Eco Friendly 3D Printer

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Abstract

This project aims to develop a 3D printer specifically designed for producing prototypes with a volume of 3 cubic centimeters or more. Our primary focus is on leveraging the latest technology and innovative methods to facilitate quick modifications and customizations of designs while minimizing material waste. The project will incorporate a blend of cutting-edge manufacturing techniques, precise engineering, and eco-friendly practices to ensure that the printer performs optimally and sustainably. A key highlight of our project is the commitment to environmental sustainability, particularly through the incorporation of e-waste recycling. The printer’s design will prioritize the use of recyclable and biodegradable materials, as well as energy-efficient components, to significantly reduce the environmental impact of the manufacturing process and contribute to the development of greener production practices. By combining these elements, we intend to create a 3D printer that is not only highly efficient and accurate but also easy to use and adaptable to various industries and applications. The printer will address common challenges in the field of rapid prototyping, such as speed, precision, and resource efficiency. Our approach will involve the integration of advanced software and hardware solutions to streamline the design-to-production process, making it more accessible for users to implement changes and produce high-quality prototypes swiftly. Ultimately, this project seeks to revolutionize the way prototypes are made, offering a solution that combines speed, accuracy, and sustainability. We believe that our advanced 3D printer, with its emphasis on e-waste recycling, will inspire new ideas and innovative manufacturing techniques, paving the way for more sustainable and efficient production methods across various sectors. Through this endeavor, we hope to set new standards in the field of 3D printing and contribute to a more environmentally conscious future.
Abstract—This project aims to develop a 3D printer specifically designed for producing prototypes with a volume of 3 cubic centimeters or more. Our primary focus is on leveraging the latest technology and innovative methods to facilitate quick modifications and customizations of designs while minimizing material waste. The project will incorporate a blend of cutting-edge manufacturing techniques, precise engineering, and eco-friendly practices to ensure that the printer performs optimally and sustainably. A key highlight of our project is the commitment to environmental sustainability, particularly through the incorporation of e-waste recycling. The printer's design will prioritize the use of recyclable and biodegradable materials, as well as energy-efficient components, to significantly reduce the environmental impact of the manufacturing process and contribute to the development of greener production practices. By combining these elements, we intend to create a 3D printer that is not only highly efficient and accurate but also easy to use and adaptable to various industries and applications. The printer will address common challenges in the field of rapid prototyping, such as speed, precision, and resource efficiency. Our approach will involve the integration of advanced software and hardware solutions to streamline the design-to-production process, making it more accessible for users to implement changes and produce high-quality prototypes swiftly. Ultimately, this project seeks to revolutionize the way prototypes are made, offering a solution that combines speed, accuracy, and sustainability. We believe that our advanced 3D printer, with its emphasis on e-waste recycling, will inspire new ideas and innovative manufacturing techniques, paving the way for more sustainable and efficient production methods across various sectors. Through this endeavor, we hope to set new standards in the field of 3D printing and contribute to a more environmentally conscious future.

Keywords: 3D printer, Prototypes, Material waste, Precision, Cutting-edge manufacturing techniques, Eco-friendly practices, Environmental sustainability, E-waste recycling, Recyclable materials, Environmentally conscious future, Arduino mega, ramps 1.6, Energy-efficient components, Fused Deposition Modeling (FDM).

I. INTRODUCTION

3D printing technology, also known as additive manufacturing, has revolutionized the manufacturing landscape by enabling the creation of intricate objects layer by layer from digital designs. This advancement has unlocked new possibilities for rapid prototyping, customized production, and the fabrication of complex designs. However, despite its transformative potential, current 3D printers often encounter limitations in speed, customization, and material efficiency, particularly when tasked with producing small-volume prototypes. In response to these challenges, our project endeavors to design a specialized 3D printer optimized specifically for prototyping applications. Central to our approach is the integration of cutting-edge technologies and innovative methodologies aimed at enhancing the speed, customization capabilities, and material efficiency of the 3D printing process. By harnessing advancements in additive manufacturing, precision engineering, and sustainable practices, we aspire to develop a printer capable of meeting the rigorous demands of rapid prototyping while also minimizing its environmental impact. The successful achievement of our project's objectives holds the promise of significantly advancing 3D printing technology. Not only will it foster innovation, but it will also promote sustainability and efficiency in product development and manufacturing. Importantly, the impact of our endeavor extends beyond rapid prototyping, as the technology we develop can be adapted for broader manufacturing applications, thus contributing to more sustainable production practices across industries.

