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# FDM 3D Printer based on Raspberry Pi

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## Abstract

3D objects are produced utilizing the additive manufacturing technique with the aid of computer-aided design software. A few of the techniques that are available in 3D printing technology include the Fused Deposition Method (FDM), Selective Laser Sintering (SLS), Multi Jet Fusion (MJF), Stereolithography Laser Printers (SL), and Digital Light Processing (DLP). In this effort, we have focused on the design and production of a 500 x 500 x 520 mm3 3D printer that is reasonably priced. We employ four-axis mechanisms, one of which is an extruder, three of which are x, y, and z. High Impact Polystyrene (HIPS), Acrylonitrile Butadiene Styrene (ABS), and Polylactic Acid (PLA) are just some of the materials used in the FDM technology that we employ. The filament material is heated until melting, then deposited as one layer at a time. The layers are combined together to form a final 3D model. In this paper, Raspberry Pi is integrated with the 3D printer to improve its usability and convenience. Also, using of Raspberry Pi will enhance the overall functionality such as wireless networking, remote control, and using a sophisticated software. Therefore, the Raspberry Pi can be considered the machine's core control system.

## Keywords

FDM, Raspberry Pi, PLA, Arduino, MJF.

## 1. Introduction

Multiple layers of material are used during the process of additive manufacturing, which creates 3D components and things. It might also be referred to as quick prototyping. 3D items are swiftly created in accordance with the needed size using a machine connected to a computer that contains blueprints for anything. [1] Other additive manufacturing techniques such as stereolithography (SL), fused deposition modelling (FDM), and others are also covered. 3D printing is also known as desktop fabrication. A physical product can be created from a 3D design using a process called fast prototyping. We shall leave the mass production lines of Henry Ford's age behind and embrace a new era of specialized, one-off manufacture with the aid of 3D printing, also known as additive manufacturing. A CAD model is used by a 3D printing device for fast prototyping [1]. Recent years have seen a steady stream of news about 3D printing. For instance, engineers use 3D printers to create automobiles. 3D printers are used by doctors to produce human skeletons. Someone is creating actual living rooms using a 3D printer [2, 3]. Rumour has it that the US has also sent a 3D printer to the orbiting International Space Station. Nobody could have foreseen the development and importance of 3D printers [3]. When we create a 3D model of an object in our CAD system, we then use the FDM method to recreate it as a physical 3D object by adding layers of material until the object is constructed. The additive procedure can differ from the subtractive process, which entails drilling or cutting away material from a block. The primary goals of 3D printing are to enhance resource consumption, lengthen product lifespan, and create lighter, stronger objects [4]. The 3D printing process consists of three steps: modelling, printing, and finishing [5]. A few of the various areas where 3D printing has applications and uses include education, clothing, construction, dentistry, medical, and domestic use [2-6]. The advantages of 3D printing are the superior model quality and high printer resolution. 3D printers are speedier, more economical, and easier to use than previous industrial technologies. The use of 3D printers enables the production of complex, large, protruding, and overlapping pieces [7]. There are a variety of mechanical and physical criteria for the created products that 3D printers make. Modern 3D printing technology duplicates both texture and functionality. 3D printers are simple to make due to their simple structure and ease of design customization. Additionally, 3D printers save time and effort because of how swiftly they run. The production cycle is greatly shortened in 3D printers. The finished product from the printer is an identical reproduction of the original. The cost of the printer is not excessive and becomes less expensive for complex shapes [7]. The following are 3D printer drawbacks: Inexpensive printing costs [1] and the printing procedure is slow and might take days or even weeks depending on the size of the product. Many 3D printer types there are different kinds of 3D printers, and each one prints using a different technique. Thermoplastic Printers (FDM), Optical Printers (Digital Light Processing) and Selective Laser Sintering (SLS) are a few popular types of 3D printers. MJF stands for Multi Jet Fusion [3, 6,7, 8].

