Cost-effective Automatic Hand Washing System

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Abstract: According to World Health Organization recommendations, people should wash their hands regularly, with soap and water for at least 20 seconds. After that, people should avoid touching surfaces. Several hand sanitizer machines were released in markets. These devices are nothing new, but they all sharing the same problems: (1) They all are expensive and not all people were able to buy them in their houses; (2) They all use a sanitizer which is not as effective as soap and water. In this paper, an automatic and cheap hand washing system, based on soap and water, is designed and implemented using simple and low cost components. The proposed system has two parts: one should be connected to the main water faucet and another must be put nearby. This system keen on reducing any virus transmission, helping people to wash their hands properly without touching the water faucet and reduce rationalize water consumption. A microcontroller is used with some sensors and simple parts to build the system. A sensor will detect hands approaching and automatically allow liquid soap flowing. After 20 seconds, a sound will alert the person that the washing time has expired. Also another sensor will check hands approaching to the water faucet. If so, then the system will allow water flowing.

Keywords: Arduino UNO, COVID-19, IDE, IR, TIP120, WHO

الخلاصة: وفقًا لتوصيات منظمة الصحة العالمية، يجب على الناس غسل أيديهم بانتظام بالصابون والماء لمدة 20 ثانية على الأقل. بعد ذلك، يجب على الناس تجنب لمس الأسطح. تم إطلاق العديد من آلات تعقيم اليدين في الأسواق. هذه الأجهزة ليست جديدة، لكنها جميعها تشترك في نفس المشاكل: (1) جميعها باهظة الثمن ولم يتمكن جميع الناس من شرائها في منازلهم (2) يستخدمون جميعًا مطهرًا غير فعال مثل الصابون والماء. في هذه الورقة، يتم تصميم وتنفيذ نظام غسيل يدوي آلي ورخيص، يعتمد على الصابون والماء، باستخدام مكونات بسيطة ومنخفضة التكلفة. يتكون النظام المقترح من جزأين: يجب توصيل أحدهما بصنبور الماء الرئيسي والآخر يجب وضعه في مكان قريب. يحرص هذا النظام على تقليل انتقال أي فيروس، ومساعدة الناس على غسل أيديهم بشكل صحيح دون لمس صنبور الماء وتقليل ترشيد استهلاك المياه. يتم استخدام المتحكم الدقيق مع بعض المستشعرات والأجزاء البسيطة لبناء النظام. سيكتشف المستشعر اقتراب اليدين ويسمح تلقائيًا بتدفق الصابون السائل. بعد 20 ثانية، سينبه الصوت الشخص إلى انتهاء وقت الغسيل. كما سيقوم مستشعر آخر بفحص الأيدي التي تقترب من صنبور الماء. إذا كان الأمر كذلك، فسيسمح النظام بتدفق المياه.

1. Introduction

To prevent infection with any virus or bacteria, people must wash their hands regularly beside other conditions according to World Health Organization (WHO) recommendations. Washing hands in the right way is an important issue and not all people are committed to it. Many studies were established to shed light on this topic. Some studies found that 63% of students washed their hands, 38% used soap, and 32% washed with soap for more than 5 seconds, but only 2% washed their hands with soap for more than 10 seconds [1].

Another study found that only 3% of people are washing their hands correctly or maybe some of the top 1% are doing it wrong [2]. In 2013, Michigan State University researchers make another study and found that 7% of women and 15% of men didn't wash their hands at all, and the men who did wash, half never used soap, whereas 22% of women skipped the soap. The observations found that only 5% of sample people washed their hands long enough, and with soap, to kill the germs that cause diseases [3].

All the results of these studies were gross. There were many times in which people need to wash their hands. And now with the spreading of COVID-19, there must be more attention for this topic. Many companies tried to focus on this subject and produce an automatic hand sanitizer devices. These devices were very expensive and it is difficult for people to get those [4]. Another issue with these machines, they based on using a sanitizer for cleaning the hands, which will only work if it contains at least 60% alcohol. According to the Centers for Disease Control and Prevention (CDC), alcohol- hand sanitizers may help in reducing the amount of germs and bacteria on the hands, but they do not kill all types of bacteria, especially if the hands have dirt and grease, so should not be used to replace hand washing with soap and water [5][6].

