FABRICATION OF LOW COST DIY 3D PRINTER

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Abstract

Additive manufacturing or 3D printing has become a popular method to create prototypes and customs object since 1980s. Recently, fabricating of your own 3D printer has attracted interest amongst undergraduate students and hobbyist, due to its constant decreases in price of electrical / electronic components, and also printing materials. This paper focuses on the development of a low cost 3D printer. Selected components used in the project are discussed briefly. The cost of building the 3D printer, including the printing material was not exceeding RM400 (USD100). The fabricated 3D printer were tested out to print three different sizes of Pikachu figurine which only took 20 minutes for the smallest one to be printed out.

Keywords: 3D printer, Additive manufacturing, hobbyist

1. INTRODUCTION

A 3D printer is a machine that can print a physical object from a three-dimensional digital model. The printing process is by laying down many successive thin layers of a material. It brings a digital object (its CAD representation) into its physical form by adding layer by layer of materials. The printing materials can be plastic, liquid, powder filaments or even sheet of paper.

There are many different techniques to print a 3D object. Some of them are very popular techniques, such as Stereolithography (SLA); Digital Light Processing (DLP); Fused deposition modeling (FDM); Selective Laser Sintering (SLS); Selective laser melting (SLM); Electronic Beam Melting (EBM); Laminated object manufacturing (LOM).

In this work, FDM printing technique has been selected due to the cost and the ease of acquiring the needed components to build the printer. FDM also known as a solid-based additive manufacturing technology works on a principle by in layers. In FDM, a thermoplastic filament is loaded into the printer head. The filament is then fed onto the nozzle once has reached the desired temperature. The printer head is attached to a three-axis system which allows it to move in x, y and z direction.

The melted filament will then be deposited layer by layer at the predetermined location. Once the melted filament is cooled, it will then solidify. In some cases, to accelerate the cooling of the melted filament, a cooling fan is attached to the printer head.
2. METHODOLOGI

In this section, selected parts and components to build a low cost FDM 3D printer are discussed briefly.

2.1 Arduino Family

In this work, Arduino Mega & RepRap Arduino Mega Pololu Shield (RAMPS) are selected to be the brain for the 3D printer. Arduino Mega was selected because it has 54 digital input/output pins. From the 54 digital I/O pins, 14 pins can be used as PWM outputs to drive electric motors. Furthermore, Arduino Mega also has 16 analog inputs, which can be used to connect to analog sensors.

Arduino Mega is also equipped with 4 UARTs (hardware serial ports) to connect the processor to other components serially. Another advantage is that it uses a USB connection to connect to a PC for programming. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

RepRap Arduino Mega Pololu Shield (RAMPS) is chosen because it has the ability to drive stepper motors by plug-in the stepper drivers and extruder control electronics. Additionally, Arduino family can be upgraded, replaced and expanded easily, making it a suitable choice for the project.

The A4988 (Pololu stepper driver board) then is added to RAMPS as a micro-stepping driver for controlling bipolar stepper motors on the 3D printer. With this A4988, controlling stepper motors can be done with using only 2 pins from the controller; one for controlling the direction, the other is to control the steps.

The driver (A4988) provides five different step resolutions: full-step, haft-step, quarter-step, eight-step and sixteenth-step. Additionally, it also has a potentiometer for adjusting the current output, over-temperature thermal shutdown and crossover-current protection.

2.2 Nema17 Stepper Motor 42HS48-1684-08AF

Nema17 Stepper Motor 42HS48-1684-08AF is then connected to the A4988. Nema17 is a brushless DC electric motor that divides a full rotation into a number of equal. The motor's position can then be controlled to move and hold at one of these steps without additional position sensor for feedback (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

2.3 Thermistor & Nozzle

Thermistor is a type of resistor, whose resistance is dependent on surrounding temperature. EPCOS 100K Thermistor is chosen for this build is because it is the cheapest on the market.

