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IoE APPLICATIONS TO FIGHT AGAINST PANDEMICS: 3D PRINTING AIDING IN SUSTAINABLE TECHNOLOGY

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ABSTRACT

Internet of Things (IoT) refers to those machines over which your company has entire authority. The data received is owned by the company; activities can be stimulated by data-driven decisions to command IoT systems to perform specific steps. The Internet of EveryThings (IoE) is an extension of the IoT. It would include all machines that are not under the control of an organisation but are either trying to present valuable information to the business or are virtually impossible to prevent from sending information across the company's network. IoE and 3D printing are two significant emerging innovations that are increasingly impacting many sectors and our daily lives. 3D printing is used in many different fields, and it can be used in the front lines facing emergencies, for example, the last and most urgent one is the spread of the outbreak virus. With the spread of Coronavirus, the world has been divided using quarantine in several countries, meaning that health services have been unable to provide emergency treatment. 3D printers or Additive Manufacturing (AM) suffer from a high error rate, small product sizes, difficulty tracking, process enforcement, and abrupt current cut-off failing print; the loss of time, 3D printers are still costly, effort and content. Industry 4.0 is transforming the supply chain more and more, thus improving technology's sustainable growth. This paper addresses these problems by using certain features such as Uninterruptible Power Supply (UPS) to avoid the printing process failure, larger frame size helps to provide maximum remote control and monitoring for the printer while printing larger items, websites, and smartphones. The methods and algorithms of connecting a 3D printer with an IoE application are recorded, and the configuration and workflow for the IoE application will be provided in the results section. Incorporating more features such as a camera for the monitoring printing process, mobile application, UPS circuit, full remote control, and website monitoring, low cost, we expect to take the 3D printers to the next generation. It became evident that this technology would significantly contribute to fighting against this epidemic and has benefited society and health and related field specialists.

Keywords: IoT, IoE, 3D printers' technology, additive manufacturing, mobile application, sustainable technology.

1. INTRODUCTION

In the 1980s, the use of 3D printers was initiated, as they were able to trace a pattern submerged in a liquid polymer by using computers [1]. Thanks to the laser, the traced pattern hardened into a sheet, and that's how you made an item out of plastic. Since then, considerable progress has been made in the manufacture of additives so that material extrusion is now being used. By this process, an object is made of matter forced out of a mechanical head, like the way an inkjet printer extrudes ink against paper [2]. There are many sectors and fields such as industrial design, manufacturing, medical and architectural engineering, aerospace, cars, dentistry, medical devices, geographic information systems, and many more that need a fast, accurate, and effective solution to produce what you need. For this, a 3D printer was found [3], [4].

Conventional subtractive manufacturing, 3D printing, or additive manufacturing may create complex structures that are impossible and give manufacturers much more versatility when designing their products. They can not only render more complicated components; they can use less material at the same time. A piece must be sculpted from more material than it takes to create the part, eventually shaving or drilling away material to get to the finished piece with conventional subtractive manufacturing [4].

The IoT and 3D printers are two of the latest innovations that impact many aspects of life and industry. The basic idea of the Internet of Things is that connecting every computer to the internet, other devices, and connected people begins to share the data they use, how they are used, and the world around them. [5], [6], and [7].

The IoE, as according Cisco, is "the networked connection of individuals, processes, data, and things, as shown in Figure-1, and the benefit incurred that takes place as 'everything' needs to join the network." So many technological transformations are combining to enable IoE, such as the Internet of Things, increased mobility, the formation of cloud computing, and the increasing significance of large datasets, among many others [8], [9].

IoE, such as IoT, has applications for several regular tasks in houses, industry, and so on. However, the appropriate approach is dominant in the practical application of IoE's available [10]:

a) Sensor network security

b) Data mining

c) Applications in different fields

d) The industrial environment.

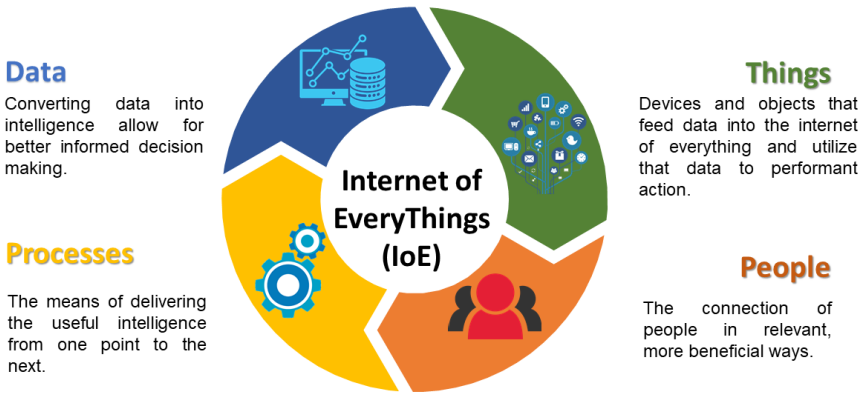


Figure-1. IoE concept representation.

Likely, intelligent materials' fast-growing production will eventually allow part of the cloud-based decision-making burden of IoE to be shared by spreading decision-making and action-making activities locally through interconnected sensors and actuators. This will make it possible to make more effective use of cloud services in the organization of other relevant integration operations, with a large number of smart objects projected to exceed a trillion [11], [12], and [13].

Manufacturers seek to become more competitive and need to reduce their waste while consuming fewer resources simultaneously [14]. All these issues are addressed by 3D printing. Until it is ready to be sold, there are still some processing criteria for a finished 3D printed part, but several more steps can be avoided using additive manufacturing. 3D printing is an incredible instrument that can be used by producers to help them become more sustainable.

The problems statement of this research could be summarized as the following:

- The difficulty of monitoring and keeping up with the process,
- Not being able to organize print queues,
- Sudden current cut-off leads to printing failure, losing more time, effort, and material,
- The need to always be close to the 3D printer for checking up on any surprising events,
- Temperature fluctuations during production could lead to a lot of problems.