2. The Proposed System

The block diagram of the proposed automatic hand washing system is shown in Figure 1. A microcontroller is completely controlling the system. When a human's hand approaching the soap liquid, it will automatically flow and then the water faucet also will flow to make a lather and help in washing the hands easily. After 20 seconds and if the hand detection system recognizes an imminent approach of the hand to the water faucet, then the water will flow again much longer than the first flow in order to wash the hands thoroughly from soap. This algorithm is performed with the help of sensors, motors, buzzer and water solenoid valves.

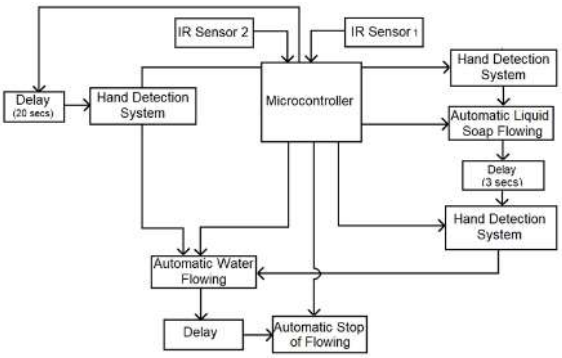

Fig. 1. Block diagram of the proposed automatic hand washing system

3. System Design Components

The components that used to build the proposed hand washing system are:

- Arduino UNO Microcontroller
- Infrared Sensors
- Mini Aquarium water Pump
- Water Solenoid Valve
- TIP120
- 1N4148 diode
- Buzzer

3.1 Arduino UNO

Arduino is an open and free source electronics platform based on a combination of hardware

and software, shown in Figure 2. Over the years, it is used in thousands of projects, from simple objects to complex instruments. All Arduino boards are completely open source, allowed users to build projects independently and adapt them according to their needs. Its software (IDE) is also an open source, and it can be installed in windows and many operating systems [7].

Fig. 2. Arduino UNO

1.2 Infrared Sensor

An infrared sensor is an electronic device that emits in order to sense the surrounding stuffs. It can measure the heat of an object and/or detects its motion. It contains two parts: a transmitter which contain a LED that emits infrared light, as shown in Figure 3, and a receiver which contain either a photodiode or a phototransistor. When the infrared light falls on the photodiode, the output voltages and the resistances will be changed in proportion to the magnitude of the light received and therefore the current passes through it will be less or more [8].

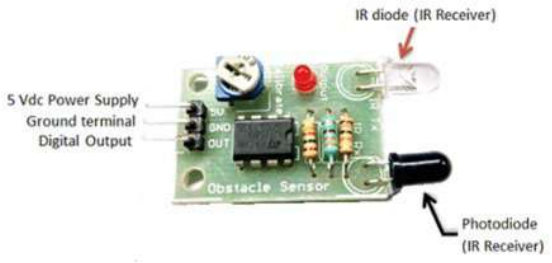

Fig. 3. Infrared sensor

3.3 Mini Aquarium water Pump

This quiet water pump (R385) can be used to water plants, or make a small fountain, and many other projects that concern with water flowing. It has a filter inside, works with a sound-level under 30db and can stick to any smooth surfaces. The R385 can operate normally when it is provided with a voltage between 6 to 12 Volt DC and a current between 0.5 to 0.7 Ampere but it delivers its maximum operating-values when the power is at the upper end of the aforementioned ranges (see Figure 4) [9].

Fig. 4. Mini Aquarium water Pump

3.4 Water Solenoid Valve

Water solenoid valve is used to control the flow of fluid. There are two outlets in this valve as shown in Figure 5. Normally, the valve is closed. When 12V power supply is applied to the two terminals (the + and - terminals), the valve will be open and water can push through in only one direction [10].

Fig. 5. Water solenoid valve

3.5 TIP120 Transistor

TIP120 is an NPN Darlington transistor. It can switch loads up to 8Ampere with a maximum voltage of 60Volt and continuous current of 5Ampere. This makes it very suitable for many electronics like controlling solenoids, motors, and high power LEDs. TIP120 has three pins (see Figure 6): (1)Base used to turn the transistor

ON or OFF by controlling the biasing of it, (2)Collector is normally connected to load and the current flows in through the collector, (3)Emitter is normally connected to ground and the current drains out through it [11].

