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# An exclusive hand protection device made of fused deposition modelling process using poly (lactic acid) polymer

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ABSTRACT

The world has been hit hardest by a type of Severe Acute Respiratory Syndrome (SARS) virus called corona. This vulnerability did not leave all the superpowers in the world. The virus, is spread through coughs and sneezes. It is also spread by touching objects or parts of an infected person. For this reason, it is considered an infectious disease. It is very difficult to protect ourselves from such a contagious disease. But the World Health Organization (WHO) says there are certain guidelines to follow. The first way is to prevent the spread of COVID-19 social infection by adhering to social spaces (i.e. 2 m intervals). Second, we can protect ourselves by using appropriate safety equipment. We can also protect ourselves from the COVID-19 virus by using sanitizers or soaps. So this study focuses on a 3D-printed hand protection device for COVID- 19 infection prevention. The design, fabrication, and testing of the gadget were all successful. Thus, a low-cost and efficient device made by eco-friendly Poly Lactic Acid (PLA) polymer material and may be utilized to operate some potentially susceptible and highly infectious surfaces in a variety of public areas, where touching and using particular components is common and frequent (eg door handles, electrical switches, ATM machines).

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## 1. Introduction

Additive manufacturing (AM) or "process of connecting materials to produce components from 3D model data, generally layer upon layer, as opposed to subtractive manufacturing and formative manufacturing techniques" is a term specified by the ISO/ASTM 52,900 standard [1-3]. These devices are somewhat inexpensive and/or low-end in total capabilities. In 1987, a revolutionary new method of AM called the stereo lithography (SLA) technology was created, and this first commercial system includes the method. Today, there are a variety of AM technologies and processes to choose from. According to the International Standard ISO/ASTM 52900, AM methods are categorized into seven distinct categories: binder jetting, powder bed fusion, direct energy deposition, sheets addition, material extrusion, material jetting, and vat photo polymerization [4-7]. AM may be utilized in a large number of applications, including fast prototyping, healthcare, and aerospace end-use parts. Several aspects of AM manufacturing make it a desirable option for companies, including the direct-from-CAD manufacturing, the flexibility of design, the simple customizing process, and the lower number of processes in production. On the other hand, the downsides of AM methods include anisotropy, the high cost of industrial equipment, and the high cost of feedstock as compared to conventional methods [2,8-10]. Certain other severe issues exist as well. For example, some machines of the same brand and type as well as successive procedures may not be repeatable. One of the major duties of civilians amidst the "Covid 19 "pandemic is to keep himself isolated and hygienic. Being a social humans have to share many public places like

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schools, malls, banks, government offices well, which can be critical in proceeding with the above said duties [11-14]. one of the spots where the idea of keeping ourselves intact or safe can be tricky is door handles. That is one of the most inevitable loopholes where the unrelenting virus can be spread through [15]. Even though automatic doors are an excellent replacement and requires less possible contacts, the installation being costly and high maintenance labours leaves that nearly impossible in most of the areas. Some of the practices that can stop the virus from invading and infecting are washing hands frequently and using hand sanitizers. Hand sanitizers are handy, very efficient, proven to be most efficient to stop the spread. But alike heads of a coin it has its own adverse circumstances as well [16-18].

Reports say that sanitizers were scrutinized for causing harm to its consumers especially in children. Sanitizers are said to be inducing risk of "Eczema", cause skin irritations, and sometimes even affecting fertility [4,19-23]. A major setback is it increasing the likelihood of bacteria developing resistance to antibiotics. Triclosan a major ingredient of sanitizers can even weaken human immune system and can impact body development as well. Prolonged usage of these sanitizers can affect the natural moisturizing ability of our skin, leaving us in a situation where externally medications should be taken to help them moisturize themselves. Excessive use of hand sanitizers can sometimes even cause hormonal deficiencies. It is horrifying to know that there have been cases were patients falling into coma and being paralyzed were reported. And final thoughts from doctors suggest to use hand sanitizers only when water and soap are not available [24-27].

In order to make PLA plastic (also known as poly lactic acid), cornstarch is usually used as a raw ingredient. Fermented plant starch is the most common starting material for the production of monomers [28]. The majority of 3D printed objects are made from this thermoplastic aliphatic polyester. Renewable resources are used to create PLA, a thermoplastic polymer that is completely biodegradable [29]. When it comes to filament creation, PLA is one of the most frequently used 3D printing materials. In 3D printing utilizing FDM (Fused Deposition Modeling) technology, PLA is a bio plastic commonly used with ABS (Acrylonitrile Butadiene Styrene) as a standard material. Because they're the two most prevalent plastics for home printers, there's a propensity to make comparisons between them. Some intriguing mechanical qualities may be found in PLA plastic [30-33]. PLA manufacture consumes 65 percent less energy and produces 68% fewer greenhouse emissions than the production of traditional plastics, and it does not contain any contaminants. End-of-life scenarios can be ecologically helpful if they're followed correctly. Even in saltwater at 25 °C, the material degrades at a glacially slow rate, according to a research published in 2017 that found no deterioration in almost a year of immersion [19,34-36].