The 3D printer has been developed in this research on the participation of the masses in the innovation and development procedure during the manufacturing progression, where individuals and industrial groups can participate in the design and manufacture of products and development until they reach the final products while reducing obstacles to innovation in complex and challenging products such as complicated order processes, waiting times and accelerate product production. It also removes distance and geographical barriers between the employees involved in the product's design and development process and those involved in printing it to achieve production efficiency and reduce waste.

The principal contributions of this research adding special features could be summarized as the following:

- At first, website monitoring and control interface.
- 3D printing store.
- Web-based monitoring and control system.
- 3D printing order management system.
- Compatible and extendable.
- Organize print queues.
- The user is ready to click and print models.
- Second, Mobile application
- Create and review orders.
- Document your prints.
- Capture the printing process through live stream.
- Keep you up with your work from anywhere.
- Linked to the website.
- Provides AR feature.
- Thirdly, Low cost
- Finally, UPS (Uninterruptible Power Supply).

The paper is organized as follows: Applications and social impact is presented in Section 2. Section 3 introduces the proposed system design and implementation,

and section 4 discusses the results and discussion. Finally, the conclusion is discussed in the last section.

2. APPLICATIONS AND SOCIAL IMPACT

2.1 3D printing in Action

As a pandemic, the current virus spreads worldwide; we see countries adopting travel bans, social distancing initiatives, and home-policy work. Many more developing countries are finding their healthcare services overwhelmed and exhausted from COVID-19, as shown in Figure-2.

2.1.1 Examples of initiatives and projects helping to fight the pandemic

- 3D printed valves are used to rescue patients with COVID-19 in Italy [15], [16]. As shown in Figure-2(a).
- Manufacture of an attachment for the door handle without hands, as shown in Figure 2-(b). This is so that viruses and microbes are not transmitted to the palm and thus to a person [17].
- China is deploying the emergency, as shown in Figure-2(c).
- 3D printing allowed drones to battle COVID-19 [18]. As shown in Figure-2(d).
- Ten thousand face shields printed by Prusa Research 3D, as shown in Figure-2(e). [19].
- CIIRC RP95 is a reusable 3D prinTable, FFP3-certified safety half-mask [20] as shown in Figure-2(f).
- Materialise creates a 3D printed oxygen mask for PEEP [21]. As shown in Figure-2(g, h).
- 3D Technologies and Veterans Health Administrator create a 3D printed stopgap mask, as seen in Figure-2 (i, j). The SFM consists of a 3d printed mask and filter cover, two elastic strips and a rectangular filter material patch. [22].
- Holder of 3D printed hand sanitizer. It also serves as a daily reminder of good grooming practice at such a crucial period, as shown in Figure-2(k).

2.2 The Proposed 3D Printer Contribution in Fighting Pandemic Spread

In the pursuit of helping to prevent this virus from spreading, the proposed 3D printer had a vital role in creating many useful tools that would allow citizens to be safer when going out. Also, we tried to simplify them having to wear a mask giving the non-comfort situations resulting from wearing a mask, especially in such hot temperatures like our region. Here are some examples as shown in Figure-3.

3. PROPOSED 3D PRINTER

At the beginning of the 21st century, when smaller and more powerful engines were developed. Hardware and software were increasingly sophisticated, in addition to the prospect of digitally interconnecting ordinary objects using the Internet - also known as IoT - the industry started a transition that had a direct effect on culture, economy, and productivity, Schwab's [23]. This study was carried in February 2020, in the Faculty of Engineering of the Delta University for Science and Technology (DU), located in Gamasa, in the state of Eldakahlya, Egypt. The proposed 3D printer development is followed in Figure-4, and the proposed 3D printer design is shown in Figure-5.

3.1 Proposed 3D Printer Hardware

Industry 4.0 has a strong effect on the supply chain and directly impacts sustainable technology growth. Ok, according to L. Agostini *et al*. [24], 3D printing is one of the developments that, before 2025, should generate new market opportunities, prototyping 3D structures and objects, using more sophisticated materials, and consolidating prototyping in various sectors and not only in manufacturing, such as health, agribusiness, household use, etc.

3.1.1 Hardware's electronics components

The proposed 3D printer consists of electrical and electronic components. The electronic and electrical components used in the proposed 3D printer will be illustrated in Table-1.

3.1.2 Hardware's mechanical components

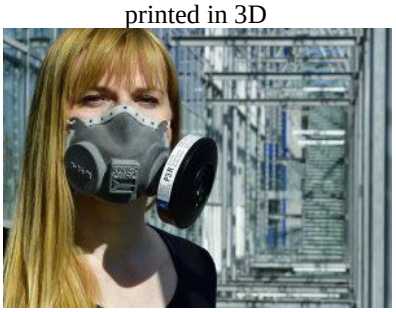
The mechanical components used in the proposed 3D printer will be illustrated in Table-2.