## 2. Motion Setup and Equipment Type

In 3D printing, motion configuration refers to the way in which the printer's hardware moves to create a 3D object. There are several common motion configurations used in 3D printers. Cartesian Configuration is pretty much named after the coordinate system the X, Y and Z axis which is used to determine where and how to move in three dimensions and the Cartesian 3D printers that have a heated bed which moves only in the Z axis. The extruder sits on the X-axis and Y-axis, where it can move in four directions on a gantry [5]. Delta Configuration feature a circular print bed, the extruder will be suspended above that by three arms in a triangular configuration thus the name “Delta”. Delta configuration is much better in building higher objects like a vase because the platform is fixed. Because the way buildingis fairly easy to make them bigger not in width but certainly in height. Selective Compliance Assembly Robotic Arm abbreviated as SCARA type robotic system has three degrees of freedom and it is actuated by three servo motors to do one vertical and two horizontal motions [7]. Feeding system for 3d printing is placed to back of robot and it is extended at the end of the robotic arm. Polar Configuration uses a polar coordinate system. It is pretty much similar to that of Cartesian configuration except that the coordinate sets describe points on a circular grid rather than a square. All of which means that you can have a printer with a spinning bed, plus a print head that can move up and down. The biggest advantage of a polar configuration 3D printer is that the printer can easily function with only two stepper motors [9].

### 2.1. Flow Chart

The flow chart shown in fig.1 describes the procedures and the methods of the building the proposed 3D printer [5]. The first step is to decide which additive manufacturing process, out of the several processes described in the previous section then a suitable mechanism is chosen for the X, Y, and Z axis movements taking into account different aspects such as fabrication cost, design simplicity, synchronization and precision. The selection of the mechanism is followed by the integration of electronics and software, after which the machine is designed and built. The synchronization of the machine's mechanical, electrical, and software components is the final stage.

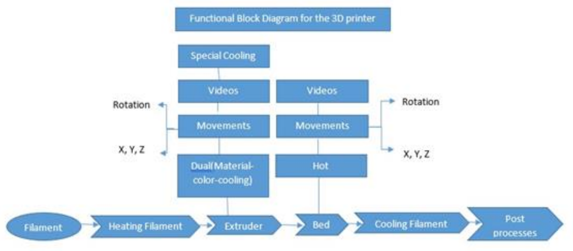


Figure. 1: the system flowchart

## 2.2. The Process Selection

Due to the ongoing development of 3D printing, the list of inventions and processes keeps growing. The 3D printing sector keeps improving its hardware, raw materials, and production techniques [2]. Since FDM is primarily used by people, it is at the very beginning of the market compared to other 3D printing technologies, FDM is considered a more economical 3D printing method. FDM starts with a product procedure which forms an STL file (stereolithography file format), scientifically cutting and situating the model for the building procedure. The machine may apportion numerous materials to accomplish diverse objectives. The model is created by extruding little amount of thermoplastic material to the desired shape layers as the material solidifies promptly after expulsion from the nozzle. A plastic filament our metal wire is loosened up from a loop and supplies material to an extrusion nozzle which can turn the flow on and off. There is commonly a worm drive that pushes the filament into the nozzle at a controlled rate. The nozzle is warmed to soften the material. The thermoplastics are warmed past their glass change temperature, then saved by an expulsion head. The substance is softened by warming the nozzle. An ejection head protects the thermoplastics once they have been heated past their glass change temperature. The nozzle can be moved by a numerically controlled component in both even and vertical bearings. The part is developed from the last, one layer at a time, as the nozzle moves along an instrument path controlled by a PC-aided manufacturing programming package. The expulsion head is usually moved by stepper engines or servo engines. The X-Y-Z rectilinear systems are often used, while various mechanical designs have also been employed. Despite the fact that FDM is a very flexible printing technology, it can manage small shades with the aid of bringing down layers.