Material and gadgets needed for a variety of critical services, including healthcare, must be manufactured on demand by firms that can meet demand [37]. A sophisticated manufacturing network made robust by a spread of 3D-printing facilities has a lot of promise in this setting. There are several advantages to collocating these "art-to-parts" companies with hospitals and transportation hubs to service the medical industry's immediate demands. 3D printing has demonstrated its competitive advantage in the crucible of COVID-19 replies by redeploying its capabilities.3D printing's digital adaptability and rapid prototyping enable rapid deployment of technologies and, as a result, quicker reaction to catastrophes [38-40]. Even if supply chains are severely disrupted, any decentralized 3D-printing plant anywhere in the globe may produce vital components on-demand by utilizing blueprints posted online. It is also possible to customize products and sophisticated designs with 3D printing because of its additive nature. Fighting COVID-19 requires a wide range of 3D-printed tools, including PPE, medical and testing devices, personal accessories, visualization aids and emergency housing.

Healthcare workers (HCW) can be protected from aerosol or accidental hand-to-face contamination during their daily clinical tasks by making their own hand protection using their own printing skills and easily available commercial items, like laser copy foils in the current study. It's possible that the prolonged epidemic may force healthcare facilities to reevaluate their supplies. Additionally, a greater focus on on-campus production provides for greater independence from external suppliers and fewer stockpiling requirements. Clinical processes will be more adaptable, and patients will have more control in times of crisis, but new regulations will need to be developed to keep up [41]. In the near future, it will be possible to print ready-to-use sterile parts in a cleanroom using special printing equipment. This will improve just-in-time manufacturing and make it possible to use more additively made items in hospitals [42-55].

## 2. Materials and methodology

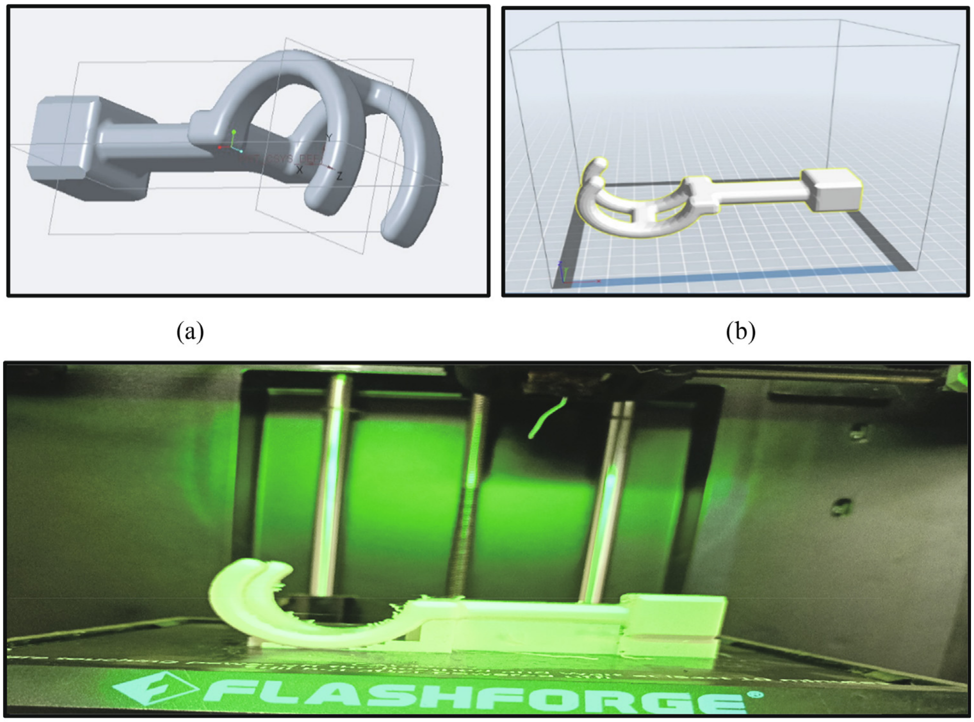
For making a hand safety device, a commercially available neat Poly lactic acid (PLA) filament used. The filament has the diameter of 1.75 mm. The main aims to use neat PLA filament was environmental friendly material, totally biodegradable after disposal as compared to the petroleum based polymers such as ABS, polypropylene and polyethylene [56-65]. In addition, lower thermal shrinkage during solidification was decisive in the choice of the first material tested compared with other possible materials such as ABS. A Fused Deposition Modelling (FDM) 3D printer was used to prepare the samples. The print speed of 40 mm/sec and the 100% of infill density with rectangle pattern was used for making the hand device [66-71]. The filaments were supplied from a coil to produce a part under maximum operating temperature of 200 °C. CAD models were generated on Solid works 2014 modeling software which were then converted to *.stl format [72-79]. Fig. 1 illustrates the proposed design to be manufactured using additive manufacturing.