(a) 3D-printed valves for coronavirus patients at a hospital

(b) Hands-free door handle attachment printed in 3D

(c) The Hawk Eye drone utilizes 3D printing technologies from Farsoon

(d) 3D printed face shields

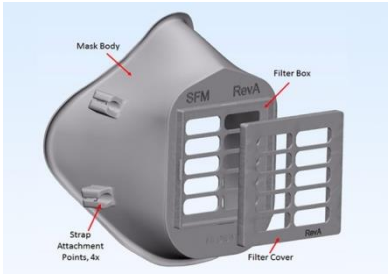


(e) The Materialise 3D printed noninvasive PEEP mask

(f) The 3D printed NIP solution

(g) The Materialise 3D printed noninvasive PEEP mask

(h) The 3D printed NIP solution



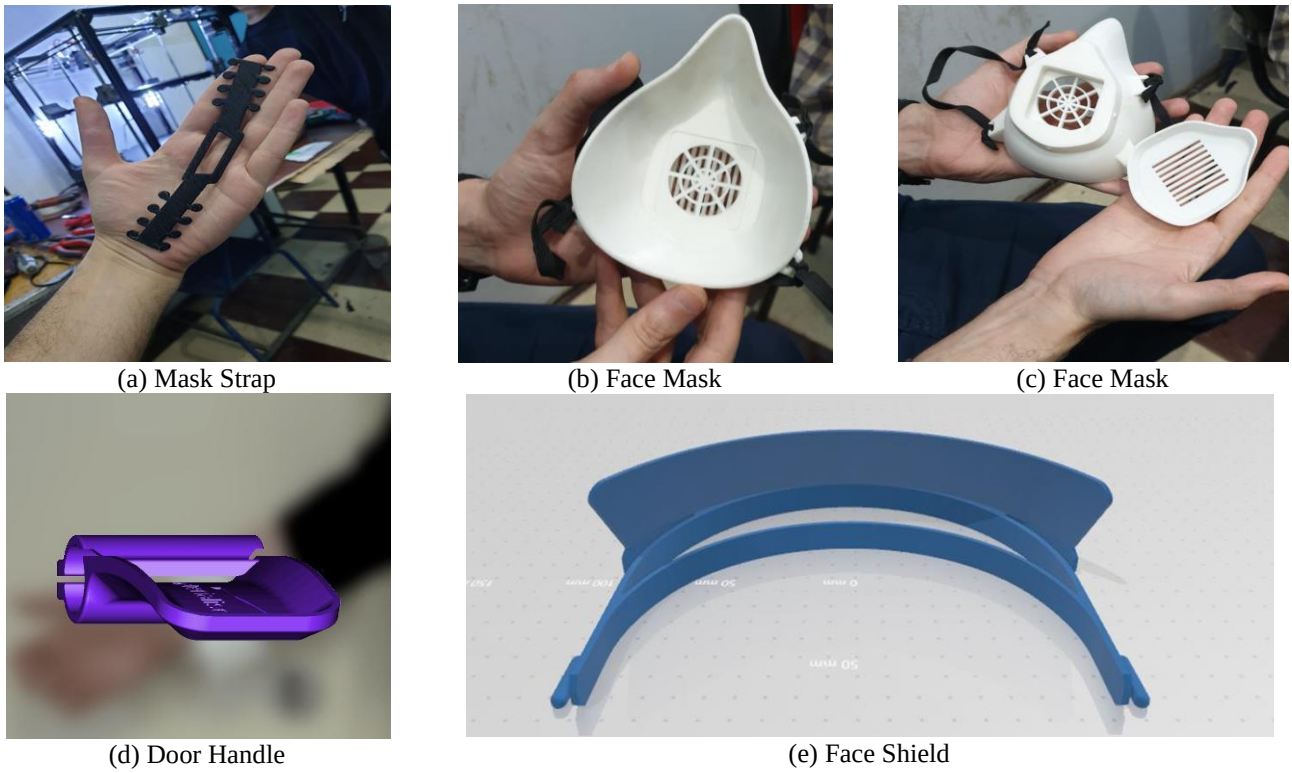
(i) The Materialise 3D printed noninvasive PEEP mask

(j) The 3D printed NIP solution

(k) 3D Printed Hand Sanitizer Clasp

(l) Automatic Hand Sanitizer

Figure-2. (a, b, c, d, e, f, g, e, h, i, j, k and l): Examples of initiatives and product helping fighting the chest infection(s) pandemic.



(a) Mask Strap (b) Face Mask (c) Face Mask

(d) Door Handle (e) Face Shield

Figure-3. (a, b, c, d, and e): The Propose 3D printer contribution.

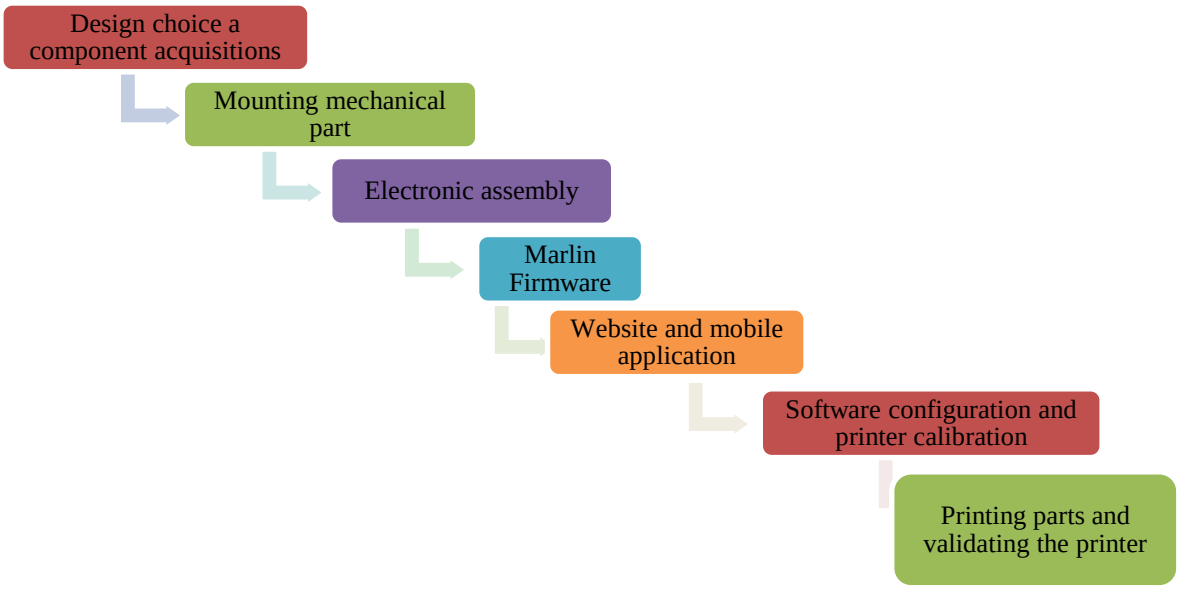


Figure-4. Proposed 3D printer architecture.

