3D Printer and Application Interface

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CONCEPT OF OPERATIONS

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Concept of Operations
for
3D Printer and Application Interface

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1. Executive Summary

Common 3D printers require local, in-person interaction to start/stop, format settings, or even insert memory devices to upload files. The sponsor for this project, Dalton Cyr, desires a 3D printer capable of printing files with the portability and ease of using a mobile device from any location. With a thoroughly designed phone application and wifi capability, this 3D printer will have similar features to other standard 3D printers and can also be controlled from any location with internet access. To print, while away from the 3D printer, it must have a server, and to preserve security, the 3D printer will access a web server provided by Amazon Web Services which has a reputation for customer security and satisfaction. This project will highlight the pleasing and straightforward user experience of printing 3D designs with the speed and quality of other printers through a mobile phone application.

2. Introduction

This document will review the concepts of operation for a 3D printer and its application interface. While many 3D printers require users to handle their operation in person, this 3D printer will solve this issue with a mobile phone application allowing the user to print from their current location. To achieve this task, the project will be broken down, researched, and executed in several subsystems: power supply, microcontroller unit, dedicated web server, and mobile phone application

2.1. Background

The combination of a mobile phone application and the dedicated web server will not only provide ease of use, away from the 3D printer but will also act as a simple form of security and solution for transferring large print files. Using the mobile phone application will minimize the need for a user interface on the printer. The only printer control will be the main power switch placing the printer in a standby state. Physical interactions with the 3D printer consist of the initial setup and powering on, adding PLA rolls to the printer, and removing completed prints.