The printing parameters in the production of PPE from the PLA and wood/PLA filaments are given in Table 1.

## 3. Results and discussion

During the current outbreak of COVID-19, it is imperative to wash hands often in order to avoid the spread of the virus. With soap and water, washing hands is the safest and most effective method. However, given the current state of affairs in most malls, workplaces, offices, schools, marketplaces, and other public locations, washing hands often with soap and water is becoming increasingly impossible [80-85]. As a result, hand sanitizers have become a popular alternative. Also, the hand sanitizers clean hands more quickly and effectively [86-95]. There are many public areas where hand sanitizers are utilized, such as hospitals, malls, public washrooms, workplaces, and restaurants. Because it is more effective at killing both germs and viruses than soap and water, hand sanitizer may have some negative side effects on the health of human skin and palms, despite the fact that it is more effective at cleaning hands.

Hands must be cleansed often with soap and water for a minimum of 20 s to disinfect COVID-19 and other hazardous germs, according to the prior discussion [96-99]. Due to little or no access to soap and water in many contexts, the most popular alternative




(a) (b) (c)

**Fig. 1.** (a) Proposed kit design (b) its in-slicing software and (c) The manufacture of personal protective equipment (PPE) from the PLA filament in 3D printing machine.

**Table 1**
The technical specifications used in the 3D printing of the specimens.

| Printing parameters in the 3D printer | Unit | PLA |
|---|---|---|
| Filament diameter | mm | 1.75 |
| Printing layer thickness | mm | 0.20 |
| Nozzle diameter | mm | 0.4 |
| Printing temperature | °C | 200 |
| Printing base temperature | °C | 30 |

to these necessities has been the usage of hand sanitizer. Additionally, the regular use of different grades of hand sanitizers might lead to the aforementioned adverse effects, as well [100–105]. As a result, there is a pressing need for a remedy that would not harm human health while simultaneously protecting against COVID-19. Thus, the proposed 3D-printed plastic gadget is one of the best and safest options. Fig. 2 shows how it may be used in public spaces for a variety of applications.

Fig. 3 gives the usage of proposed additive manufacturing kit in lift operation. Fig. 4 shows the usage of kit in ATM machines and operating electrical switches. As a result, in this experimental investigation of 3D printer-created pocket and hand-held door-opening gadget was developed and tested. As a result of this device, the user's hands will not come into direct touch with commonly infected or COVID-contaminated surfaces like door knobs.