Table-1. The proposed 3D printer hardware's electrical components.

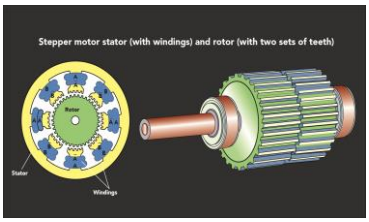
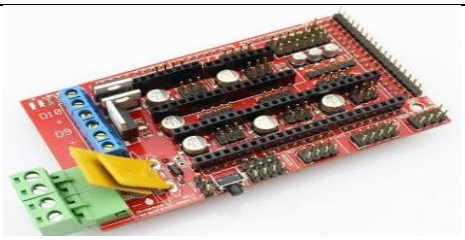
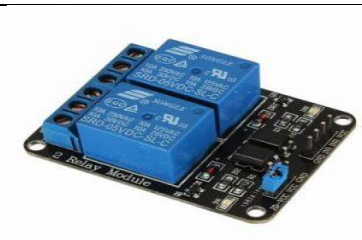
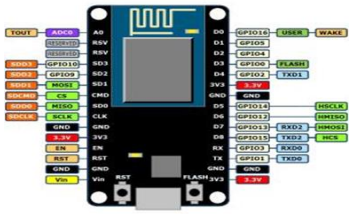
 Stepper Motors	 Arduino Mega	 RAMPS RepRap Shield for Arduino Mega
 Power Supply	 MK8 Extruder	 V6 HotEnd
 PCB Heat-bed	 Limit Switch Module	 LCD Module
 5V 2 Channel Relay Module Shield	 NodeMCU (CH340)	 Raspberry Pi Zero W V1.1

Figure-5. Proposed 3D printer design.

3.1.3 Uninterruptable power supply (UPS)

If the device senses a lack of power from the primary source, it requires a 'kick-in' charger. If the end-user is running on the computer when the UPS notifies the power failure before the secondary power supply (battery) runs out, they have time to conserve whatever data they are working on and off. The data in your device's Random-Access Memory (RAM) is erased as all the power runs out. If power flows occur, the UPS intercepts the flow so that, as shown in Figure 6, it does not damage the system.

3.2 Proposed 3D Printer Software

3.2.1 3D Printer firmware

Firmware is a bridge between hardware and software for computing devices. The firmware interprets

and transforms the software commands into a type that the hardware detectable as the software sends commands to the computing device's hardware. In our case, the firmware converts G-code commands into simple

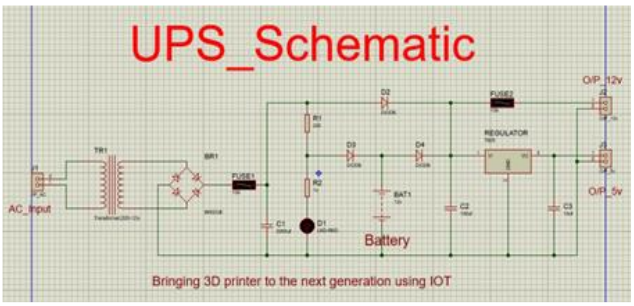


Figure-6. UPS schematic.

electrical signals transmitted to the motors, heaters, fans, and other components of the 3D printer when you're 3D printer software (such as Repetier Host, Cura, or OctoPrint) sends G-code to your 3D printer.

3.2.1.1 Marlin firmware

Marlin started as the descendants of two more firmware, the sprinter and the grbl. It has been under constant production since then and is used in a wide range of 3D printers worldwide. One drawback is that 32-bit logic controller boards are not compatible, which means that the Delta printer will not operate at the fastest speed for Marlin. Although the code is well documented, the number of features can initially make the configuration a little daunting.

Table-2. The proposed 3D printer hardware's mechanical components.

 V-Slot Aluminium 20mm x 20mm Linear Rail	 Linear Shaft, hard Chrome Plated	 Stainless Lead Screw with Nut
 Plum Flexible Duty Coupler	 Linear Motion Bearing LM8UU (8mm Dia)	 GT2 Timing Belt Black
 T-Nut for V-Aluminium Bar	 T-Nut drop for V-Slot Aluminium Bar	 Aluminium Corner Joint Bracket

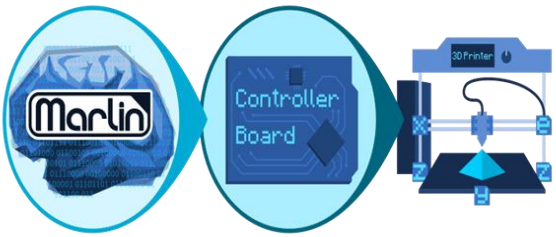


Figure-7. Marlin firmware.

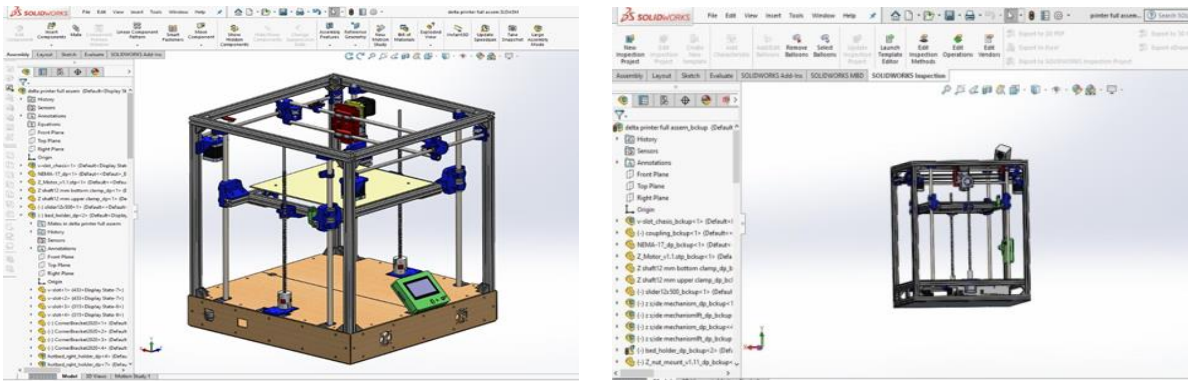
- Reasons for Choosing Marlin Firmware

Marlin is an open-source firmware with strong community support, one of the many keys to Marlin's popularity. It's a community-supported firmware on GitHub, so there are almost no bugs because they're easily patched. Another secret to Marline's success is that it runs on several 8-bit Atmel AVR low-cost microcontrollers. You will find these chips in the centre of the famous open-source Genuine/Arduino platforms.

