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A 3D printing face protection shield design for nursing homes at COVID-19

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Abstract- the COVID-19 pandemic of 2020 is the subject of this research, which examines how it will affect Slovakia. Voluntary cooperation was prompted by the shortage of protective equipment provided by State Material Reserves. One thousand 3D face shields were printed in two months by our civic association Slovak Python User Group, while many others assisted by sewing face masks and printing 3D face shields for hospitals. During the last two months, we have optimised all of our 3D printers and 3D models in order to boost productivity. Patients at nursing homes around the country received all face shields.

Keywords- 3D printing; COVID-19; 3D face shield; Slovakia

I. INTRODUCTION

Coronavirus disease outbreak COVID-19 has become a global pandemic because of its rapid dissemination and high death rate [1]. More people are becoming ill with COVID-19's causal agent, acute respiratory syndrome coronavirus 2 (SARSCoV-2), which is spreading worldwide. Acute respiratory distress syndrome (ARDS) and multiple organ failure may occur in patients with COVID-19.

23 states in the United States have gathered statistics on the number of fatalities in nursing homes [2]. COVID-19 was shown to be responsible for 27% of all fatalities. This data shows that 50,000 people have died from COVID-19-caused fatalities through 23rd April 2020, which accounts for 11% of all coronavirus cases in 29 states. Over 50% of fatalities in nursing homes and long-term care facilities have been linked to COVID19 in Delaware, Massachusetts, Oregon, Pennsylvania, Utah, and Colorado. This shows that any nation that was badly impacted by COVID-19 may have experienced a similar predicament.

Of the 181,000,000 recorded COVID-19 cases, 166,000,000 individuals have recovered and approximately four million people have died [3]. [1]. Most fatalities occur in the United States, India, or Brazil. Slovakia ranked 54th out of 222 nations. Due to disparities in population, it is impossible to compare the absolute number of cases each nation. Slovakia ranks 11th out of 190 nations based on the total number of cases per one million people. According on the number of tests performed per one million people, Slovakia ranks 78th in the world with 545,297 tests.

At the beginning of spring in 2020, the first cases of coronavirus illness were reported.

[4] It resulted in a decrease in public transportation as well as the closure of businesses and educational institutions.

ISSN- 2394-5125 VOL 08, ISSUE 02,

Almost all public institutions, such as schools and nursing facilities, have moved away from a physical location to a virtual one. Many of them, on the other hand, were unprepared.

Because of the elderly population, nursing institutions were particularly vulnerable. First Slovak nursing home with proven COVID-19 instances was Nursing Home Pezinok, which opened its doors for patients in April 2020. (Domov v Pezinku). More than 60 senior citizens were tested, and 16 of them died as a result. There were also 27 people who tested positive, but none of them died as a result of the test. A crisis manager has taken over as director of the company.

A 15-year term is expected to be handed down to the current Chairman of State Material Reserves, who is presently serving a 15-year sentence in jail for managing bids for the procurement of medical items such as respirators [5]. He is accused of causing the state up to five million euros in harm and receiving bribes of 220 680.

II. THE SHIELD CALL

Founded in 2015, the SPy (Slovak Python User Group) aims to educate the public about the Python programming language, educational technologies, and open-source resources. In our opinion, [6]: PyCon SK and regular Bratislava Python meetups, the We Teach with Hardware project aimed at increasing digital skills, an EduSummit section at PyCon and the SPy Cup competition, and the Open Education community by publishing openly licenced materials and spreading awareness about open education among teachers are all examples of our efforts to serve the Python and education communities.We have to postpone PyCon 2020 as a result.

This was a terrible time, and we wanted to be a part of the solution. Although no instances of COVID-19 had been found in Slovakian nursing homes at the time, we had read about coronavirus cases in other countries, notably Spain. The death toll among the elderly was consistently high. In the following months, investigators made even more horrific findings, such as the discovery of two dozen murders at a single nursing home in Madrid. 24 people have been confirmed dead in a Madrid nursing facility that was cleaned by the army on Sunday, according to local media reports. The average age of the people who died in Spain was above 65 percent.

[7]. At the time, Slovakia had volunteers who printed 3D face shields, such as those from the Department of Informatics at Constantine The Philosopher University in Nitra or the Faculty of Management Science and Informatics at the University of [8, 9]. Many of the volunteers chose to work at medical facilities. We couldn't find anybody in Slovakia who helps nursing homes when we did a search. As a result, we have made the executive decision to begin producing 3D face shields for nursing homes right now! We had previously printed face shields for physicians at that point, and they provided us with great input on how to make the design even better.