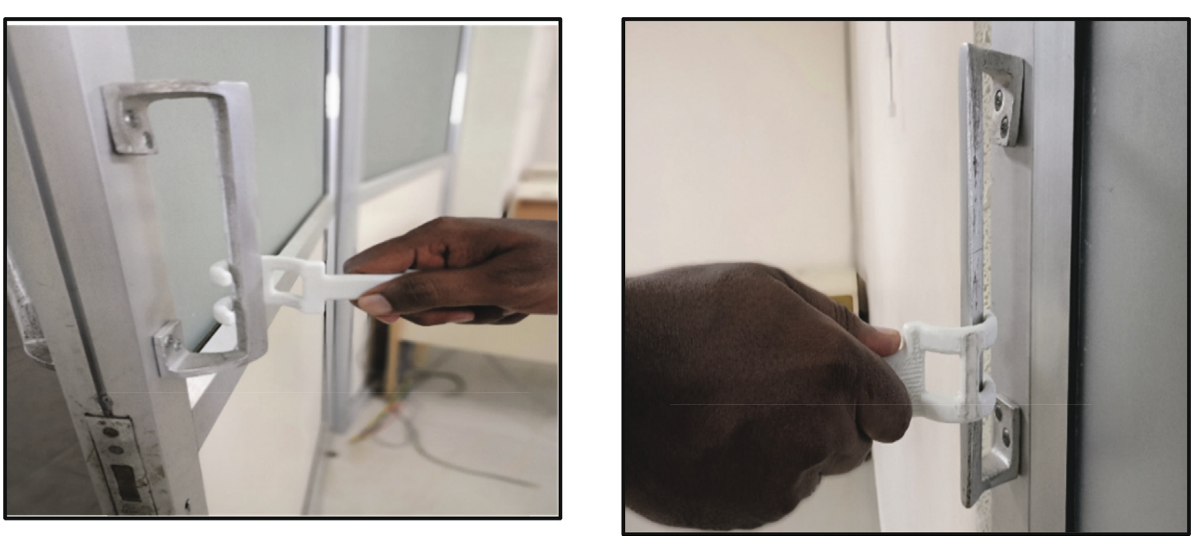


**Fig. 2.** Door opens by using the 3D-printed device.

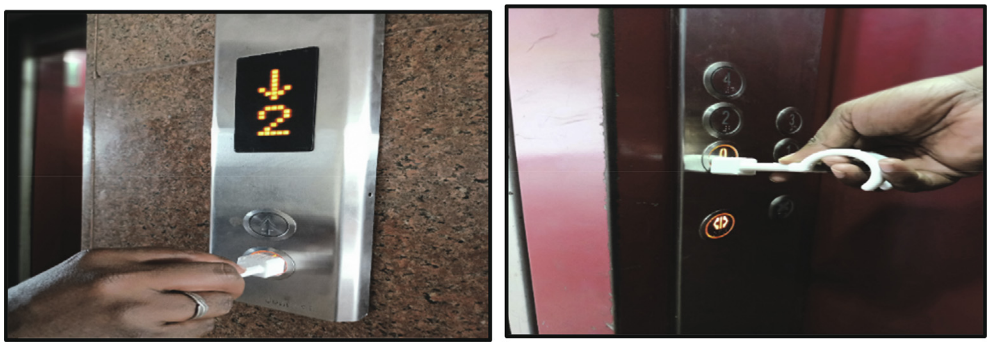


**Fig. 3.** Elevator operates with aid of the 3D-printed hand safety kit.

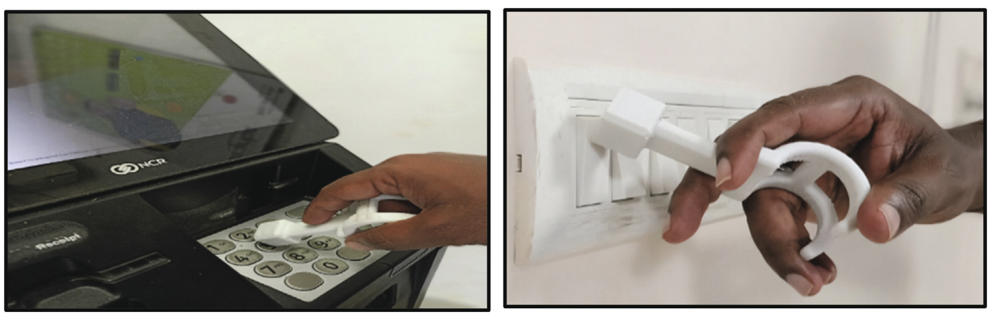


**Fig. 4.** Other proposed major applications of the 3D-printed device: automated teller machine (ATM) (left) and switches (right) operate by using the 3D-printed hand safety device.

## 4. Conclusion

Thus after all the researches carried out they were able to produce a gadget which can be of excellent use to help all civilians to reduce the probability of coming to contact with the corona virus and other microorganisms that can cause harm to ourselves and them being spread thus breaking the transmission chain. Using this device can protect humans from infection caused by COVID-19. When one node on this device has been utilised, the other node should be cleansed with sanitizer. The suggested gadget may be cleaned or wiped with sanitizer to prevent users against COVID-19 infection instead of slapping hands with sanitizer constantly. With the help of the gadget and practices like washing hands, sanitizing them with hand sanitizers, wearing masks in public places etc can put the transitory period of distress, that is the period where we have to be afraid and alert of the dreadful virus, dissolve as soon as possible.

## CRediT authorship contribution statement

**S. Thamizh Selvan:** Writing – original draft. **M. Mohandass:** Conceptualization. **Dinesh Kumar vairavel:** Methodology. **P. Sethu Ramalingam:** Investigation. **K. Mayandi:** Investigation. **S. Joe Patrick Gnanaraj:** Supervision. **M. Appadurai:** Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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