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# WIRELESS CONTROL AND MONITORING OF FUSED DEPOSITION MODELER

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***Abstract***

***Rapid prototyping is the present trend in the the field of manufacturing that works on the principle of additive manufacturing. The 3D printing is a form of additive manufacturing technology where a three dimensional object is created by laying down successive layers of material one above the other. Fused Deposition Modeling(FDM) is one of the method of 3D printing where a hot thermoplastic is extruded from a temperature-controlled print head to produce fairly robust objects at a high degree of accuracy. The general setup for the 3D printer requires a computer to be connected continuously to the printer during the printing. My thesis focusses in eliminating this sacrifice of a computer and instead controlling and monitoring the printer remotely using a PC or an android device. The printer uses wireless mode of communication such as Wi-Fi and Bluetooth.***

***Keywords:* c**

## I. INTRODUCTION

Rapid Prototyping is a revolutionary method for creating 3D models with the use of inkjet technology saving time and cost by eliminating the need to design, print and glue together separate model parts. Now, we can create a complete model in a single process using the 3D printer.

In the past, prototypes were costly and often required outsourcing to companies who specialized in producing these prototypes using traditional methods like machining, welding, sand casting, and other costly processes. Now, it's a common place for an engineering team to have a 3D printer in their office with which they can print a prototype in a matter of hours.

The recent trend of a wireless lifestyle and 'Internet Of Things' has channeled my design of the printer to perform wirelessly and to connect to a cloud for online access to the printer. The printer is designed with the optimum necessities to keep it at a low cost without hindering the performance.

## II. OBJECTIVE

The main objectives of my thesis is focused on,

1. Optimum design for a 3D printer.
2. Low cost 3D printer assembly.
3. Bluetooth connection for the 3D printer using the HC-05.
4. Wi-Fi connectivity for the 3D printer using a Raspberry Pi.
5. Monitoring and control of printer on the Android application '3D Fox'
6. Online monitoring and control of the printer using the Astroprint cloud.

## III. PROBLEM DEFINITION

The present problem that exists in rapid prototyping are that the printers which are commercially available come at a very high cost which makes it a considerable investment for any industry. Another problem that persists is the sacrifice of a computer solely for the sake of printing on a 3D printer. The 3D printer can be accessed only through that computer and hence limits the accessibility to the printer.

## IV. METHODOLOGY

The printer is switched on and initial calibrations such as bed levelling and extrusion is tested. The 3D file is designed and converted into the G-code file using various software. The file, either in the .g format or the .stl format is uploaded into the printer using various connections. The connection can either be directly from the computer to the printer or the file can be written into a SD Card and the SD card can be connected to the printer. Another option is using the wireless communication like using the HC-05 Bluetooth module that is integrated to the circuitry, or using the online cloud which uses the Wi-Fi module connected through the Raspberry Pi to the 3D printer. Both controlling and monitoring of the printer can be performed using any method chosen for the interface.

## V. PROCESS DESCRIPTION

The thesis used different hardware combined together using different software to control the printer. The various s hardware and software are elaborated in the further subheadings.

### A. Hardware

Initial steps carried out was the estimating and designing an optimum 3D printer. The thesis began with the design of a 3D printer which included the assembly of a frame to support the axis's assembly and the bed assembly. This includes the screw rods, the smooth rods, bearings, extruder carriage, belts, pulleys, couplers, heater bed, motors and the limit sensors. The cooling unit for the extruder and the carrier sides of the z axis were printed to fit the assembly. the entire design for the printer body was inspired from the Prusa i3 and RepRap printers.

The use of stepper motors gives a good control to the fluidity if the movement of the axis. The X and the Y axis are moved linearly along the supporting smooth rods with a pulley and belt assembly. the Z axis is controlled by two motors on either side using screw rods. The screw rods have a square thread. The square thread provides remarkable stability to the assembly and is also easier to calibrate.

The extruder and bed can heat up to temperatures of 300 and 90 degrees respectively.

The Hardware setup of the basic 3D printer is shown in the Figure I.

