IoT Based Auto-Disinfectant Sprinkler System for Large Enclosed Space

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Abstract. *COVID-19* created the necessity of sanitizing every corner to keep life secured. In conventional means, sanitization is handled by sprinklers in a variety of shapes and sizes. These sprinklers are either human controlled or machine-controlled and does the job by placing them on the floor. The conventional sprinkling system is risky and exerts tremendous pressure on the working personnel; also, it does not assure of covering the entire space intended-for. The proposed auto-sprinkler overcomes these limitations by attaching it to the roof/ceiling and performs the process of sprinkling the disinfectant solution in mist form while being rotated at a 360° angle to ensure more coverage. The sprinkling distance is measured automatically using ultrasonic sensor. The Wi-Fi module in the system gets the data inputs from a website where the admin user can enter the start/stop time and duration of the spray. This system keeps a strict check on whether the place is sanitized or not and gives an alert notification if it has been a long time since the last sanitization took place. The prototype was tested and found to be very useful during the *Covid-19* pandemic.

Keywords: Auto-Sprinkler, Auto-disinfectant, Internet of Things, Sanitization.

1 Introduction

Sanitization is maintaining public health conditions by adopting stringent hygienic measures, and this activity is essential for the well-being of the society. This process of sanitization helps to maintain good health and increases the lifespan of humans on earth. As a result of inadequate sanitization, around 827,000 people die per year [1]. During this Covid – 19 pandemic period, it is our responsibility to make sure that everything around us is cleansed and sanitized [2]. This pandemic situation taught the human community to be extra careful in all our movements, especially while dealing with people through physical means [3]. To ensure safety, the World Health Organization (WHO) insists on the sanitization of all places usable in real-time. Hence sanitization becomes mandatory and is becoming a regular activity [4]. There are many sanitization mechanisms and devices [5-7] available in the market which helps to disinfect the surroundings in different ways. Sharnil et al [6] discussed a prototype that could help an individual to protect himself using an automatic sanitizer spray system. This system is equipped with a sanitizer sensing unit that works on solar power. Kodali et al [7] designed a solar-powered sanitized toilet as part of a smart city project. The authors used ICT techniques with IoT to design a self-cleaning toilet that requires less water and is free from water clogging. Gnanasekar et al [8] discussed a smart system to protect the hospital environment from overflowing bins.

The sanitization approach discussed in the literature limits to a localized area or a group of people. When the area to be sanitized is large, sanitizing the region or area puts a lot of hardship. But, with the smooth transition to adopt to the new-normal life through unlocking measures by the government such as opening malls, theatres, educational institutions, etc., the need for sanitization in a proper way for a large area becomes inevitable. Internet of Things (IoT) made things possible and has brought control of the entire world into a single point [6]. Taking advantage of this, and using Information and Communication Technologies (ICT), in this research article, a user-friendly system of sanitizing without human intervention for making life simpler and safer [7-10] is discussed. There are many solutions suggested by researchers, but the methods available in the literature have limitations such as manual intervention, heavy lifting of sanitizing equipment, and time-consuming to sanitize nook and corner of the place [11].

2 Proposed Architecture

IoT based auto-sprinkler system works by receiving inputs from even a remote place through a web-based portal controlled by an administrator. This sprinkler system model is attached at the center of the ceiling of an enclosed space such as a seminar hall or auditorium. The size of the sprinkler depends on the shape and size of the hall to be sanitized. The sprinkler has 40 holes and can vary based on the diameter of the sprinkler and the amount of disinfectant. Spray nozzles atomize the sanitizer in the form of mist. The container for holding the disinfectant/sanitizer is connected to the nozzle through a pipeline. The sprinkler is also attached to a motor capable of rotating through 360°.

