LOW-COST AUTOMATIC HAND SANITIZER DISPENSER: DEVELOPED AND DISPATCHED AGAINST THE COVID-19 PANDEMIC IN INDIA

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Abstract: Frequent hand hygiene practice is one of the most important precautionary measures to control the spread of viruses like coronavirus and many other disease-causing pathogens. During the initial outbreaks of the COVID-19 pandemic, the essence of using contact-free hand sanitizer dispensers was realized all over the world. This work primarily focuses on developing a fast, efficient, and a hassle-free method for hand sanitization in large public gatherings. An Infra-Red (IR) sensor-based automatic hand sanitizer dispensing device which uses alcohol-based sanitizer and locally available materials and components with basic functionality was developed. An Extended Reality (XR) approach was employed in design and assembly steps for visualization purposes. This cost effective contact-free device can be quickly replicated remotely and can be immediately pressed into actions, particularly in rural parts of India to fight the COVID-19 pandemic effectively.

Keywords: Innovation, automation, hand sanitizer dispenser, COVID-19 Pandemic, low cost device, augmented reality

I. INTRODUCTION

The Coronavirus Disease 2019 (COVID-19) pandemic is the result of an outbreak of the novel Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in December 2019 in Wuhan, the capital of Hubei Province in the People's Republic of China. As of 1 June 2021, the COVID-19 has infected over 168 million people and has caused well more than 3 million deaths across the globe, including 27 million cases and 0.3 million deaths in India [1]. Adding to the havoc created earlier, new strains of mutant SARS-CoV-2 have led to the resurgence of COVID-19 in many parts of the world including India. The resurgence of cases known to be the second wave of a pandemic has been observed largely in countries that had presumed that they have had almost succeeded in overcoming the pandemic and were shifting back to normal [2]. In India, the surge in confirmed cases was observed to be in the factors of 2 to 4 the cases of the first wave. In most cases, the SARS-CoV-2 infections cause severe damage in the lungs, affect the gastrointestinal tract culminating in inflammation and lead to diarrhea in other cases [3]. Recently, it has been reported that few patients recovering from the COVID-19 have been affected by black fungus or Mucormycosis disease. The fungus invades the sinus then it takes control over infraorbital and intracranial regions and causes death in 60-80% of untreated patients [4].

Earlier, understanding the highly contagious nature of the virus, the World Health Organisation (WHO) had issued guidelines to reduce the transmission of the virus in numerous ways [5]. Maintaining hand hygiene either through frequent hand sanitization or regular washing with alcohol-based soap was one of the obligatory actions to be mandatorily followed according to the guidelines issued [6]. The rise of critical cases of COVID-19 superimposed by Multi-Drug Resistant (MDR) pathogen infections has forced everyone including the healthcare professionals (HCPs) to go back to the basics of preventing infection by simple measure like hand hygiene [7]. According to a recent study by White et al. [8], a significant 39.9% decrease in the symptoms of respiratory disease was observed among the residential students after implementing effective use of hand hygiene methods.

Disinfection is nothing but a method of cleaning or sterilizing an object or part of the body, such as the hands or the whole body to get rid of disease-causing pathogens by exposing them to heat, radiation, or substances like sanitizers. Depending on the active ingredient used in the sanitizers, hand sanitizers can be classified into one of two types, alcohol-based or alcohol-free [9]. Among the above methods, alcohol was found to be more effective in killing viruses and is preferred due to its high volatility and likely causes less harm to the skin. However, alcohol can be expensive for large-scale disinfection and it also requires careful storage particularly in large volumes, to avoid disasters due to its high volatility [10]. Alcohol does to cause dry skin as it absorbs moisture. Modern commercially available alcohol-based hand sanitizers also come with antiseptic ingredients like chlorhexidine gluconate. The minimum alcohol concentration in hand sanitizers must be greater than 70% to be effective against viruses [11].