To be clear, we did not endorse the use of a face shield in isolation. A face shield by itself does not provide enough protection, as has been shown in earlier studies. When compared to just donning face masks, however, wearing a face shield was shown to be more effective [10]. When caring for the elderly in nursing facilities, nurses are unable to maintain the necessary 2 metre social distance. Face shields may help minimise transmission, according to some physicians [11]. When a person sneezes or coughs, the face shield is designed to reduce the distance the aerosol travels, so reducing the danger of spreading the illness to people around. In addition, wearing a face shield may reduce the likelihood of the wearer touching his or her face with dirty, unwashed hands.

TABLE I SUITABILITY OF USING FACE SHIELD IN NURSING HOMES

ISSN- 2394-5125 VOL 08, ISSUE 02,

Attributes of face shield	Occurrence in nursing homes
Suitable as an additional stuff while wearing a face mask	Yes
Sneezing or coughing (large particles)	Yes
Touching relatively contaminated objects	Yes

In order to pay the cost of materials and provide face shields to nursing homes for free, we have sought for grant money in different grant programmes. Both the Orange and the Henkel grant programmes were awarded to us. For the first wave of the epidemic, we've opted to use a courier service to get the face shields out to as many people as possible while still keeping ourselves safe. Grant funds also covered the cost of courier services. Our goal of producing 500 face shields was finally accomplished.

With people from all around Slovakia, we wanted to be a resource for anybody in need, no matter where they lived inside the country. For lack of Slovak nursing facility contacts, we created a scraper in Python to collect data in the form of nursing home email addresses. Other national entities (such as municipal councils and regional governments) were also on our list because we believed they could know someone who might help us locate local nursing facilities.

How many personnel (nurses) were in each team?

How many seniors?

How many face shields were requested?

We couldn't foresee how many nursing facilities would respond to the questionnaire.

Every nursing facility was required to have a crisis team in place in case of an emergency. Isolated or COVID-19 seniors at a nursing home were cared for by a group of nurses. We got 93 forms with a total of 1841 face shield requests.

This country is also split into three primary areas based on location: Western (BA), Central (BB), and Eastern (PO). There were fewer applications and requests for face shields in Eastern Slovakia due to the fact that many nursing facilities lack websites or email addresses. A phone call was made to them, but the number of applications in Slovakia was still low in contrast. When compared to Western Slovakia or the Middle Slovakia, Eastern Slovakia is by far the most impoverished area.

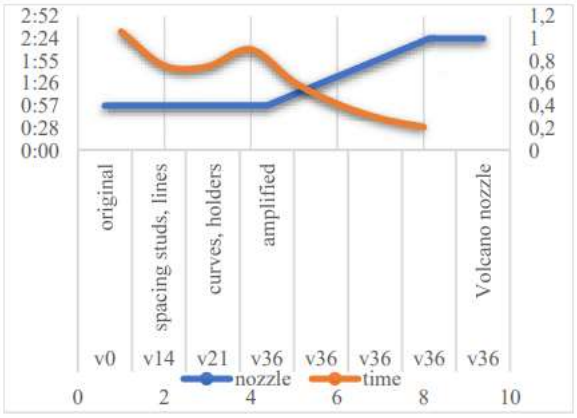

Figure 3 Face shield optimization

III. METHODOLOGY

In order to print and optimise our 3D printers for the Shield grant, we had to choose or design a model of a face shield.

ISSN- 2394-5125 VOL 08, ISSUE 02,

A. Modelling the Face Shield

Many of the models we looked at for printing didn't enable us to wear glasses or goggles with a face shield while we tested them on ourselves. First and foremost, there was this. Screwless models were very popular due to the ease with which they could be assembled.

In the beginning, we used Prusa RC2, which we eventually upgraded to RC3. It has fulfilled both of our requirements. Quality and speed of printing were two areas where we hoped to improve the product. We began by focusing on the product's quality. The side plastics of the Prusa model sometimes snapped and the studs were spaced irregularly. To accommodate the use of goggles, we shifted the front portion (which houses the studs) forward. After moving and increasing the portion where rubber is fitted, we also reworked the overall design. We designed a holder for the PET-G sheet's tail end. A new feature was the curvature of the side front, which connected to the rear. The primary portions of the front and rear were connected in more locations. In order to maintain the standard spacing, the studs were shifted. Finally, we came up with 36 alternative variations of the same design.

B. Prusa i3MK3

When the Prusa i3MK3 printer's printing speed was first increased, the nozzle size could be increased from 0.4 mm to 0.6 mm, then to 0.8 mm, and eventually to 1 mm.