Moreover, our research underscores the importance of environmental sustainability in the development of this new 3D printer. We are dedicated to promoting eco-friendly practices by incorporating e-waste recycling and utilizing recyclable and biodegradable materials[2], its overall environmental footprint and aiding in the advancement of greener production practices. In summary, our project represents a concerted effort to address the limitations of current 3D printing technology while also prioritizing environmental sustainability. Through the integration of advanced technologies and sustainable practices, we aim to pave the way for a future where 3D printing is both efficient and environmentally responsible.
II. LITERATURE SURVEY

Sadiq Ur Rehman. [1] Delta 3D Printer: Metal Printing July 2019, Block diagram for the working of proposed 3D printer

Sanket Barad. [2] The Fused Deposition Modeling (FDM) is an Additive manufacturing process that belongs to the material extrusion family. In FDM an object is built by selectively depositing melted material is extruded through a nozzle and deposed layer wise on a heated table. The material used are thermoplastic polymers and come in a filament form and it is Biodegradable.

Sadrina Sadrina. [3] The Arduino Mega 2560 is employed in the current machine, marking an improvement over the previous version. The main goal of the research is to develop a new 3D printer design that reduces production costs while enhancing design and performance compared to existing machines. The primary mainboard, which uses Arduino Mega and Ramps, is chosen because it is highly suitable for running programs and is very cost-effective.

III. SYSTEM DESCRIPTION

- **Hardware components**
  1. **Arduino Mega 2560**: The Arduino Mega 2560 is the central microcontroller of our 3D printer. It is based on the ATmega2560 microcontroller and provides the necessary processing power to handle complex tasks. It features 54 digital I/O pins, 16 analog inputs, and 4 UARTs, making it versatile and capable of managing multiple components simultaneously. Its affordability and open-source nature make it an ideal choice for our project.[3]
  2. **RAMPS 1.4 Board**: The RAMPS (RepRap Arduino Mega Pololu Shield) 1.4 board is designed to fit on top of the Arduino Mega 2560. It serves as an interface between the microcontroller and the printer's hardware components. It provides connections for stepper drivers, heaters, thermistors, and other peripherals. This board simplifies the wiring process and enhances the modularity of the system, making it easier to assemble and troubleshoot.[4]
  3. **Stepper Motor Drivers**: Stepper motor drivers, such as the A4988 or DRV8825, are connected to the RAMPS board and control the current supplied to the stepper motors. They enable smooth and precise motor operation, which is crucial for achieving high-quality prints.
  4. **Endstops**: Endstops are switches placed at the ends of the printer's axes. They serve as reference points for the printer, allowing it to determine the limits of its movement and home its position accurately.[5]
  5. **Hot End**: The hot end is the part of the extruder where the filament is melted and extruded onto the print bed. It includes a heating element, a thermistor for temperature sensing, and a nozzle. The hot end's temperature is carefully controlled to ensure optimal melting and deposition of the filament.

6. **Stepper Motors from CD Drives**: Repurposing CD drive components for 3D printers is a cost-effective and eco-friendly approach. Stepper motors from CD drives provide precise movement control for the printer's axes, while guide rails ensure smooth, accurate movements of the print head or platform. This reduces electronic waste and promotes sustainability. Using these readily available parts lowers production costs and encourages innovation. This practice highlights the potential of converting e-waste into valuable resources for technology development.

7. **PLA Filaments**: PLA filament is a biodegradable, eco-friendly material made from renewable resources like cornstarch or sugarcane. It decomposes naturally, reducing environmental impact. Ideal for 3D printing, PLA offers ease of use, minimal warping, and a lower melting point, making it a sustainable choice for various applications.[6]

- **Software Components**
  1. **Marlin Firmware**: Marlin is based on previous firmware called sprinter.marlin is made up of bunch of different files, which control the function of the printer such as moving stepper motor, reading from SD card and about pins for the hardware that simply tells marlin what's connected to what on our main board.
  2. **Cad & 3d Modelling**: 3D modeling involves creating digital representations of three-dimensional objects using specialized software. These models serve as blueprints for physical objects, guiding the 3D printing process. CAD (Computer-Aided Design) software tools are commonly used for 3D modeling.
  3. **Cura or slicer**: Cura is a 3D printing software that is used to prepare 3D models for printing. It is produced by Ultimaker and is simple to use but also has advanced features for more experienced users. Cura supports STL, 3MF, and OBJ 3D file formats and also has a function that will import and convert 2D images to 3D extruded models. It allows you to open and place multiple models on the print bed and has over 400 expert settings for advanced users. It is available for Windows, Mac, and Linux and is free to download from the Ultimaker website.
  4. **Prorface**: Prorface is a powerful 3D printing host software suite that allows you to interact with your 3D printer and manage the printing process. It provides both a graphical user interface (GUI) and an interactive command-line interface for controlling your printer, slicing objects, and running prints. Whether you prefer a visual interface or command-line control, Prorface has you covered.
**Implementation**

Our 3D printer consists of several key components, each playing a crucial role in transforming a digital design into a physical object. The system starts with the software part, which includes CAD, Cura, and G-code. CAD (Computer-Aided Design) software is used to create the 3D model. This model is then imported into Cura, a slicing software that processes the model and converts it into layers, generating G-code. G-code is a language that provides detailed instructions for the 3D printer, including how to build the object layer by layer. This G-code file is sent to the 3D printer through a serial port, establishing communication between the software and hardware components.