XR which stands for Extended Reality, is one of the fastest-growing technologies and includes Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR). Many researchers, technocrats, industry professionals have started exploring the use of AR technology in answering some of the complex issues in fabrication and assembly. In recent times, XR applications have been commonly reported in many of the virtual prototypes, assembly, fault diagnosing, and learning [12].

The idea of maintaining hand hygiene is a pivotal concern and challenging for the prevention and control of infections in largely populated countries like India. Direct contact with devices dispensing the sanitizer or containers can contribute to the spread of viral diseases. A touch-less and complete automatic hand sanitizer dispenser is the ultimate solution to these kinds of sanitary crises. A couple of previous works have highlighted the use of complex and significantly costly parts including microcontrollers in the development of automatic sanitizers. The simplest solution to this problem is to combine a simple transistor with an infrared proximity sensor, which cuts the costs. The lack of a microcontroller poses a challenge to prevent overflow power, however, the use of a smaller nozzle would physically restrict the liquid (sanitizer) flow. This work aims to explore a simple and cost-effective way to develop an automatic hand sanitizer dispenser and which can be replicated by anyone remotely. At the time when rural India is seeing surges in COVID-19 cases and deaths, the developed low-cost device is proposed for early deployment to control the further spread of the virus in rural parts of India.

II. COMPONENTS AND MATERIALS USED

2.1 Proximity IR sensor

The Proximity Infra-Red (PIR) sensor module mainly consists of the IR transmitter and receiver. In a typical IR sensor, the IR LED transmitter emits light, in the infrared frequency range. Infrared light is invisible due to its wavelength range (700mm - 1mm), which is much higher than the range of visible light. Infrared LEDs have a light emission angle of 20-60 degrees and a range of approximately from a few centimetres to several feet, it depends on the type of infrared emitter and the manufacturer. The photodiode acts as the infrared receiver because it conducts when light falls on it. The photodiode is a semiconductor that has a P-N junction, which operates in reverse bias, which means that it begins to conduct current in the reverse direction when light is incident on it, and the amount of current is proportional to the amount of light. This property makes it useful for infrared detection. The photodiode looks like an LED, with a black layer on its outer side, the black colour absorbing the highest amount of light. IR sensor as shown in Figure 1(a) was used in this unit to detect hands. The range of the IR transmitter is up to 20cm.

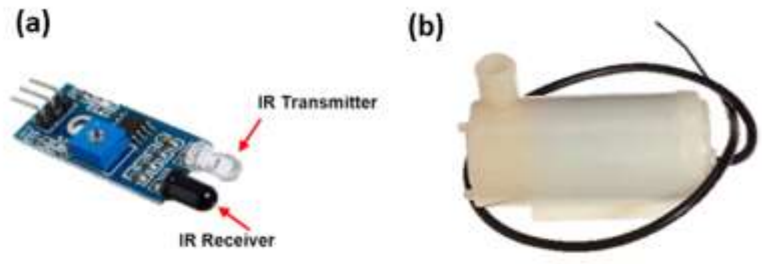

Figure 1. (a) IR Sensor (b) Micro-submersible DC Water pump

2.2 Micro submersible DC water pump

A DC-operated 3-6 V micro submersible pump as shown in Figure 1 (b) was used in the current work. This is a low-cost, small size submersible pump motor that can be operated by a 3 ~ 6 V power supply. This can take up to 120 liters per hour with a very low current draw of 220 mA. During the use, caution should be taken to make sure that the water level is always higher than the motor level since running dry can permanently damage the motor due to the heat.

2.3 PNP Transistor

The transistor in which one n-type material is doped with two p-type materials of this type of transistor is called the PNP transistor. It is a current controlled device. A commercially available TIP 32C PNP transistor used for the current study is as shown in Figure 2(a).