## 2.3. The Mechanism Selection

Different factors must be taken into account in choosing the suitable mechanism for the FDM 3D printer, including print quality, speed, accuracy, and cost [7]. Cartesian, Delta, and Scara mechanisms are a few of the often-employed ones in FDM 3D printing. One of the most well-liked and frequently applied mechanisms in FDM 3D printing is the Cartesian mechanism. The print head is moved in a linear motion system along the X, Y, and Z axes to produce precise and accurate prints. Cartesian printers are renowned for their dependability, simplicity of operation, and adaptability to various print sizes and materials. They are a common option because they are also fairly simple to assemble and maintain. There are several factors to take into account while choosing a Cartesian configuration, including the quantity of motors, the kind of driving system, the dimensions and the form of the build volume. As an illustration, a conventional Cartesian printer might have two motors for the X and Y axes, one motor for the Z axis, and lead screws or belts to drive the motion. Overall, the Cartesian mechanism strikes a nice balance between speed, precision, and usability, making it a good option for an FDM 3D printer. When choosing a mechanism for your printer, it's crucial to take into account a variety of aspects, including the materials you intend to use as well as the size and intricacy of your prints.

## 3. Control System and Software

The three-dimensional forms are created using firmware, which is computer software and this prior to being sent to printers. A variety of software applications were used to develop the forms and shapes that will be printed [1, 10]. These forms and shapes must be levelled firstly using the UltimakerCura program before being sent to the printer; they cannot be sent straight to the printer. Marlin is an open-source firmware that may be used to control the printer's electronic and mechanical components. It can be installed on an Arduino kit. The contents of a Marlin package uploaded to the controller; however, it need few minor adjustments to work properly. These changes result in minor modifications to the values in the source code [4]. The only file that needs modifications is located in the configuration folder. This file stores the needed numerical data needed calibrate the printer as well as information about the printer's electronics [4]. Any information that computer systems employ to manage data and programs is referred to as software. Software is essential to the 3D printer because it enables the transmission of information from one place to another. It would be difficult to slice and print any virtual objects without software. The 3D printer's programming environment is made up of embedded C and C++ applications, the C++ plays a key role because it instantly calibrates and loads the controller with the parameters and movement requirements. Any 3D model can be created using any 3D program on the software's platform. A 3D printer is instructed on where to travel, how quickly to proceed, and how much material to extrude by means of computer programming [11]. Controlling a 3D printer is a critical aspect of achieving excellent and precise printing results. The printer can be controlled in three ways; firstly control via screen, in which the users who utilize this control form can modify the default printing settings on the built-in printer screen, it is suitable for beginners and basic operations. Secondly, control via Computer using Cura Software, software tools like Cura offer a comprehensive graphical user interface that lets users completely alter printing preferences and it is suitable for sophisticated users and sophisticated designs. Finally, remote control using Raspberry Pi and OctoPrint and this is obtained through the usage of the internet, users can monitor and manage the printer using this sort of control.

## 4. Calibration of the FDM 3D Printer and Work Flow

Calibration is an important step in the setup of a 3D printer using fused deposition modelling to achieve precise and reliable printing. Calibration aids in enhancing print quality, minimizing errors, and ensuring that the printer is operating at its best [5, 6]. Although calibrating an FDM 3D printer might initially seems difficult, with the correct equipment and understanding, it can be a simple procedure. The creation of high-quality 3D models requires accurate and consistent prints, which can only be achieved with proper printer calibration.

In order to ensure that the first layer adheres correctly and the subsequent layers are printed accurately, bed levelling entails adjusting the distance between the print bed and the printer nozzle [7]. Regular bed levelling calibration checks are advised, especially if you relocate your printer or alter the build surface. Regular temperature calibration is advised, especially if you've changed the filament or the hot end you're using. An accurate print is produced by proper temperature calibration, which guarantees that the filament is melted at the proper temperature.

Calibration of print speed depending on the kind of printer, the filament, and the object being produced [6]. When using a fresh filament or when moving to a different kind of object to print, it is advised to calibrate the print speed. The printer produces quickly and with the best print quality when the print speed calibration is done correctly. Retraction to prevent excess filament from being extruded when moving between various portions of the printed product, calibration involves pulling the filament back into the extruder. Because even slight differences in flow rate can have a big impact on the final print's precision and quality, flow calibration is crucial. When using a new filament or when moving to a different kind of object to print, flow rate calibration is advised. A more precise and high-quality print is produced by using proper flow rate calibration, which guarantees that the printer is extruding the right amount of filament. Although the Stepper motor calibration may involve some trial and error, it is a crucial step to guarantee precise and reliable printing [7]. The quality of your prints will increase and print faults will be less likely with proper calibration.