3.2.2 Design building programs

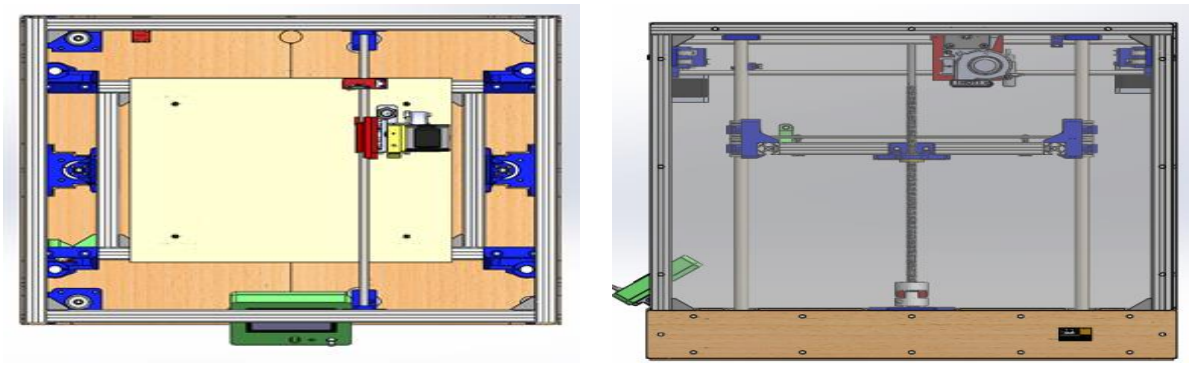
3.2.2.1 Solid works

Solid Works is a Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) computer modelling software that allows you to design 3-dimensional products. The technique is usually to draw 2D profiles and then use extrusion and lofting methods to create a solid form. We used the 2018 Solid Works Student License as the most sTable and standard version as seen in Figures (8, 9).



(a) (b)

Figure-8 (a, b): Solid Works Proposed 3D printer workspace.



(a) (b)

Figure-9. (a, b): SolidWorks Proposed 3D printer design.

3.2.2.2 Grab CAD

The Grab CAD Group is a place where engineers and designers worldwide can share their CAD models, learn from each other, and solve the world's challenges, as shown in Figure-10.

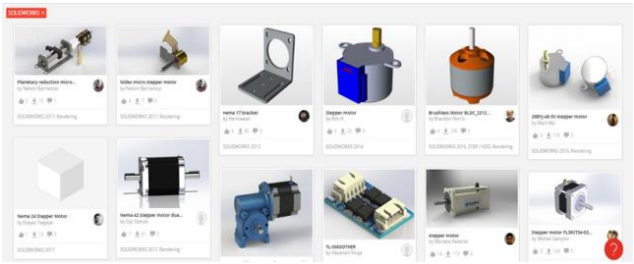


Figure-10. Grab CAD.

files. Cura is the largest slicer for 3D printing, and while the S3D is known to be the highest-rated slicer on the market, Ultimaker Cura ranks first in open source slicers.

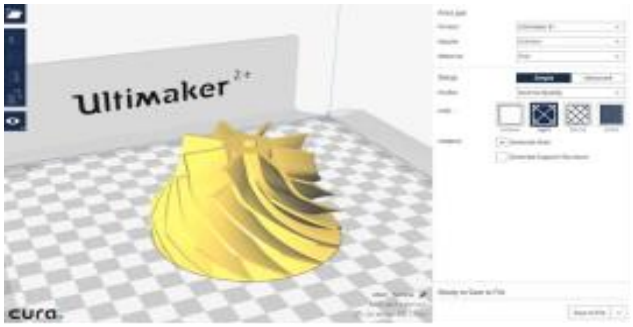


Figure-11. Cura.

3.2.2.3 Printing programs

- **Slicing**

The 3D printer prints layer by layer, so the 3D models are sliced into layers. The cutting algorithm is fundamental in the 3D printing process. The most common cutting technique is developing contour data from STL

- **Prusa slicer**

Slic3r Prusa Edition or Slic3r PE is a feature-rich and regularly modified open source slicing software based on the Slic3r project that contains everything you need to export the perfect print files to the original Prusa 3D printer as shown in Figure-12.

(a) (b)

Figure-12. (a, b): Prusa slicer's models.

4. RESULTS AND DISCUSSIONS

4.1 Data and Pricing Sheet of All Components

The total cost of the 3Dprinter proposed was approximately R$ 579.37, purchasing all the components on the national market, as shown in Table-3. When comparing the value of 3D printers similar to the proposed 3D printer, already installed in Brazil, would have cost R$ 1126.10 [25], it is observed that the project produced would have cost a little more than R$ 546 less if one prefers to buy a printer assembled and sold in Egypt. If the quantity of 3D printer components had been purchased on the international market, it would have cost a little more than R$ 546 less.

Table-3. Component of the proposed 3D printer.