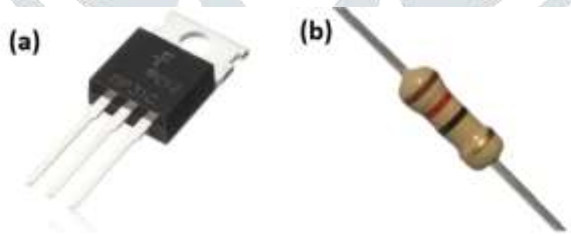

Figure 2. (a) PNP Transistor (b) Resistor

2.4 Resistor

A resistor is an electrical component that limits or controls the flow of electrical current in an electronic circuit. Resistors can also be used to supply a specific voltage to an active device such as a transistor. The commercially available 1 k Ω resistor used is as shown in Figure 2(b).

2.5 Sun board

Sun board is a mounting solid material that is stiff, light, easy to cut, and waterproof. It is widely used to create prototypes, architectural models, and make casting patterns. They are generally rigid and made from thin polyvinyl chloride (PVC) sheets that are stacked and glued with a foaming agent. Locally available sun board material was procured from a nearby market and was utilized to fabricate the outer body casing to reduce the overall weight of the device and to cut down the costs.

III. DEVELOPMENT

The methodology as depicted in the following flow chart [Refer Figure 3] was followed to develop the automatic hand sanitizer dispenser device.

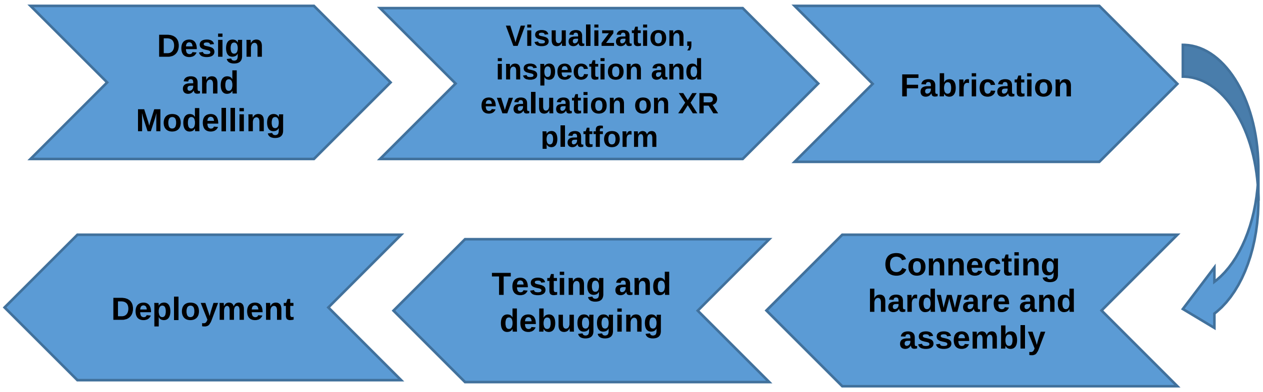

Figure 3. Flow chart of the methodology followed in developing the device.

3.1 Design and Modelling

Firstly, a walk through some of the prototypes was done using 3D model software (CATIA V5). Then, numerous trials with possible dimensions to fit all the parts to be assembled inside the casing were analysed. The roughly optimized dimensions of the casing are given in Table 1. The drawing of the casing with different views and finalized dimensions can be seen in Figure 4.

Table 1. Design parameters of the dispensing device

Physical measured	Parameters	Units (mm)
Base	Length x width	250 x 210
Sidewalls	Length x width	350 x 250
Sensor & Nozzle placement	Height	230