2.2. Overview

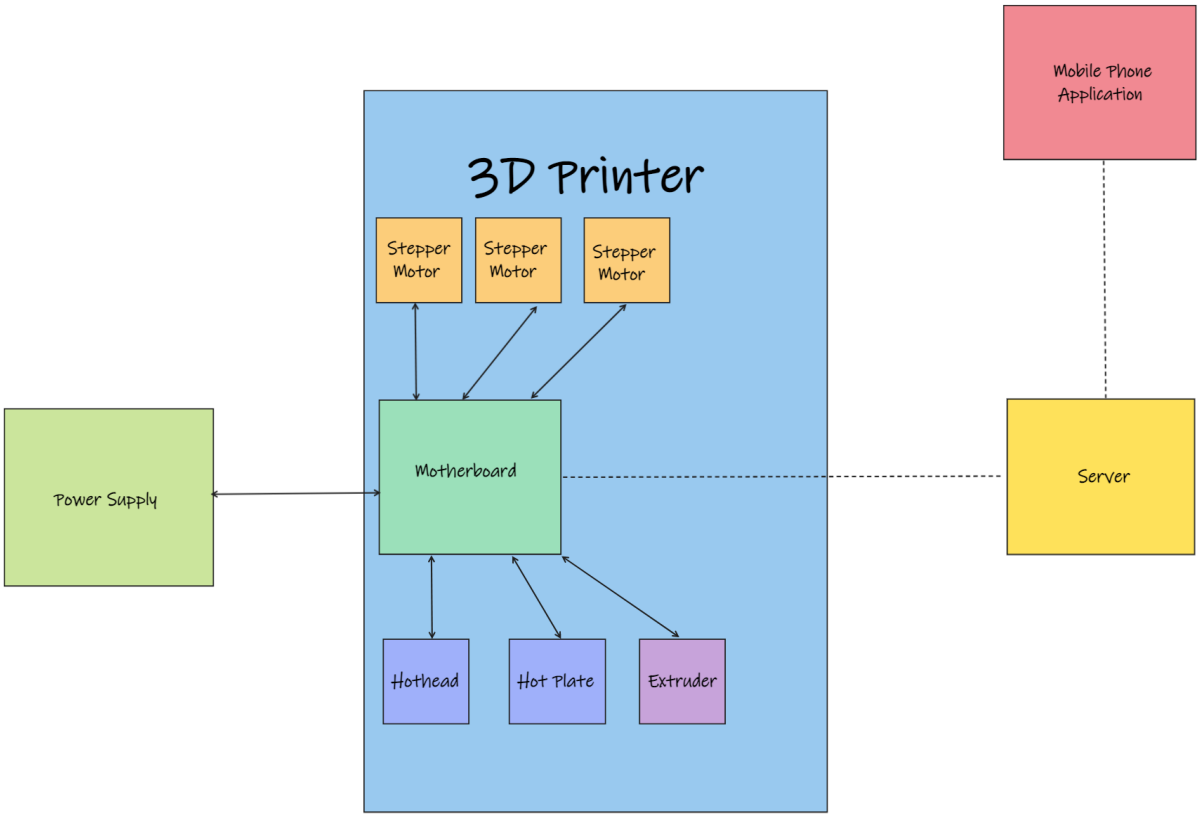

Fig 1: 3D Printer Block Diagram

This 3D printer will be designed to work exclusively through a mobile phone application. The application will take in commands and files and send them to the web-based server setup for the printer. Once uploaded, the server will store the files and pass on commands to the motherboard in the 3D printer if any are received. The motherboard will then read the codes and in one situation initiate the printing by heating the hot plate and hothead. Once the hothead and heated bed are at temperature, the motherboard will start reading the G-code from the server and initiate printing. The motherboard will also send a code to the server to forward to the application to start the timer. Another command that would be sent would be to cancel/end print in a situation where there is an issue with the print or an issue with the design and the person doesn't want to waste PLA. Once printing is completed the printer will then send a complete command to the server to forward to the application to notify the individual that the print is complete and stop the timer. To operate the 3D printer, a power supply will be built that can power the motherboard, the stepper motors, the hothead, the hot plate, and the extruder.

2.3. Referenced Documents and Standards

- IEEE Wi-Fi Std 802.11-2020
- IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz, ANSI C95.1-2019
- Android App Development, “Core App Quality” https://developer.android.com/docs/quality-guidelines/core-app-quality

3. Operating Concept

3.1. Scope

The goal is to develop a 3D printer that is controlled by a phone application that stores the G-code files on an internet server and allows the printing of the G-code files from anywhere with internet access.

3.2. Operational Description and Constraints

This 3D printer system requires internet access from both the 3D printer and mobile device. Before using the 3D printer, its built-in microcontroller unit requires an initial connection to the web-hosted server and local network at its location with its main power switch on standby. The user will send G-code files and printer commands from the mobile phone application to the server. On the printer side, the microcontroller will send pull requests in intervals receiving packets of the files/commands to control the 3D printer while also sending push requests of collected data to the server. This data is displayed through the mobile application allowing the user to monitor the 3D printer's progress. The 3D printer design must meet the following criteria:

- Operate within 10-15% speed of the initial hardware and software used for the Ender 3 3D printer
- Print area of 220mm x 220mm x 250mm
- Print height of 0.2 mm per layer
- Use 1.75mm PLA for print material
- The heated bed must reach a maximum temperature of 80℃
- The hothead must reach a maximum temperature of 220 ℃

The printer will have an input of 120V 60Hz AC power that will be converted to 24V 15A. The system will use an esp32 microcontroller to communicate with the host server and provide commands to the motherboard. The interface for the 3D printer will be through an android mobile application with the host server designed through Amazon Web Services.

3.3. System Description

There are three main subsystems for the 3D printer and mobile phone application. The first subsystem is the interface consisting of the mobile phone application and the web server. The mobile phone application will take G-code files and upload them to a web server and allow the initiation and shutdown of the 3D printer. The application will also handle initializing specific printing specifications desired by the user such as heated bed/hothead temperatures and stepper motor adjustments. Other features of the application are keeping track of print progress, the amount of material used, and housing a library of prints sent from the phone. The web host server will act as an intermediary for file transfer and controls between the phone application and the 3D printer while also housing previous 3D print files.

The second subsystem is the motherboard and microcontrollers for the 3D printer. While in standby mode, the microcontroller will send requests every so often to take in commands from the cloud server and send the commands to the motherboard. Some such commands require printing and the start and stop of printing. The motherboard will process and distribute the commands such as the movement of the stepper motors to the stepper motor control board or regulating the temperature of the hotbed and hothead to meet the specified

temperatures. The microcontroller will also collect information to be sent back to the phone application allowing the user to monitor printing progress.

The third subsystem will be the power supply. The power supply will take 120V 60z AC power and convert it into 24Vs capable of supplying 15A worth of current. To power the motherboard, hot plate, hothead, extruder, and all three stepper motors, the power supply will use DC-DC converters to supply each component with its specified voltage. The power supply will also provide overload and overvoltage protection.