The nozzle to spout out melted filament will come from the E3D V5 Extruder with aperture of 0.4mm nozzle. A small DC fan is attached on it to act as a cooling for the heat sink. Besides that, the thermistor is also attached in the heated block of the extruder to measure the temperature.
2.4 Wooden Frame

Our DIY 3D printer’s frame is designed and created using plywood as shows in Fig.1. It is low cost and provides a good stability in order for the 3D printer to run smoothly.

![Fig. 1: low cost 3d printer design](image)

2.5 Stainless Steel Linear Shaft (Diameter= 8mm)

Each axis will use the 1 pair of linear to provide motion for three axes which are X, Y and Z to move. The 3D printer was designed and fabricated based on a tight budget. During the development, many trial and errors were made based on the structure to verify the printer’s sturdiness.

In this work, Repetier-Host software and Arduino software were used for the aim of printing process. The SolidWork software also been used to draw the 3D schematic of the printed object. Some tests were carried out after the drawing is done in SolidWork. To calibrate the DIY 3D printer, many objects with various sizes and complexities were printed. The same object also printed few times with different hollowness in order to test the stability and time consumed that used for printing.

3. RESULTS & DISCUSSION

The fabricated 3D printer has been carefully calibrated. The fabricated build volume was 370 mm x 380 mm x 310 mm; with printing ability of 300 mm x 300 mm x 260 mm.

Overall, Fig. 2 shows that the DIY 3D printer able to print the objects with different size and dimension. The desired result is thus obtained. The different size of objects takes different time to complete it. The hollowness of the object is different for each of it. The biggest object has low hollowness thus provide the good stability and can last longer. The smaller object can having high hollowness as its centre of gravity is low and stable than largest object naturally. The time required to print this three object is shown in Table 1 below.
Table 1: Object And Corresponding Time Taken To Print The Object

<table>
<thead>
<tr>
<th>Object to print (w, l, h) mm</th>
<th>Time taken to complete the task</th>
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</thead>
<tbody>
<tr>
<td>Small size Pikachu (12, 17, 29)</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Medium size Pikachu (32, 22, 44)</td>
<td>40 minutes</td>
</tr>
<tr>
<td>Large size Pikachu (45, 26, 57)</td>
<td>60 minutes</td>
</tr>
</tbody>
</table>

The time taken to print the object is directly proportional to the size of the object based on the observation. This also shows that the DIY 3D printer able to print the desired object. The small size Pikachu is however more fragile than large size Pikachu as some part of the body such as the ears and tail are easier to be tear off and hence the stronger printing material such as Acrylonitrile Butadiene Styrene (ABS) is suggested to used. However as the main aim for the design of the DIY 3D printer is to design a printer that suitable for all class of society, therefore the only printing material used in the process of printing is Polylactic Acid (PLA) which is lower in cost. The PLA is used also because due to its temperature control. PLA required lower temperature to be melt compare to the ABS, therefore temperature control for PLA is easier and consistent result is obtained.

Fig. 3 shows the smallest size Pikachu. The edge of its ear and tails are printed successfully as observed. The problem of not enough time for cooling down the printing material is successfully overcome. The major problem for most of the small size printing material is not enough time for cooling down the printing material. As fused deposition modeling is used in the design, if the lower base printing material is not solidified before the upper part is printing, the overall printing object will be spoilt and not success to be printed anymore. Therefore, it can be concluded that the DIY 3D printer has been designed and worked perfectly.
4. CONCLUSIONS

In conclusion, this project implements a new and effective way for design of DIY 3D printer. In this 3D printer, only RM400 is used for the fabrication of the 3D printer. The main cost can be further decrease if cheaper components imported from China are used. The printer is easier to design at low cost and easily to be manipulated with the knowledge of software. The printer had been used for the undergraduate in the university for the sake of their study.

Many objects that are hardly to be manufactured can be printed and thus can be used for prototype or studying. The main focus on DIY 3D printer is about the cost consuming. In the future, some rectification and changes can be make such as adding the sensor on printer so that to increase the accuracy and consistency of printing process. By using the open source distributed manufacturing library, the user can produce high value items at the lower cost.

REFERENCES