Items	Used	Quantity
V-Slot aluminium 20mm x 20mm Linear Rail	**Aluminium rod V slot**	**4 sticks * 3 meters * 80 g / meter**
Power supply	-	1
Linear shaft hard Chrome plated 8mm & 12 mm	Hard Chrome shafts 8 & 12 mm	4
Heatbed	-	1
Linear motion bearing LM8UU (8mm Dia)	Rosary ball 8 mm	8
Linear motion bearing LM12UU (12mm Dia)	Rosary ball 12 mm	8
Plum flexible duty coupler	Kopplin for the Z movement	2
Stepper NEMA 17	Motor Estber Nema 17	4
Lead screw 8 mm	Screws 8 mm	2 length of 40 cm
Lead screw Nut	Brass nut	2
MK8 Extruder	MK8 Extruder	1
T-Nut for V-Slot Aluminium	T-Nut	180
Aluminium Corner Joint Bracket	Angle	44
GT2 Belt	Bios GT2	4
Aluminium plate 3 mm	Aluminium 3 mm thick	
3D Printed parts	3D printer printed material	1000 gm
Bolts	-	20
Arduino Mega	-	1
LCD Module	-	1
Ramps 1.4	-	1
Wires	-	7
Limit switch	-	3

Wood plank	-	1
Laser cutting	-	-
Acrylic	Transparent acrylic 50 * 50 Sides	3
Web camera	-	1
3D Printed parts for screen	-	105 gm
Power wires	-	1
Power switch	-	1
MosFET circuit	Rosetta power	2
Fans	-	2
PLA Filament Esun	-	1
Toothless Timing Pulley GT2	-	(8*30) + 60
LEDs	-	8
LEDs wires	-	2
5V 2 channel relay module shield	-	1
NodeMCU (ESP8266 Wi-Fi Programming & Development Kit) (CH340)	-	1
Raspberry Pi Zero W V1.1	-	1

4.2 Website and Mobile Application

4.2.1 Dynamic web application

If customers need 3d-print a model, they attach the model files to the owner or printer via email, social media, e.g., WhatsApp, or physically, so they need to fly to the owner via a USB flash drive as shown in Figures 13, 14.

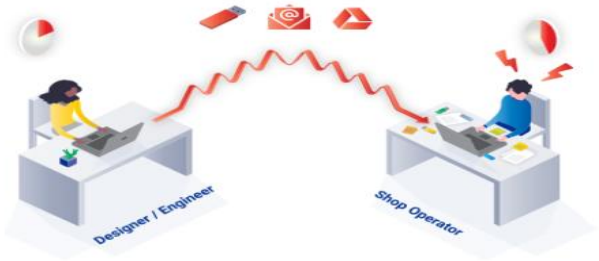


Figure-13. 3D printing store problems.

- **Store solution**

The store enhances your workflow, saves time and money, and increases efficiency with these features developed especially for 3D printing model shops.

Figure-14. Store solution.

- **Store Features**
  - Remote monitoring
  - Remote controlling
  - Manage work orders
  - Capture dates and estimates
  - Reduce time to print
  - Set print job expectations
  - Easy to use
  - Attach relevant job files
  - Always be up to date

4.2.2 Proposed 3D printer technology and tools

Several technical techniques have been used in the proposed 3d printer, and the creation and programming process consists of two main components: client-side, front-end, and back-end as shown in Figures [15-20].

- **Front-end development**
  - HTML

```
<div class="float-child2">
    <div class="form-group"><label>Model Name</label>
      <input class="form-control" placeholder="Enter name" type="text" name="model_name1" required="required" />
    </div>

    <div class="form-group"><label >Model Color</label>
      <input class="form-control" placeholder="Enter color" type="text" name="model_color1" required="required" />
    </div>

    <div class="form-group"><label >Model Material</label>
      <input class="form-control" placeholder="Enter Material" type="text" name="model_material1" required="required" />
    </div>

    <div class="form-group"><label >Quantity</label>
      <input class="form-control" placeholder="Enter Quantity" type="number" name="quantity1" required="required" />
    </div>

    <div class="form-group"><label >Needed_by</label>
      <input class="form-control" placeholder="Enter color" type="date" name="needed_by1" required="required" />
    </div>

    <div class="form-group"><label >Status</label>
      <input class="form-control" placeholder="Enter status" type="text" name="status1" required="required" />
    </div>
      <button class="btn btn-primary btn-lg" type="submit" value="Submit" >Submit Model</button>
  <br />
</div>
```

Figure-15. An HTML code snippet from the model upload page.

- CSS

```
.files input {
  outline: 2px dashed #92b0b3;
  outline-offset: -10px;
  -webkit-transition: outline-offset .15s ease-in-out, background-color .15s linear;
  transition: outline-offset .15s ease-in-out, background-color .15s linear;
  padding: 120px 0px 85px 35%;
  text-align: center !important;
  margin: 0;
  width: 100% !important;
}
.files input:focus{
  outline: 2px dashed #92b0b3;
  outline-offset: -10px;
  -webkit-transition: outline-offset .15s ease-in-out, background-color .15s linear;
  transition: outline-offset .15s ease-in-out, background-color .15s linear;
  border:1px solid #92b0b3;
}
```

Figure-16. CSS Script from the Orders Page.

- Bootstrap
- JavaScript

```
script.js
// Carousel Auto-Cycle
$(document).ready(function() {
  $('.carousel').carousel({
    interval: 6000
  })
});
```

Figure-17. JavaScript code from the upload page.

- 3D Model viewer

```
<body>
    <div id="target" class="madeleine"></div>
    <script>
    window.onload = function(){
        var madeleine = new Madeleine({
          target: 'target', // target div id
          data: './mask_strap.stl', // data path
          path: './src' // path to current html file
        });
    };
    </script>
</body>
```

Figure-18. Snippet of the js code used to implement Madeleine.js.