## 5. Raspberry pi

The Raspberry Pi foundation created a line of compact single-board computers called Raspberry Pi in the UK to support the teaching of fundamental computer science in classrooms and underdeveloped nations. With a range of input and output options for connecting to other devices and sensors, it is intended to be inexpensive, portable, and highly configurable [15].The common application for Raspberry Pi is the education to teach fundamental computer science, coding, and electronics concepts, the Raspberry Pi is frequently used in classrooms and universities. Automation of numerous household functions, including the management of lighting, heating, and security systems is also possible using the Raspberry Pi. The Raspberry Pi can be used as an Internet of Things (IoT) device to monitor and control a variety of smart devices. The Raspberry Pi is frequently utilized in robotics projects because of its tiny size and versatility when it comes to interacting with different sensors and motors. The Raspberry Pi provides an all-around adaptable and cost-effective platform for learning and experimenting with different computer science and engineering tasks. However, the Raspberry Pi use in 3D printing is among its most fascinating and inventive uses. You may develop a potent combo that can control the 3D printing process and even observe it using a camera by connecting a Raspberry Pi to an Arduino kit and a 3D printer [12,13]. Connecting a Raspberry Pi to an Arduino, a 3D printer, and a camera to capture the printing process is essential for a number of reasons; better Control by linking a Raspberry Pi to an Arduino and a 3D printer, users can have more control over the printing process. Also, with the use of a camera, they may even observe the process from a distance. The following is the main features of using Raspberry Pi in the 3D printing.

Real-Time Monitoring: By monitoring the printing process in real-time, users may identify and fix any issues that can

arise during printing, such as a filament jam or a printer malfunction.
Improved Efficiency: Combining a Raspberry Pi, an Arduino, and a 3D printer can speed up and increase the accuracy of printing by streamlining the procedure.
Flexibility: When a Raspberry Pi, an Arduino, and a 3D printer are used together, users can change the printing procedure and experiment with different factors to acquire the desired outcomes.

Therefore, A Raspberry Pi can be connected to an Arduino, a 3D printer, and a camera to capture the printing process for improved control, real-time monitoring, higher efficiency, and flexibility [7,8].

## 5.1. Connecting Raspberry Pi to the FDM 3D printer

To connect a Raspberry Pi to the 3D printer, you will need the following components: Raspberry Pi, Arduino, USB Cable, 3D Printer Board, Stepper Motor Drivers and Power Supply [7].Once you have all the components, you can connect them according to the instructions provided with your 3D printer kit. Typically, you will need to connect the Raspberry Pi to the Arduino via USB, and then connect the Arduino to the 3D printer board using jumper wires. Finally, connect the stepper motor drivers to the 3D printer board and connect the motors to the drivers. With everything properly connected, you should be able to control the 3D printer from the Raspberry Pi using software such as OctoPrint [14] and the final product will be as shown in Fig. 2.