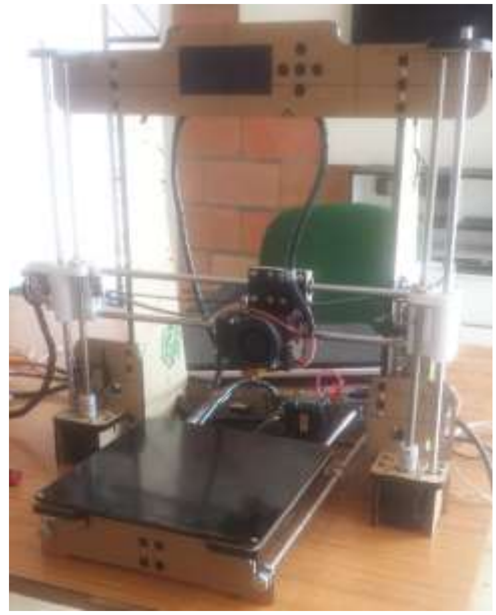

Figure I : Hardware setup of the 3D Printer

### B. Electronics

The electronics for the basic printer required an Arduino Mega 2560. A Ramps 1.4 with four A4988 stepper motor drives to control the motion of the various axis and the extruder on the printer. A LCD display unit is also connected to the ramps board using a suitable converter. The heater bed and the extruder are fitted with thermistors to determine and control the temperature.

The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. The arduino mega board was the main cintriller into which the further interfacing was performed.

RAMPS is the short form for RepRap Arduino Mega Pololu Shield, The RAMPS is mainly designed for the purpose of using pololu stepper driven board and hence named so. Ramps can work only when connected to its mother board Mega 2560 and 4988/DRV8825. Owning to its stability in operation and great compatibility with most 3D Printers.

Pololu's A4988 microstepping bipolar stepper motor driver features adjustable current limiting, over-current and over-temperature protection, and five different microstep resolutions (down to 1/16-step). It operates from 8 V to 35 V and can deliver up to approximately 1 A per phase without a heat sink or forced air flow (it is rated for 2 A per coil with sufficient additional cooling).

LCD Display Controller is a smart controller which contains a SD-Card reader, a rotary encoder and a 20-character x 4-line LCD display. We can easily connect it to our Ramps board using the adapter included. After connecting this panel to our Ramps we don't need the pc any more, the smart controller supplies power for the SD card. Furthermore, all actions like calibration, axes movements can be done by just using the rotary encoder on the smart controller.

The entire electronics assembly that is used in the printer is shown in the Figure II.

Figure II: electronic assembly used to control the 3D printer

### C. Firmware

The firmware for the Arduino to control the printer was derived from the Marlin as the key firmware. Various calibrations and editing to the firmware was made to make the Arduino compatible with the hardware assembly of the 3D printer.

### D. Wireless Connectivity

For the Bluetooth connectivity I used a HC-05 Bluetooth module and interfaced it through the voltage divider to the ramps. The HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint size as small as 12.7mmx27mm which makes it very compact for various robotic operations.

The programming was performed on the firmware to make the 3D printer compatible with the HC-05. And the printer was controlled using the 3D-Fox application that can be installed from the android playstore. The Bluetooth module is shown in the Figure III.

Figure III: HC-05 Bluetooth module

For the wifi connection to the printer I used a Raspberry Pi 2 Model B. It has a 1GB RAM and a 900MHz Quad Core Broadcom BCM2836 CPU it also provides a 40 Pin Extended GPIO and a Micro SD slot where the firmware is installed to run the printer on the cloud based server of astroprint. The RPi privides Multiple ports such as a 4USB Ports, full Size HDMI, 4 Pole Stereo output and Composite Video

Port,CSI camera Port & DSI Display Port. The RPi runs on a Micro USb Power Source of 5V.

Connecting the RPi to a Wi-Fi dongle and the printer and powering it on, it established the printer a connection to the cloud of Astroprint which can be remotely accessed from any part of the world with the right username and password. The Raspberry Pi used for the Wi-Fi module is shown in Figure IV.

Figure IV: Raspberry Pi 2 Model B

## VI. CONCLUTION

The thesis presents the various methods that can be used to access the printer. Total control and monitoring of a FDM 3D printer is achieved. The printer designed is a low cot printer which can be easily affordable, thanks to its optimum design. The printer can help in revolutionizing the manufacturing process and can be used by entrepreneurs, industrial manufacturers, designers, architects and other enterprises that require quick and reliable models.

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