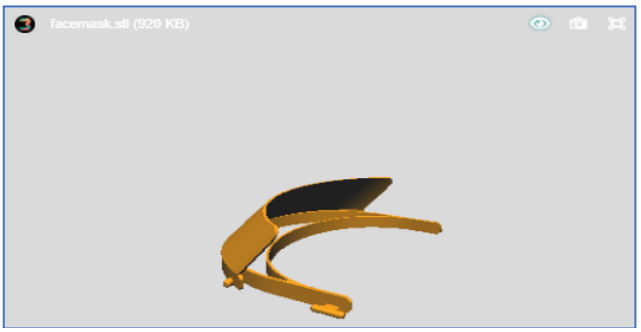


Figure-19. 3D view of facemask.stl file on our website.

- **Back-end development:**
- Subrion CMS
- MYSQL
- PHP

```
<?php
    $conn = mysqli_connect("localhost", "root", "", "store");
    // Check connection
    if ($conn->connect_error) {
    die("Connection failed: " . $conn->connect_error);
    }
    $sql = "SELECT * FROM orders";
    $result = $conn->query($sql);
    if ($result->num_rows > 0) {
    // output data of each row
    while($row = $result->fetch_assoc()) {
    echo "<tr> <td> <a href='{$row["filename"]}' target='_blank'>{$row["model_name"]}</a> </td> <td>
        {$row["model_color"]} </td> <td> {$row["model_material"]} </td> <td> {$row["quantity"]}
        </td> <td> {$row["needed_by"]}  </td> <td>{$row["status"]} </td> </tr>";
    }
    echo "</table>";
    } else { echo "0 results"; }
    $conn->close();
    ?>
```

Figure-20. The PHP Code that retrieves the Orders from the database.

4.2.3 Proposed 3D printer website pages

The website consists of multi pages as shown in Figures [26-30]. Firstly, the home page, which is the first page that the user has to face. It includes information about the project and what special features we will offer. There are also six other main pages, each of which has its functionality, design, and permission.

Figure-21. Website pages.

From Figure-21 above, the six pages are:

a) **Stores page:** to submit your model files to the store owner.

b) **Monitoring and control page:** control and Live view of the printer.

c) **COVID-19 page:** 3d models to protect against the COVID-19 pandemic.

d) **About page:** information about the team members and the supervisors.

e) **Orders page:** to view the submitted and received orders.

f) **Access page:** Login and signup pages.

- **Stores page:**

One of the unique features we build is the Stores section. Any 3d printer owner can contact us and create a new block as an online shop.

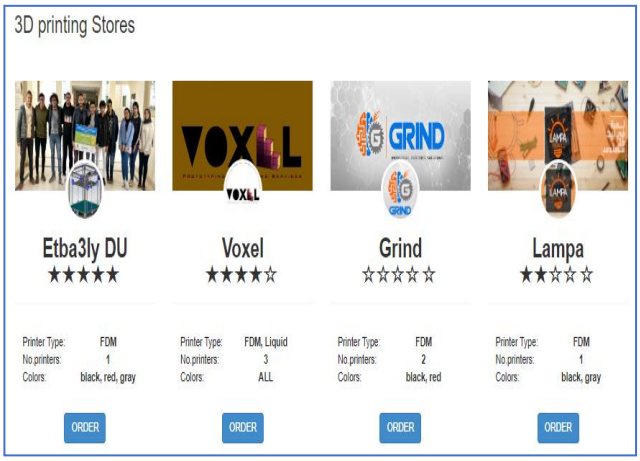


Figure-22. 3D Printing stores.

- **Monitoring and control page**

This page allows the owner of the store and the printer to track and control the printer in real-time via IoE using the hardware we have connected to:

- Raspberry pi: It is the mind and processor of the monitoring process, on which the streaming software server is also installed.
- Nodemcu esp8266: Contains a web server with control commands from the user via the web page of the control.
- USB web camera: Mounted on the Printer and Connected directly to the Raspberry pi board.
- Relay module: Mounted inside the printer button and attached to the Nodemcu module controls the power transferred to the power supply.

We can divide this main page into two blocks:

a) The live stream monitoring block

b) The Power Control Block

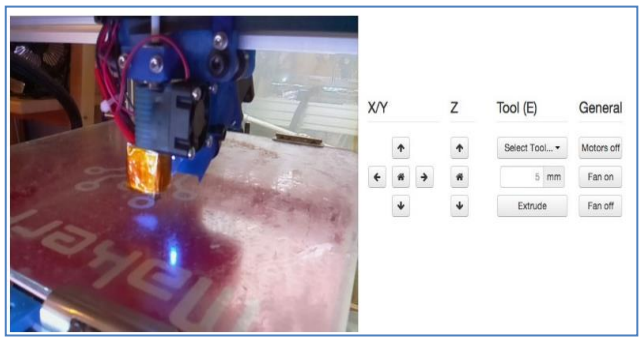


Figure-23. Monitoring and control panel.

A. Live stream monitoring

We've installed a USB web camera on one of the printer corners to get a large view angle, so there's no need to search for progress or errors physically.

We used Motion to stream live video from a webcam to the webpage. Motion is a highly configurable application that tracks video signals from many camera types. We mounted it on the Raspberry-pi board and then changed its configuration file to suit the iframe website.

Figure-24. Live stream monitoring.

B. Web-based power controlling

Controlling the printer power from the website and the printer - powered by a physical switch - at the same time was not a big deal for us. We used the "Nodemcu esp8266" WIFI Module in Station (STA) mode, which means that the board connects to a Wi-Fi network and acts as a server that contains our built webpage, and then connects it to the Relay Module with a custom link as shown:

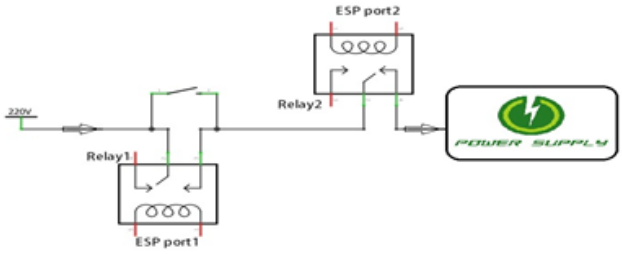


Figure-25. Relay Module controls the source power.