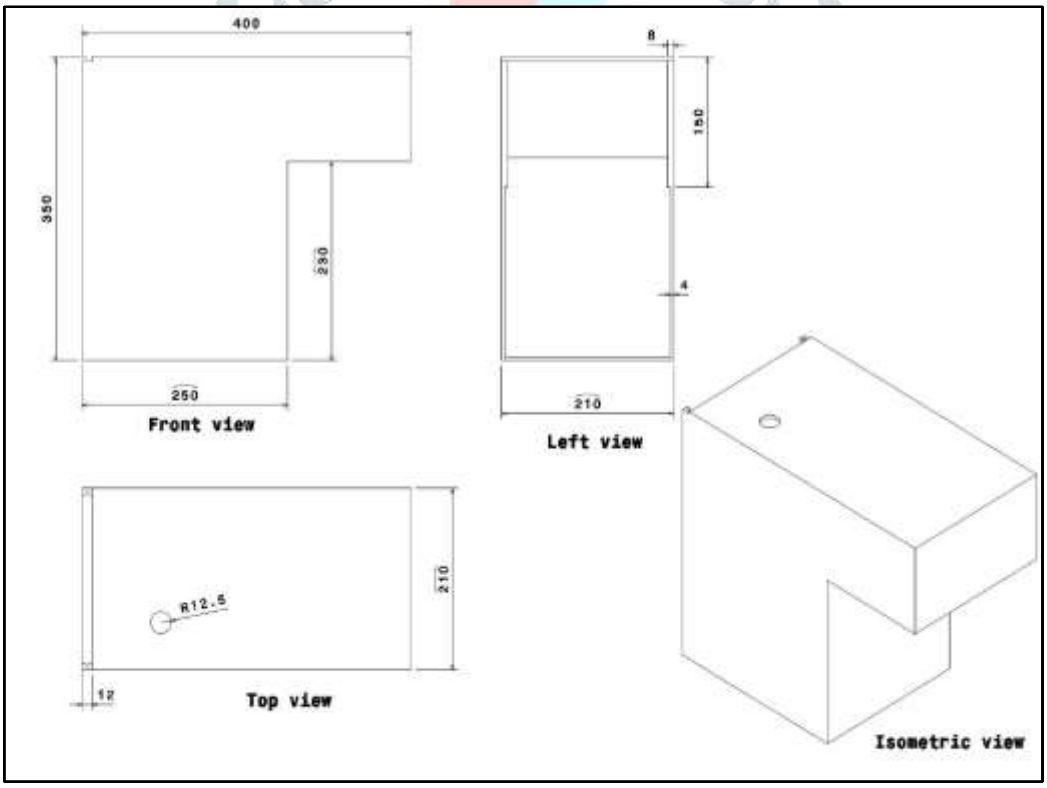

Figure 4. Dimensions of automatic hand sanitizer dispenser design

3.2 Visualization using XR platform

In this work, a novel approach of utilizing the XR for visualization and evaluation of the design was employed. The 3D model was imported into the EON Reality's XR platform and a lesson was created. The AR has allowed the users to experiment with different features of the product including material, assembly, colour, texture, and interfaces. The preview of rendered models in desktop mode used for AR visualization and inspection are as shown in Figure 5 (a) to (f). Initially, from the assembly inspection, it was inferred that the placement of the hole for the nozzle was not a threat for assembly of other parts and no change in the dimensions was necessary throughout the model.

Later, the simulation was published to a library using the same platform. Finally, the published model simulation was experienced in AR mode using the EON-XR mobile application and is as shown in Figure 6 (a) to (c). The AR evaluation was successfully carried out using EON-XR platform to decide on the design model selected.