This setup is controlled by a user interface that could send and receive data from sprinklers through the cloud. The Wi-Fi module ESP8266 sends the data to the cloud by booting the module to Serial mode which enables modifications using “AT” commands which are basic communication commands used (*Thingspeak* cloud, an open-source software is used to collect and view the data in real time through various forms like charts and graphs) [12]. Ultra-sonic sensors are used to determine the distance that the mist spray will cover so that the entire area is covered. The IFTTT (If-This-Then-That) protocol is used to inform the administrator about the time since the last usage and also the amount of disinfectant available in the storage container [13]. Once the setup is done, the sprinkler will start working according to the time interval which is entered through a website by the administrator.

The disinfectant spray will automatically stop its operation after the specified time, and this is communicated to the administrator. The device operates on both battery and electric power sources to provide 24x7 availability.

2.1 Design and Assembly

The various components that are chosen for arrangement including base, nozzle, rotating axle, DC Motors, ultra-sonic sensors, ESP8266, and Arduino UNO are identified through literature study.

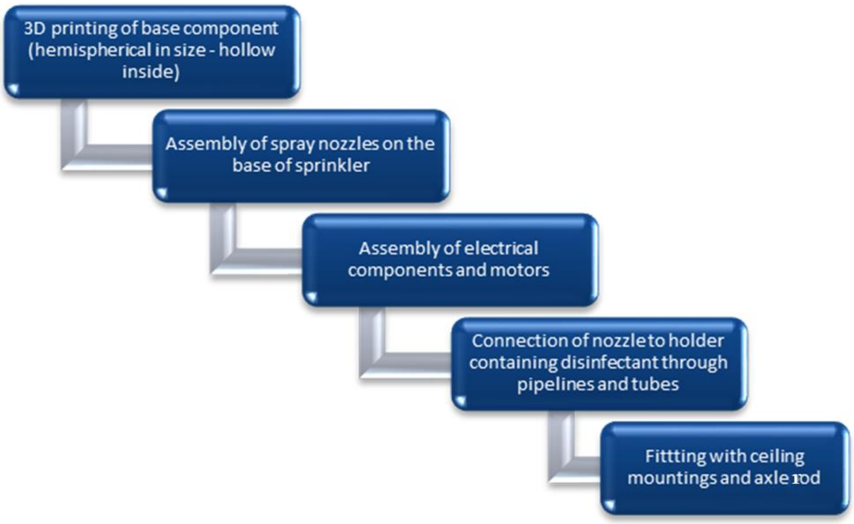

Fig. 1: Sprinkler - Assembly steps

Figure 1 represents the flow of activities to assemble a sanitizing system. The components of the device are 3D printable and made up of recyclable PLA plastics, so the overall cost of the device is minimum, and this helps in mass production of the device in a lesser time duration. Figure 2 shows the design of the components of the disinfectant auto-sprinkler and the assembly of the device.

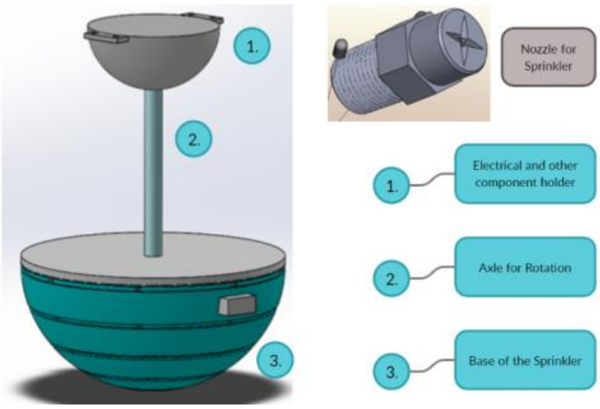

Fig. 2: 3D view of Sprinkler

Figure 3 depicts the circuit design of auto-sprinkler system. A motor is placed for facilitating the spinning action that covers 360 degrees ensuring that maximum distance is covered by the disinfectant mist droplet in the particular region [21]. A pump motor is connected to activate the sprinkler atomization. ESP8266 helps in getting the input from the user in order to program the device to sanitize in regular intervals [10], [13].