![Fig. 2. Flow Chart](image)

On the hardware side, the central microcontroller is the Arduino Mega 2560. This device is crucial as it processes the G-code instructions and controls various components of the printer. It is connected to the RAMPS 1.6 board, which serves as an interface for connecting stepper motor drivers, the hotend, thermocouples, and other components, simplifying wiring and making the system more manageable. The G-code interpreter on the Arduino reads the incoming commands and translates them into electrical signals that control the printer’s hardware. The stepper motor drivers, such as A4988 or DRV8825, receive signals from the RAMPS board and control the stepper motors, regulating the current supplied to the motors to enable precise control of movement along the X, Y, and Z axes. Stepper motors are vital for driving the movement of the printer’s axes and the extruder, operating in discrete steps to allow for precise positioning and controlled movements. These motors are connected to linear actuators, which convert the rotational motion of the stepper motors into linear movement, positioning the print head accurately to build the model layer by layer. The hotend driver manages the heating element of the hotend, ensuring the filament reaches the correct temperature for extrusion. The hotend itself is where the filament is melted and extruded onto the build platform. It includes a heating element and a nozzle that work together to deposit the filament accurately. To ensure the hotend maintains the correct temperature, a thermocouple provides real-time temperature data to the Arduino, enabling precise temperature control. The printing process begins when the G-code file is sent to the printer, and the Arduino Mega interprets the commands. The stepper motor drivers activate the motors, positioning the print head and the build platform according to the G-code instructions. The print head moves along the X and Y axes, while the build platform moves along the Z axis.

![Fig. 3. Schematic Diagram](image)

The hotend heats up to the specified temperature, and the extruder pushes the filament through the hotend nozzle, melting it and depositing it in thin layers. Throughout the printing process, the Arduino and RAMPS board continually adjust the motors and hotend based on the G-code. The thermocouple ensures the hotend maintains the correct temperature, while the stepper motors and linear actuators ensure precise movement and positioning. This layer-by-layer construction continues until the 3D model is complete. Once the printing is finished, the print head returns to its home position, and the final product can be removed from the build platform.

![Fig. 4. Eco Friendly 3D Printer](image)
In summary, our 3D printer transforms digital designs into physical objects by coordinating software and hardware components. CAD software creates a 3D model, converted into G-code by Cura. This G-code guides the Arduino Mega 2560, connected to the RAMPS 1.6 board, which controls stepper motors and the hotend. Stepper motors and linear actuators position the print head for precise layer-by-layer construction, facilitated by the hotend’s heating and extrusion. The process continues until completion, with the print head returning to its starting position.

- **Results**

![Fig. 5. Output Before Calibration](image)

Before Calibration: Fig.5
- Y-axis inconsistencies led to distorted shapes.
- Layer misalignments resulted in rough and uneven surfaces.

![Fig. 6. Output After Calibration](image)

After Calibration: Fig.6
- Accurate Y-axis calibration produced consistent and symmetrical shapes.
- Enhanced layer alignment resulted in smoother surfaces and stronger prints.

**IV. REAL TIME APPLICATIONS**

a. Construction Sector: One of these innovations is the utilization of 3-dimensional printing technology. Civil engineers build structures using materials and techniques available in the times. 3D printing technology attracts attention since it is faster than traditional construction, less costly, less labor and less error margin in today.[7]

b. 3D Bioprinting of Tissues and Organs: Recent advances have enabled 3D printing of biocompatible materials, cells and supporting components into complex 3D functional living tissues. 3D bioprinting is being applied to regenerative medicine to address the need for tissues and organs suitable for transplantation.[8]

c. Marine Applications: The materials used in the production of these parts produced using 3D printers can be of various types. AM technologies have found an industry in which they can bring great innovations for development. As in other fields, the maritime sector is increasing the use of 3D printing technologies and renewing itself according to different needs.[9]

d. Aerospace Applications: Astonishingly 3D printing has excited the world of aerospace. This paper takes stock of the popular 3D printing processes in aerospace. Reasons for their popularity over the traditional manufacturing processes are dwelled upon.[10]

e. Self-design and Manufacturing: The material extrusion and the stereolithographic 3D printers, which were recently launched in a desktop size, herald a new time whereby common people will be able to own manufacturing means in their home. [11]

**V. CONCLUSION**

Our 3D printer project successfully integrates e-waste components like CD drive stepper motors and guide rails, promoting environmental sustainability. By using biodegradable PLA filament, we further reduce environmental impact. Cost-effective components like the Arduino Mega 2560 and RAMPS 1.6 board ensure affordability without compromising performance. Calibration improvements have significantly enhanced print accuracy and quality. Overall, this project demonstrates a sustainable, efficient, and cost-effective approach to 3D printing, highlighting the potential for eco-friendly innovation in manufacturing technology.

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