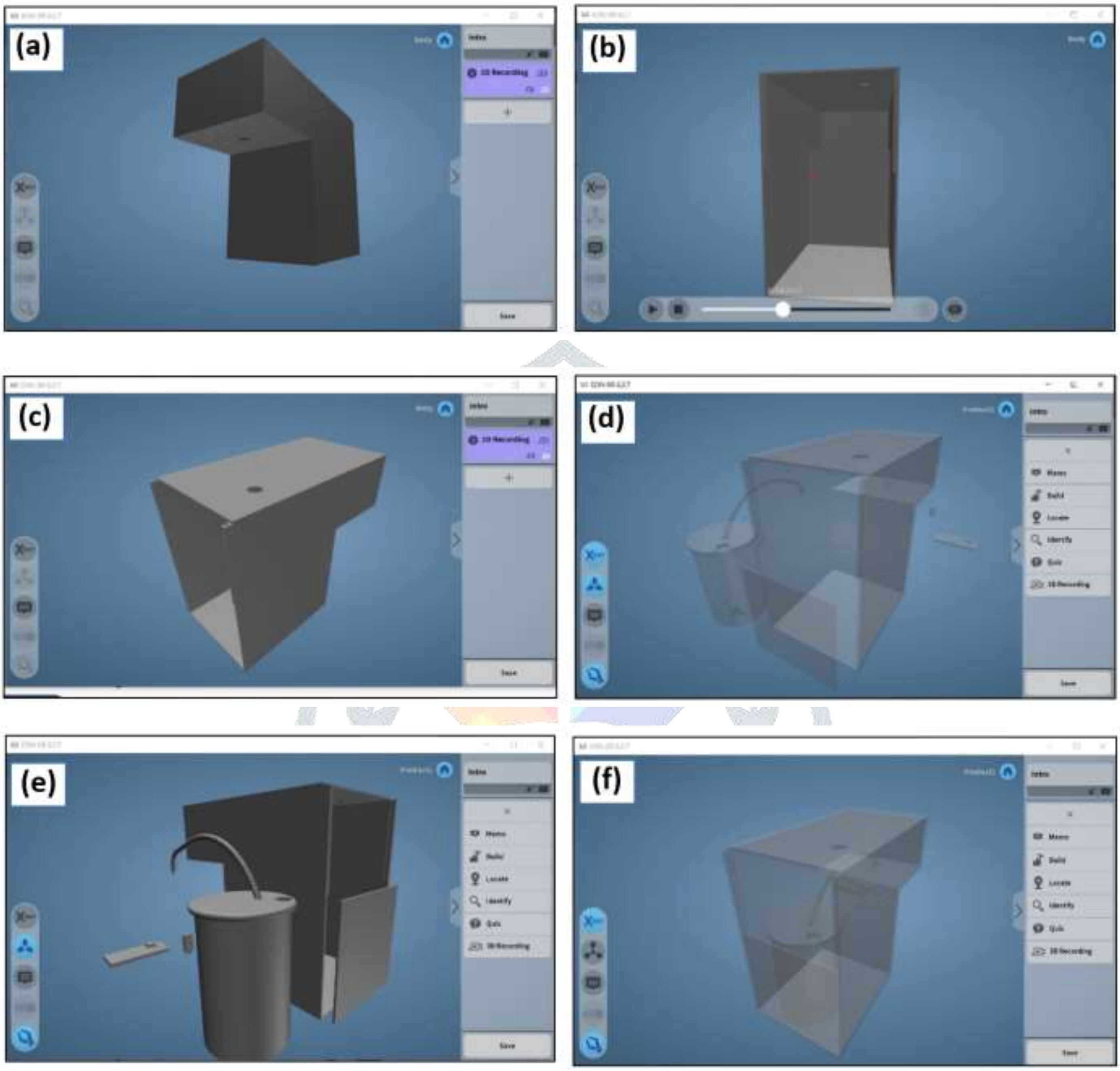

Figure 5. Rendered model on desktop mode (a) – (c) various views of casing body (d), (e) exploded view and (f) assembled view of various components of the automatic hand sanitizer dispenser

