal LED is added in the scheme circuit, to confirm that the program is still running in the microcontroller device. The AAGD mounting is based on the following connections:

- The Arduino Nano is supplied by a supply of 12 DC Volts and 1.5 Ampere (but it could be 5V as well if the USB is used, but would need filtering)
- The Servo-motor, HC-SR05 sensor and the signal LED are powered by the 5 Volts of Arduino Nano.
- The Ground of microcontroller device is related with the grounds of LED, sensor and servo-motor.
- The TRIGGER pin of HC-SR05 sensor is linked with D2 pin of Arduino Nano.
- The HICHO pin of Ultrasonic sensor is attached with D3 pin of microcontroller device.
- The PWM pin of servo-motor is connected in D4 pin of Arduino device.
- The signal LED is attached in the D5 pin of microcontroller.

5. Operating Principle Of Aagd

Figure 6 presents an automatic alcohol dispenser. Using it is very easy; it is enough to approach the hand to the Ultrasonic sensor about 5 cm. In this state, the servo-motor will be rotated with 150 degrees for duration of 500 milliseconds, after that will be returned to the initial state (0 Degrees). This mechanism of servomotor will press the push-pull button of AAGD. In the case of the user forget his hand close to the sensor, the servo-motor remains in the initial state. Therefore, the AAGD is worked one time when the sensor detects the close of hand, and it will repeat the operation each a new detection, as detailed in the organizational chart of Fig. 7. It has also an advantage that both hands can be approached together, as for children with smaller hands.

6. Benefits And Future Development Of An Aagd Device

The AAGD is a device that could be placed in the schools, transportation means and companies. This device is easy to use it for different people (Children, youth and elderly people). The benefits of the AAGD device can be cited as follows:

1. Giving more confidence as people may be reluctant to push the button on the dispensers.

2. It may have a positive psychological effect.

3. Door handles remain clean from the Covid-19, by placing the AAGD at the main entrance.

4. More confidence of parents while sending children to school.

Despite the good efficiency of AAGD, it can be still improved by integrating it in a more complete system. For this purpose, among the future developments that can be made on the AAGD can be mentioned as follows:

1. Connecting the door of main entrance by the AAGD device, to ensure more protection for the staying inside the companies or markets. In this state, the door will not open until the visitor has washed his/her hands.
2. Integrating the temperature sensor to the device to ensure that the visitor is not infected.
3. Integrating the IoT technologies (Internet of Things) to the device. In this state, when the device detects that visitor infected by the virus, it will send a remote warning to the administrator of company or market.
4. Developing an AAGD device where the dose depends on hand size.
5. Implementing a small camera (Rpi camera) in the device, to ensure the AAGD protection. Especially, when the automatic dispenser is placed in the street.

7. Conclusion

All countries of the world are going through a difficult time due to the spread of Covid-19 that can be rapidly transmitted between people. In this complex period, most government companies decided to stop their activities, and some private markets even made the same decision to avoid the spread of coronavirus infection. However, despite all these difficulties, technology can play a non-negligible role to alleviate the problems. Also, spreading the knowledge and communication of findings may help, to develop open source. In fact, even a sterilizer distributor can become smart, by introducing the right technology into it. In this study, the alcohol dispenser has been transformed into a non-contact automatic dispenser, to reduce the spread of the Covid-19 virus.

This development of AAGD is based on microcontroller device that detects the right distance measurement between the hand and alcohol dispenser. In addition, it will control the mechanism of push-pull button of dispenser, by managing the angle rotation of servomotor. This mechanism can be changed depending on the design proposed by the manufacture company. On the other hand, the program can be extended, to obtain a smarter device.

This device has the possibility to be integrated it in the companies and markets, to reduce the spread of coronavirus between the people, and spreading psychological confidence inside the society. For sure, some mockup will help the social acceptance, but a technical base is still needed.

Declarations

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Conflict of Interest: In this study, all authors have no conflict of interest to declare.

Authors' contributions: M. B.: provided the analytic study, performed the numerical simulation and realization, interpreted the results of the curves and performed the drafting of the article; A. M. and A. B : provided the right orientation of this study, discussed the results, revised the research paper and gave final approval of the manuscript version to be submitted.

Data Availability Statement: This manuscript is a theoretical research, it has no associated data or the data will not be deposited.

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Figures

Figure 1

Hands Free Dispenser Stand.