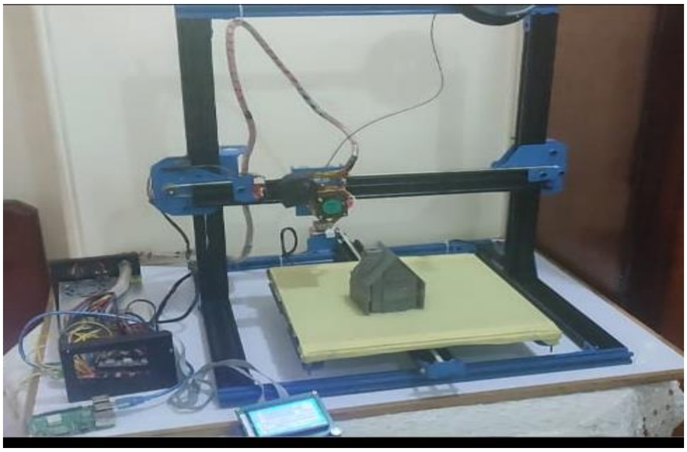

Figure. 2: prototype of the system

## 5.2. OctoPrint

Octo Print is a free and open-source software that allows you to control and monitor the 3D printer from a web interface as shown in Fig.3. It was designed specifically for Fused Deposition Modelling (FDM) 3D printers, but can be used with other types of 3D printers as well [12,13]. OctoPrint is a powerful tool for managing and monitoring 3D printers, and can significantly enhance the 3D printing experience [12].

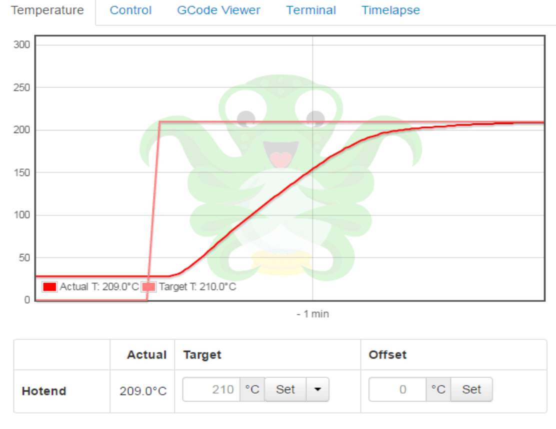


Figure 3: The octoPrint software window

## 5.3. Connecting Camera to Raspberry pi

To connect a camera to a Raspberry Pi for monitoring 3D printing, a ribbon cable is used to connect the camera module to the Raspberry Pi. OctoPrint is the software that will be used to monitor the printing process and view the camera feed. To get the best view, you might need to change the camera's position and angle. It can be quite helpful to diagnose and make corrections as 3D printing is being done by using a camera to record the process. It can also be a handy tool to remotely monitor lengthy prints, enabling you to check on the print's progress without having to be present. Therefore, you can build a strong and adaptable 3D printing setup using OctoPrint, a Raspberry Pi, and a camera [12,13].
With the help of 3D printers, we are able to build civil models like prototype of building or plan structures (as shown in Fig. 4). So that the customers can easily visualized the models.3D printing has come to the point where companies are printing consumer grade eyewear with on demand custom fit and styling as shown in Fig. 4.

Figure 4: 3D Printer prototypes

## 5. Conclusion

3D objects are produced utilizing the additive manufacturing technique with the aid of computer-aided design software. A few of the techniques that are available in 3D printing technology include the fused deposition method (FDM), selective laser sintering (SLS), multi jet fusion (MJF), stereolithography laser printers (SL), and digital light processing (DLP). In this paper, we have focused on the design and production of 3D printer that is reasonably priced. We employ four-axis mechanisms, one of which is an extruder, three of which are x, y, and z. High impact polystyrene (HIPS), acrylonitrile butadiene styrene (ABS), and polylactic acid (PLA) are just some of the materials used in the FDM technology that we employ.By raising it to that temperature, any filament material may be melted and then deposited one layer at a time. We will combine many of these layers to form a final 3D model. We improved the 3D printer's usability and convenience by integrating a Raspberry Pi, which offers capabilities like wireless networking, remote control, and the ability to run sophisticated software. The 3D printer's user interface and overall functionality are both enhanced by the Raspberry Pi, which acts as the machine's core control system.Technology for 3D printing has the potential to change the world. Thanks to advancements in 3D printing technology, it is now possible to change and improve local manufacturing processes, which lessens the need to import a variety of commodities. In computer-aided design software, an object is scanned or modelled to create the intended product, which is then divided into thin film slices that may be printed to produce a solid 3D object. The importance of an invention can be determined by how well it satisfies a specific human need. Applications for 3D printing are virtually limitless because it will make it simple and quick for people and companies to build goods of any size or scale.

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