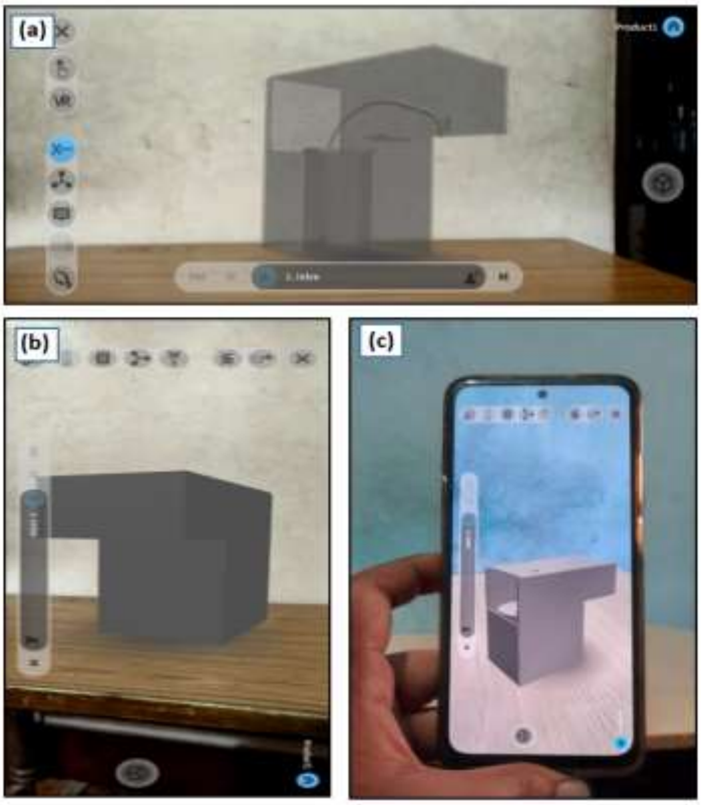

Figure 6. (a) – (c) AR mode experience on EON-XR mobile application

3.3 Fabrication

After the successful visualization and evaluation using AR, the fabrication and assembly steps were initiated. The procured sun board material was cut accurately according to the dimensions of the decided design and was glued by using a strong adhesive. To keep the unit stable and centre of gravity as low as possible, the sanitizer container with submersed pump was placed on the bottom surface of the dispenser and the nozzle was placed at hole provided at the top of the dispenser (230 mm height from the bottom of the dispenser). The PIR sensor was placed inside the casing and just beside the nozzle in such a way that only the transmitter and receiver end is visible from outside. This was to facilitate the detection of objects in front of it keeping the other parts of the sensor safe from the outside environment.