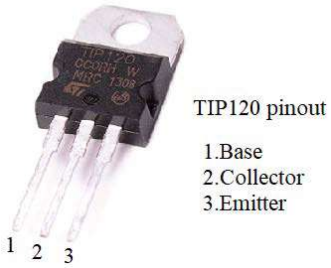

Fig. 6. TIP120 Transistor

3.6 1N4148 diode

1N4148 diode is a standard silicon switching-signal diode which allows current flow through only one direction (flow from the Anode to Cathode), as shown in Figure 7. It is one of the most popular diodes because of its characteristics, fast switching, low cost and dependable specifications. It is very useful in switching applications and protecting devices [12].

Fig. 7. 1N4148 diode

3.7 Buzzer

A buzzer is a small efficient component that add sound features to projects. It is small and compact two pins structure (positive and negative), hence can be easily used. It is widely used in most electronic applications [13]. Figure 8 shown the buzzer and its pins.

Fig. 8. The buzzer and its pins

3.8 Other Supportive Components

In order to connect the above components together, some supportive parts are required. These components, shown in Figure 9, include breadboard, jumper wires, 12 volt power supply and 1kΩ resistor.

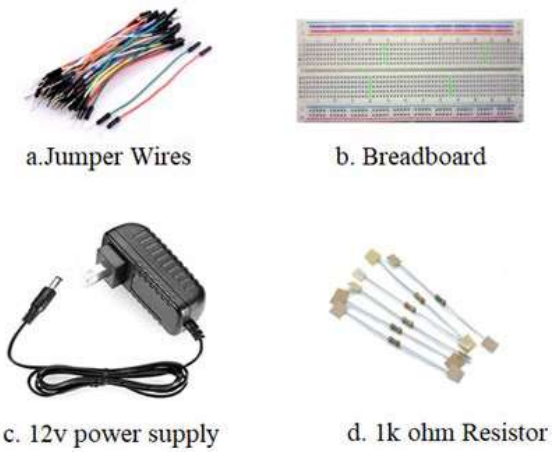

Fig. 9. Supportive Components

4. System Connection and Programming

The system complete connection will be explained by the following steps:

First the connection is performed and established by preparing the GND and VCC from the microcontroller, Arduino UNO, on the breadboard with -ve pin of the power supply.

Two IR sensors, sensor 1 controls the action of the soap liquid parts (pump 1 and solenoid valve 1) whereas sensor 2 controls the action of the water faucet parts (pump 2 and solenoid valve 2), will be connected to Arduino. They have three pins: (VCC and GND) both are connected with connection 1, OUT 1 is connected with digital pin (0) and OUT 2 is connected with digital pin (1) as shown in Figure 10.

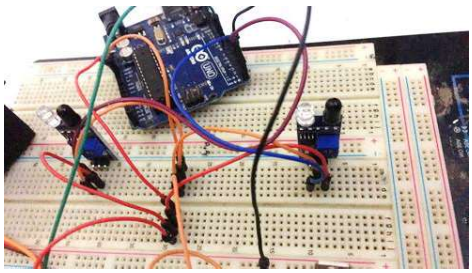

Fig. 10. IR sensors connection

The water pump (R358) must be connected to the solenoid valves using small water hoses. It has two pins: GND is connected the main GND in connection 1, the second pin is connected with the +ve pin of its own solenoid valve, the -ve pin of its own diode and the +ve of the 12V power supply as shown in Figure 11.

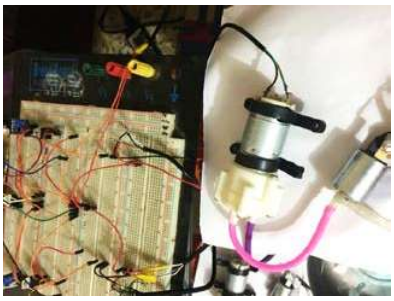

Fig. 11. Water pump connection

Two TIP120 transistors are used as switches to turn the water solenoid valves ON or OFF. TIP120 has three pins: base is connected to Arduino digital pins (6 and 7) through 1k resistors, collector is connected to the -ve pin of its own solenoid valve and the +ve pin of its own diode, emitter is connected to the common GND of connection 1 as shown in Figure 12.