Aside from expanding the breadth of the print, the larger nozzle also increased the height of one printed layer, which reduced the number of nozzle transitions required. Increases in printing speed were made feasible because to this change. (With a mainline print width of 2.4 mm, the number of transitions needed were as follows: - 6 transitions for 0.4 mm nozzle, - 4 transitions for 0.6 mm nozzle, - 3 transitions for 0.8 mm nozzle, - 2 transitions for 1 mm nozzle.)

Despite the fact that this adjustment doubled printing speed, the filament did not have enough time to overheat. Step skipping and printing errors were caused mostly by overheating the extruder's stepper motor. This necessitated the use of a separate fan to cool this engine. We were also able to raise the temperature of the nozzle to 250 degrees, but we ran into the limitations of the PTFE tube, which degrades and becomes hazardous at this temperature. We were able to aid in this instance by switching out the PTFE tube with PTFE Capricorn, which can withstand temperatures up to 300 degrees.

C. Creality ENDER-3-PRO

In light of the demand for face shields, we decided to purchase and customise an Ender 3 Pro 3D printer. Due to its low cost, additional changes were required; nevertheless, this printer also allowed for a greater amount of customization.

Although the Bowden tube approach proved unsuccessful, the whole extruder system was modified to the Direct Drive method for incredibly rapid printing. The slider mechanism, which used just one driving wheel to move the filament, was also found to be unreliable, resulting in filament jamming on a regular basis. We chose to employ the Bondtech BMG extruder system since it used two driving wheels to move the filament and also conveyed it in a 3:1 ratio (Fig. 4). It was also able to employ a less powerful stepper motor because of this gearbox. The ability to swap the X-axis and extruder motors was excellent in this case. With the Direct Drive technology, the extruder's weight and inertial forces have been lowered, but the X-axis motor power needed has risen. As the extruder weighed more, the Z-axis lift was moved to the right side of the gear wheel shift from the original stepper motor on the left, owing to the increased weight. Additionally, a substantial improvement was made to the design of the extruder stepper motor, which resulted in reduced wear on the guide carriage, as well as increased printing accuracy at higher speeds, compared to solutions published on the Internet.

ISSN- 2394-5125 VOL 08, ISSUE 02,

Figure 4 Bondtech BMG extruder system

E3D's hotend system, which is more widely used and has a greater choice of accessories, was also replaced with the BMG extruder.. Due to the increased temperatures, the Capricorn tube was utilised in this modification, as well as in the Prusa printer modification. Extruder stepper motor cooling was essential even in this situation. It turned out that switching to more dependable and even quieter Noctua fans was a good idea for fixing printer problems that cropped up when the printer was running continuously. Despite the fact that it had no effect on print speed, this source-side change made the office considerably more peaceful.

To boost print speed after making all of these modifications, inadequate nozzle heating time was the main stumbling block. The Volcano nozzle from E3D was able to be used with a heating cube because of a prior printer modification to the E3D system (Fig. 5). This adjustment allowed the filament to remain in the nozzle for a longer period of time, resulting in a better and quicker transmission of heat from the heating cube to the filament.

This change dramatically raised the filament heating rate limit and enabled for an even faster print speed to be achieved once it was made.

Figure 5 E3D Volcano

D. Constructing Face Shields

This is why we choose with PETG for printing a face shield - it offers a noteworthy tensile toughness, flexibility and good processability [12]. After that, we had to clean and warm up the surface so that the connections between the layers would be stronger. Foam cushioning for comfort was added and a perforated (adjustable) rubber band was connected to the shield after this step. Finally, we attached the Polycasa HIPEX PETG translucent shield. In spite of being twisted and bent, it remains robust and translucent. Even at lesser thicknesses, it possesses a high level of impact resistance.

IV. CONCLUSION

One thousand face shields were printed by the SPy civic organisation and distributed to nursing homes in Slovakia. We arranged a programme in which nursing homes filled out an application for a face shield requirement thanks to Slovenku and Accenture. With 93 applications and 1941 needed face shields, we were able to start the process.

Based on the Prusa RC2 face shield model, we were able to develop our own face shield model thanks to input from healthcare workers. We produced 36 different iterations, each with a different set of studs, stud spacing, Polycasa PETG holders, and the curves that joined the various components together. Prusa i3MK3

and Creality ENDER-3-Pro 3D printers were also fine-tuned for improved printing. We were able to manufacture an amplified face shield in 30 minutes thanks to model and printer optimizations. In the end, we distributed 1000 face shields to 93 care facilities.

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