Figure 2

Connection between Arduino nano and Ultrasonic sensor

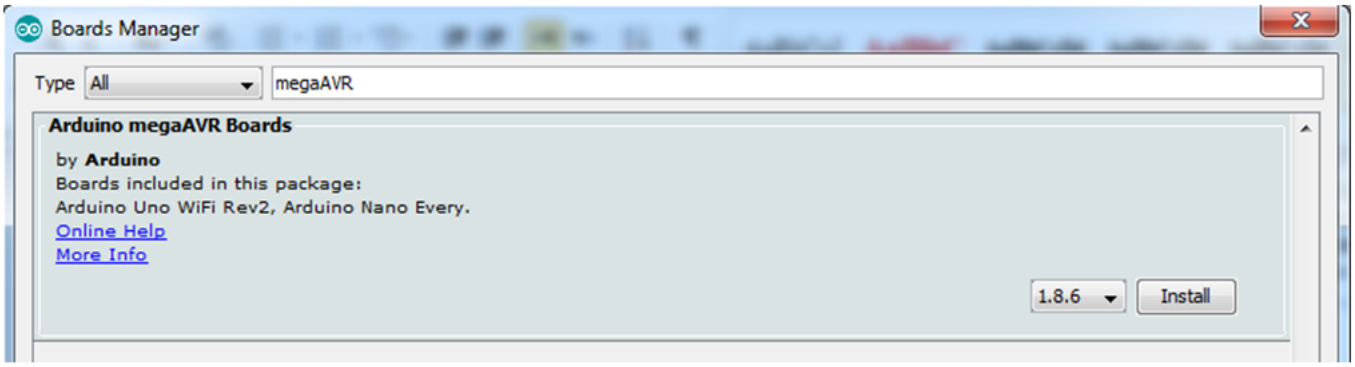

Figure 3

Implementing of Arduino megaAVR in IDE software.

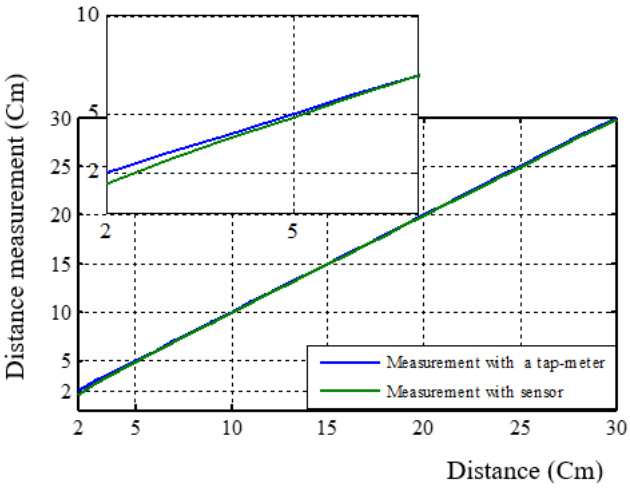

Figure 4

Distance measurement by tap-meter and sensor

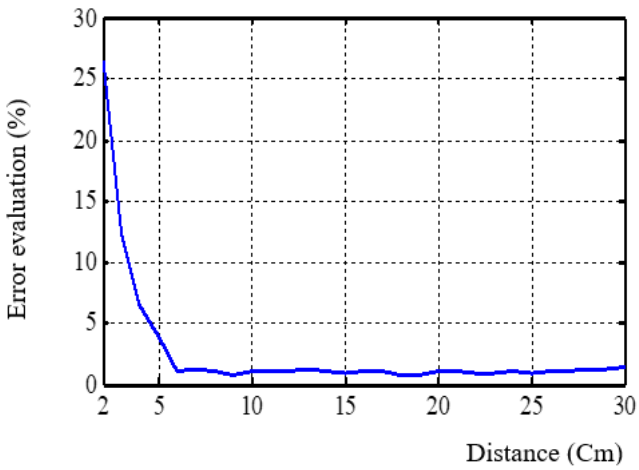

Figure 5

Error evaluation between the measurements

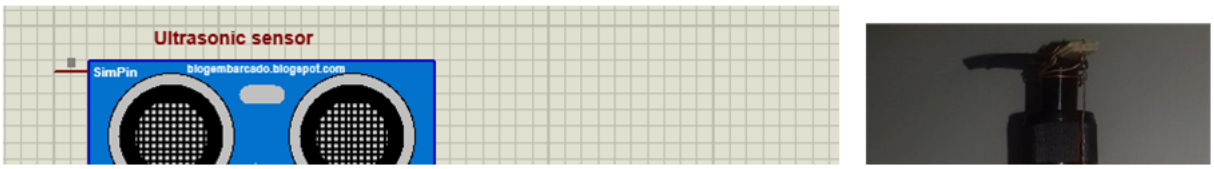

Figure 6

Non-contact automatic alcohol dispenser. (a): Global circuit of AAGD mounting, (b): Development of an automatic alcohol dispenser.

Figure 7

Organizational chart of automatic alcohol dispenser.

Supplementary Files

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