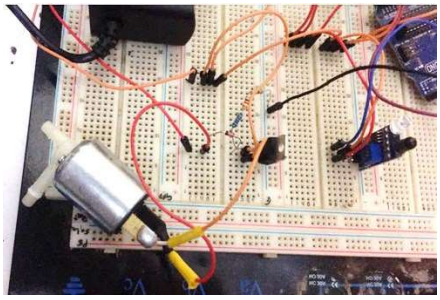

Fig. 12. TIP120 and solenoid valve connection

The buzzer is also connected to arduino. It gives a sound whenever the 20ms is finished so that the people can start washing their hands, with water, from soap lather. Buzzer's positive pin will be connected to digital pin (5) of Arduino UNO and negative pin of it will be connected to GND. Figure 13 shows the connection of the buzzer.

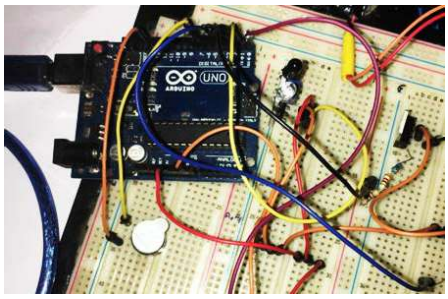

Fig. 13. Buzzer connection

The -ve pin of the power supply is connected with the main GND in connection 1. Figure 14 shows the complete connection of the system.

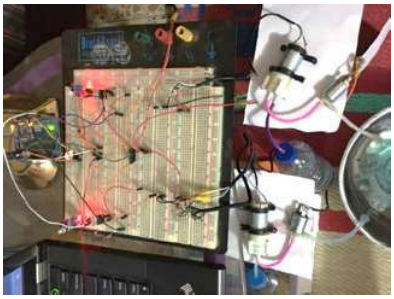

Fig. 14. System full connection

Final step is the programming of the hand washing system. It is performed in IDE platform that assist to logically connect the hardware components with the software.

5. Result and Discussion

After operating project software, the proposed device worked and performed its task properly. The link in [14] shows the system operation and performance. The system allows an automatic soap liquid flow whenever a hand approaching it and after 20 seconds and only when a hand is detected, the water will flow also automatically without any need to touch the water faucet. Both automatic flowing, of soap liquid and water, were done only when the hands is close to the device so that a frugal water consumption will be also presented. The proposed algorithm will make sure to wash the hands for 20 seconds to get rid of all bacteria and germs as the WHO recommended. In these days, there is a high demands for a methods for reducing COVID-19

transmission; the proposed system may contribute a little something to prevent the spread of the virus in crowded places and hospitals.

Based on the proposed system performance, and after gathering some samples of automatic hand sanitizers in the markets; a comparison between specifications of these marketer sanitizers and the proposed system is presented in the table below. The comparison was based on several points in terms of capacity, sterilization material, sanitizing method and price.

As noticed, the specifications of the proposed system had a preference over the rest, as its capacity is subject to change according to need, its price is cheap, and the sterilization material is optimal (washing with soap and water programmed for at least 20 seconds) according to the WHO recommendation.

Table 1: A comparison between the proposed system and the marketer systems

Hand sanitizer system	Capacity (in ml)	Sanitizing Material	Sanitizing Method	Price (in $)
[15]	1000	alcohol	Provide alcohol as hands approach	24
[16]	8000	alcohol	Provide alcohol as hands approach	81.37
[17]	1000	sanitizing gel	Provide gel as hands approach	65.85+ 2.99 shippin g
[18]	1000	alcohol	Provide alcohol as hands approach	107.24
The proposed system	adjusted as need	liquid soap and water	Provide water as only hands approach	24

6. Conclusion

This paper provides a cost-effective approach based on automatic hand washing system. In the current situation, the spreading of coronavirus infection must be completely prevented. The proposed system represents a good way to protect people from being infected by COVID 19 and any virus. Even in daily life, the project can be used to protect against all kinds of germs, bacteria, especially in public outgoing, and any future similar global pandemics.

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