3.4. Modes of Operations

There is a single planned mode of operation for the 3D printer electronic system. That operation is to control the 3D printer through a mobile phone application that requires only a main power switch on the printer to stop all external power.

3.5. Users

This 3D printing system is aimed toward hobbyist 3D printers. The setup requires some basic knowledge to connect the printer's built-in microcontroller to the web server and local network by following the instructions in the manual. After the server's setup is completed, anyone with proper G-code files can use the printer.

3.6. Support

The manual will provide assembly instructions for the 3D printer as well as instructions to set up the connection to the web server and local network. The manual will also display the mobile application name and link to download it. The app will provide a walkthrough of all its features along with how to send print files, adjust heating components or motor positioning, and start or stop a print design.

4. Scenario(s)

4.1. Parts Rush

A man at a drone competition has a build that uses as many 3D parts as possible. After a challenging event, one of the structural components broke. He has a 10-hour drive back home and must have the drone operating within 16 hours of getting there. The necessary part takes 18 hours to print. Luckily, with the mobile phone application and the 3D printer on standby, he only needs to select the part from the saved library of print designs and initiate the printing process. After arriving home the following day, his part will be completed and ready to be installed on the drone in time for the next match.

4.2. Printing on the Go

An Etsy store owner's business is booming and her 3D printer is operating 24/7. She is out running errands when she receives a new order notification for a 3D trinket. She promises same-day shipping on new orders placed before a certain time of day but fears she will not be home in time to start the print and ship it. So she opens the application on her phone and uploads the new order's file to start printing. When she arrives home, the print will be completed and she can keep her shop's positive reputation.

4.3. Work Prototyping

A woman brings in a prototype of a design she 3D printed last night for her boss to examine. After seeing it, the boss decides to make some adjustments and tells her that he wants to see the updated version of it by tomorrow. She drafts the new piece in SolidWorks, slices it, and uploads the G-code to her phone. From the office, she sends the G-code file and print command through the dedicated web server. By the time she arrives home, the job is finished and ready to be inspected, allowing enough time for a reprint if necessary.

4.4. Hobby Printing

A hobbyist's mind is constantly running and coming up with new ideas. Whether in another room of the house, at a neighbor's, or commuting on a bus, they are always drawing up designs for inventions to improve their life. No matter where they are, they can quickly bring their designs to life by drafting them, sending files through the app, and starting the print job remotely so that they can maintain productivity in their bustling life.

4.5. Multidisciplinary Skills

A man with a passion for woodworking, metalworking, 3D printing, and electrical engineering is often busy crafting new designs. He always finds a way to incorporate all of his interests together into one project. Whether he is soldering something in the garage or working with a bandsaw, he can now easily use the 3D printing app to check what is printing and how much longer till the job is complete. Doing so is less intrusive, saves time, and lets him focus on the tasks at hand.

5. Analysis

5.1. Summary of Proposed Improvements

Improvements include user-friendly setup, ease of feature adjustments, print progress notifications, the ability to start and stop jobs remotely, virtually infinite file storage, and convenient communication between devices.

5.2. Disadvantages and Limitations

A major disadvantage would be if there is a feeding issue with the 3D printer such as running out of filament. The limitation of having only a phone application to communicate with the 3D printer would prove to be a problem if wifi is down since the device can only print files when connected over the internet.

5.3. Alternatives

One alternative is that the printer could be controlled through Bluetooth instead of a network connection to the server. A drawback to that would be the need for users to stay within range of the printer to control and operate it.

5.4. Impact

Possible impacts:

1. The capability to 3D print from anywhere, allows people to be more social and not be confined to their homes to print an item.
2. With the freedom of not having to constantly monitor the printer, the individual can now volunteer to clean up around their neighborhood, town, or city.
3. By making the 3D printer user-friendly, it allows people who are not technically inclined to a platform to perform 3D printing.
4. An ethical issue would be leaving the printer to run unattended with the 80℃ hot plate and a 200℃ hothead. This could lead to a fire if a short occurs, it is knocked over, or even if something falls on the 3D printer. Without supervision, these heated components could cause dangerous outcomes such as a major injury to another person or pet.