3.4 Connecting hardware and assembly

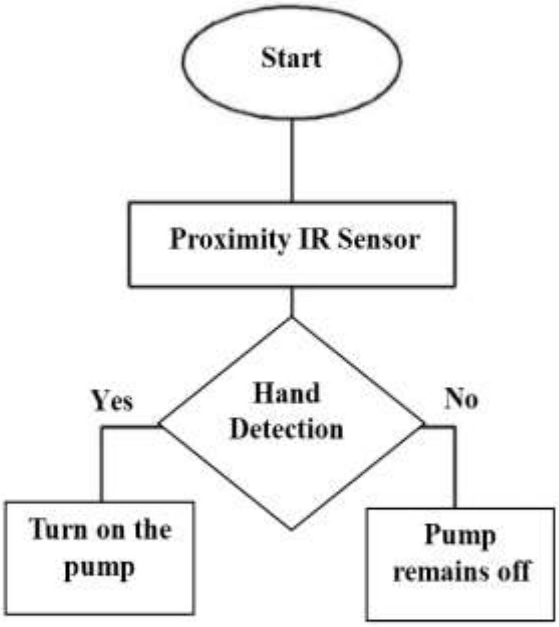

Figure 7. Flow chart

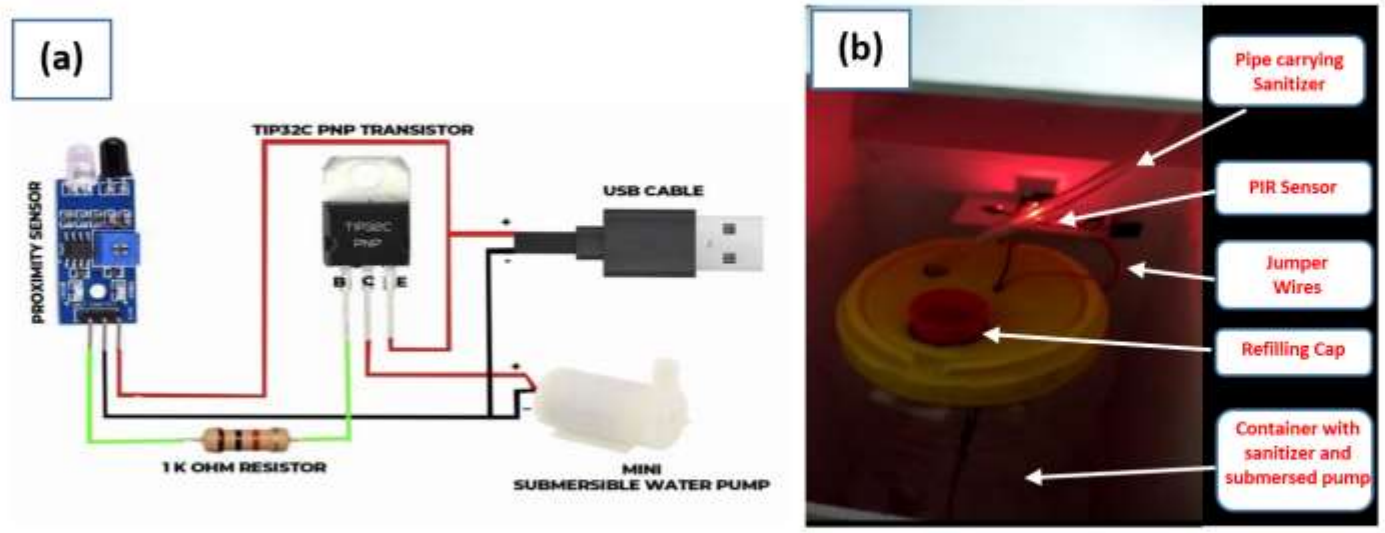

Figure 8. (a) Circuit diagram (b) actual connections made

The working principle of the proposed electronic hardware system is represented in the form of a flow chart as shown in Figure 7. The pump is powered by a 5v supply in this circuit. When the power is turned on, the circuit will be in condition, which means that when the IR sensor detects an object (a hand) in its proximity, the pump is directed to run. In this circuit, the transistor serves as a switch. As the IR sensor detects, a current is passed through the transistor, which turns the transistor ON, allowing the pump to operate. When the IR sensor detects nothing, no current is passed, and the pump remains turned off.

Components used in the circuit diagram are IR proximity sensor, 1 kΩ resistor, TIP32C transistor, connector wires, submersible water pump, and USB cable. This circuit requires a 5 v DC supply to drive the actuators and sensors. The sensor has 3 pins such as VCC, ground, and a data pin. The current is supplied from the source through the USB cable. Firstly, the positive terminal of the USB is connected to the VCC of the sensor and emitter pin of the TIP32C PNP transistor. Secondly, the negative terminal of the USB is connected to the submersible pump and the ground pin of the sensor. Then, the positive terminal of the submersible pump is connected to the collector pin of the TIP32C PNP transistor and the negative terminal of the pump is connected to the ground pin of the IR sensor and another negative terminal of the submersible pump is connected to the negative terminal of the USB. Lastly, the Base pin of the TIP32C PNP transistor is connected to the data receiver pin of an IR sensor through a 1 kΩ resistor to complete the circuit. The overall circuit diagram and the actual connections can be seen in Figure 8 (a) and (b) respectively.