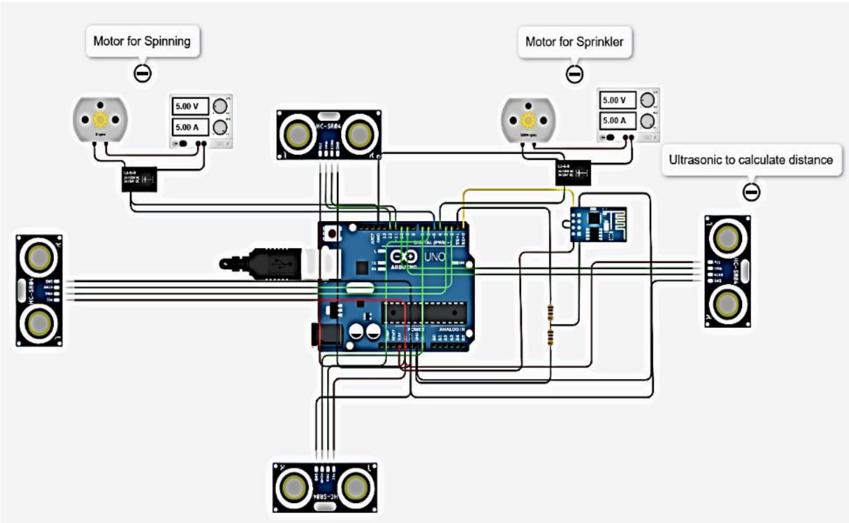

Fig. 3: Circuit diagram of Auto-Sprinkler

2.2 Distance Covered

The sprinkler is provided with four ultra-sonic sensors at the edges to determine the distance the disinfectant will reach [7], and to calculate the area of coverage. The power required for driving the sprinkler and the DC motor speed depends on the area of spray coverage. When the content of the sprinkler is below 20% of total capacity, the user will get an alert for refilling.

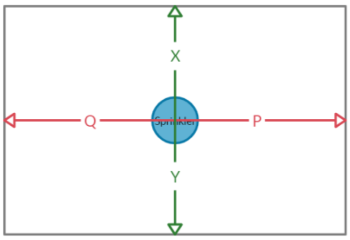

Fig. 4: Distance coverage by Auto-Sprinkler.

Figure 4 indicates the distance covered by the spray and the notations used in equation 1. The area of coverage and number of sprinklers required are calculated using equation 1.

$$A = (X+Y) * (P+Q) \tag{1}$$

Where,

A - Area of the region covered by the disinfectant,

X, Y - distance reached by the spray along Y direction

P, Q - distance reached by the spray along X direction

Figure 5 depicts the graphs generated by four ultra-sonic sensors placed on the disinfectant auto-sprinkler to find the maximum distance that will be covered in the sanitization operation for a closed square area hence resulting in similar graphs [17], [21].

Fig. 5 Ultrasonic distance covered by sprinkler

2.3 Threats to Validity

The device proposed is controlled by a remote website, and hence security is a major concern as the data sent and received are from the cloud. The chance for vulnerability attacks is more while using open source software compared to licensed software [24]. So, an open-source update plan is required, and an individual is assigned to watch for published vulnerabilities as-and-when it is necessary, and to test the integrity of the information and deploy an update to reduce the user's risk.

3 Conclusion and Future works

Complete sanitization of the space is possible with minimal human involvement and with a satisfactory level using this proposed system. This system functions on the data such as the start time, end time, and duration of the spray. These data are provided on a website, which also gives an alert when it has been too long (3 hours approx.) since the last sanitization process occurred. The plastic used in manufacturing this device uses recycled PLA plastic, which makes the device eco-friendly.

In future work, the refilling of the disinfectant can be automated with mobile storage tanks, and Artificial Intelligence (AI) can be implemented when the system is made available for commercial use. The device can be made to receive crowd size as an input along with the size of the room to sprinkle the disinfectant. It can also be integrated with a fire sprinkler system and can act as both disinfectant sprinkler and fire rescue sprinkler.

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