- **COVID-19 page**

After the COVID-19 pandemic, we reacted quickly and developed a new section from which anyone can download or order 3d printed models that can be used to defend against the coronavirus.

Figure-26. Ready to print models.

- **About page**

The About page includes information about our job, what we have done, bosses, team members, and a contact form, so a user needs to contact us just fill out the form and submit an email easily.

Figure-27. Top of about page.

- **Orders page**

Users can easily upload the model via this tab, select the model file, fill in the appropriate model details, and then click submit.

Figure-28. Order submit a form.

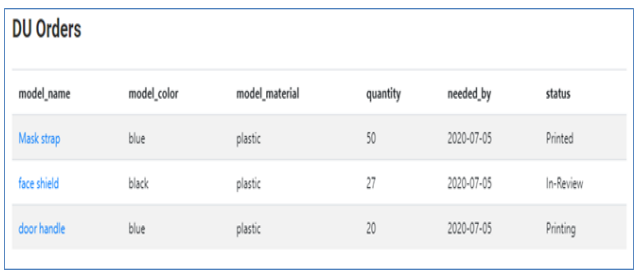


Figure-29. DU received orders Table.

After the customer uploads the model files, there must be a page where the customer and the store administrator can access and monitor the orders to link the Table to the database. The submitted data can be retrieved from the user.

- **Access page**

The access page includes the username and authentication forms such that the first-page user needs to pass to access the privileged sites.

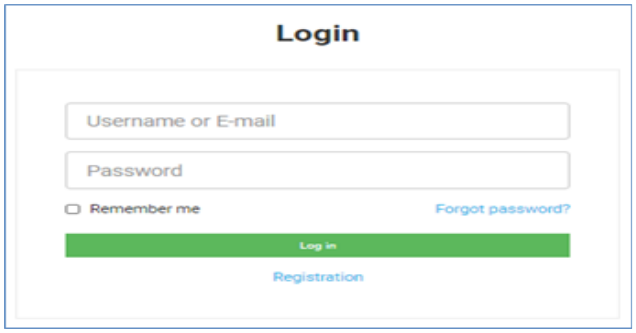


Figure-30. Login and registration box.

- **Proposed 3D printer website permissions**

Our website has four main permissions, as follows:

a) Admin

b) Store Owner

c) Customer

d) Visitor

Each page appears to the user depends on these permissions given by the Admin. But there are Usergroups in which is more detailed permission policy contains six permissions, and it increases as we add more stores and pages as follows:

- Administrators: is the highest privilege at the website and have access to all the pages' source code, database, users' permissions, and the website development.
- Moderators: It has access to the customers' orders and has access to the printer monitoring and control page.
- Guests: anyone who hasn't logged in yet, so no access to view the orders or submit an order, or even monitoring the printer.
- Registered: can make an order, upload the model files, view the made demands, and monitor its progress.
- Store owners: any store managers have access to store orders, and the printers, Admin, or moderator manages the stores' permissions and pages.

- **Proposed 3D printer augmented reality**

Augmented Reality (AR) is a technology that makes it possible to apply overlay content to the real world. It can be supported for many types of devices: handle held (like cell phones), headphones, laptop displays, and so on.

To manage held devices (more commonly for video-see-through devices), the 'reality' is taken from one or more cameras and then projected on the device monitor, adding some kind of content to the Augmented Reality Application.

- **AR.js**

AR.js is a lightweight web-based Augmented Reality library featuring features such as Image Tracking, Position-Based AR, and Marker Tracking.

Marker Tracking: When the camera identifies a marker, any content can be shown. Markers are very sTable but limited in type, color, and scale.

```
<script src="https://aframe.io/releases/0.9.0/aframe.min.js"></script>
<script src="https://cdn.rawgit.com/jeromeetienne/AR.js/1.6.2/aframe/build/aframe-ar.js"></script>

<body style='margin : 0px; overflow: hidden;'>
<a-scene embedded arjs='sourceType: webcam; debugUIEnabled: false;'>

    <a-marker type='pattern' patternUrl='https://etb3ly.github.io/ar/pattern-qrc.patt'>
    <a-entity obj-model="obj: url(https://etb3ly.github.io/ar/model.obj)>

</a-entity>
</a-marker>
<a-entity camera></a-entity>
</a-scene>
</body>
```

Figure-31. AR.js used code.

4.2.4 SWOT analysis of the proposed 3D printing

3D printing has been praised as a catalyst for the next manufacturing market. Revolution is seen as having the potential to move manufacturing to a more local level- from industrial production to customized products.

Figure-32 below summarizes the non-environmental strengths (S) and weaknesses (W), opportunities (O), and threats (T) associated with 3D printing (environmental concerns are discussed in the following section).

5. CONCLUSION AND FUTURE WORK

The 3D printing industry is set to follow developments as shown by growth forecasts. Applications for 3D printing are increasing as more and more research is carried out. 3D printing is going to change the way people buy products. The sector is undoubtedly a game-changer with plenty of opportunities to watch out for Fused Deposition Modelling (FDM) is a less costly process than any other 3D printing form. This makes it perfect for use at home. The level of precision and surface finish it offers is worth the cost of production. However, the materials sponsored by FDM are mainly confined to thermoplastics.

The experimental printing process with ABS material for precision printing in geometric dimensions ensures that the system complies with the technical requirements. Some ABS plastic parts mounted on a 3D FDM printer have been printed to replace such metal parts. Optimum printing parameters to ensure product consistency for various plastics will be used for further study. By adding features such as mobile camera tracking, UPS circuit, and full remote control and monitoring website, we expect to take 3D printers to the next generation. In future work, we will enhance the proposed to print the nano dimension to develop 3D printed.

Figure-32. SWOT study of the proposed 3D printing compared to conventional mass production.

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