3.5 Testing and debugging

A series of trial runs were made in the testing phase. The device was fully functional and circuitry seemed to be operational without errors or issues for numerous trials conducted. Also, the device was tested in various lighting conditions including in the bright daylight. The IR rays from the sunlight have chances of interfering with the sensors when placed outdoor. This is the most common flaw in any commercially available sensor-based dispensers, and some are limited to being used only indoors due to interference from excessive light. But in the current design, the position of the sensor is such that the interference from the sunlight when placed outdoor is very minimum and was found to be fit for outdoor use.

3.6 Deployment

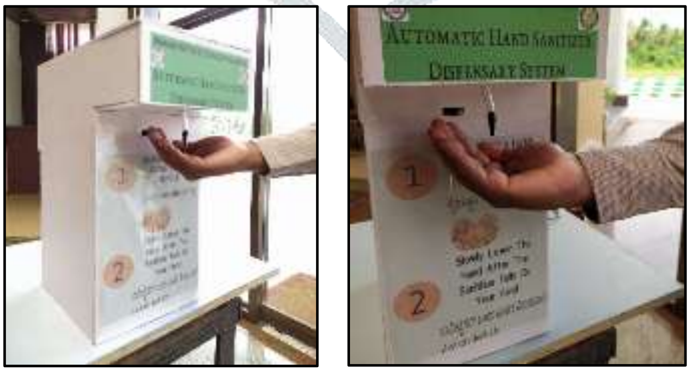

Figure 9. Deployed Automatic hand sanitizer dispenser (Table mounted unit)

Two table-mounted automatic hand sanitizer dispensers were deployed at Maharaja Institute of Technology Thandavapura, Nanjangud taluk, Mysore district, Karnataka, India, [Refer Figure 9] and one such similar device was deployed in Bharuni Constructions Pvt. Ltd., Pandavapura, Mandya district, Karnataka, India, to fight the novel coronavirus in an effective way. As of 1 June 2021, both of them were reported to be in the working condition since more than six months, showcasing their long run reliability.

IV. RESULTS AND DISCUSSION

During the operation, when a hand is placed under the PIR sensor, its output goes high, this output drives the relay driver TIP32C PNP transistor and in turn drives the submersible pump. When the hand is removed, the submersible pump is disconnected from the power supply, which stops the flow of sanitizer. The dispenser gets ready for the next person quickly within a second and the sanitizer will be dispensed as soon as a hand is detected under the nozzle again. The developed dispenser has several benefits, for example, considering an Arduino-based automated liquid dispensers commercially available across different off-line and online platforms costs over five-time the cost of production of the proposed design. Table 2. provides the details of the list of the components used, suppliers, and costs. The use of a simple transistor with a PIR sensor has significantly reduced costs. However, the lack of a microcontroller confiscates the overflow control, but using a smaller diameter nozzle can physically limit the flow of liquid. AR approach used for visualization, inspection and evaluation even before the actual operations, has ensured the fabrication and assembly operations to be carried out right-the-first-time, thus eliminating many trials and re-works, saving materials, energy, labour, and most importantly time.

Table 2. List of all components that were used to fabricate the automated hand sanitizer dispenser

Sl. No	Components	Manufacturer	Quantity (Nos.)	Price (Rs.)
1	Pump	Sound Land Corp.	1	125
2	Sensor	Electronic Spices	1	70
3	PNP transistor	Hitex Shoppe	1	35
4	Resistor	Supreme Mart	1	05
5	Jumper wires	Alpha Shoppe	1 set	20
6	Sun board	Twinkling Parrots	1	300
7	Container	Cloudtail India Private Limited	1	20
8	Pipe	K T Hardware Solutions	1	20
9	Data cable	Quantum Hitech Merchandising	1	85
			Total	680

V. CONCLUSION

The developed automatic hand sanitizer dispenser is a cost-effective, simple, and robust device that is capable of fighting the COVID-19 like diseases commendably. The proposed methods and model can be used to quickly replicate a fool proof and efficient dispensing device remotely, particularly in the rural parts of India with the most commonly available components and materials.

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