3D Printer for Printing Biological Structures

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Abstract— 3D printing is called as desktop fabrication. It is a process of prototyping where by a structure is synthesized from a 3d model. The 3d model is stored in as a STL format and after that forwarded to a 3D printer. It can use a wide range of materials such as ABS, PLA, and composites as well.3D printing is a rapidly developing and cost optimized form of rapid prototyping. The 3D printer prints the CAD design layer by layer forming a real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CAD 3D data. 3D printing significantly challenges mass production process in future. This paper describes the core technology in biological domain and its applications. Additive manufacturing which is also referred as 3D printing, is a new way of manufacturing products and components from a digital modal.

Keywords—*3D printing, Additive manufacturing, Nicrome wire, Structures, FDM technology, Rapid prototyping.*

1. INTRODUCTION

3D printing called as desktop fabrication. It is a rapid prototyping process whereby a real object can be created from a 3D design. A 3D printer machine uses a CAD model for rapid prototyping process. 3D printing is called as desktop fabrication which is a process of prototyping where by a structure is synthesized from its 3d model. The 3d design is stored in as a STL format and after that forwarded to the 3D printer. It can use a wide range of materials such as ABS, PLA, and composites as well.3D printing is one kind of rapidly developing and cost optimized form which is used for rapid prototyping. The 3D printer prints the CAD design layer by layer forming a# real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CAD 3D data. 3D printing is diversifying and accelerating our life, letting various qualities of products to be synthesized easier and faster. Three dimensional (3D) printing has the ability to impact the transmission of information in ways similar to the influence of such earlier technologies as photocopying. This identifies sources of information on 3D printing, its technology, required software and applications. Along 3D printing, companies are able to extract and innovate new ideologies and various design replications with no time or tool expense. 3D printing possibly challenges mass production processes in future. 3D printing influences many industries, such as automotive, architecture, education, medical, business and consumer industries.

Since over a century the visual world of printed scriptures has been dominated by the 2-D printing methods. Be that easy to read or comprehend but when it comes to imaging of definite and real life models it is sorely outsourced. Any 3-D model cannot be represented and displayed easily in a 2-D workplace. The only thing worth mentioning for likable perception is the rendering of the image. This ushered in the era of the much needed idea of "3-D" printing.

Basically the singular purpose for the division of 3-D printer was to prepare 3-D samples directly on the bed of the printer. It has been an effective way of manufacturing since many companies are now opting for this type of method for their production operations. 3-D printing was originally developed for rapid prototyping purposes, making less complicated physical samples. It allowed designers to identify and rectify design flaws quickly and cheaply, thereby speeding up the product development process and minimizing commercial risks.

Medical sector is one of the most promising areas of usage. It is being applied to face many medical situations, and develop medical research, also combining the field of "regenerative medicine". In 2012, using a 3-D printer, engineers and doctors at Hasselt successfully experimented the very first patient-specific instrument of prosthetic jaw transplant.

2. Literature Survey

The beginning of 3D printing is related to studies of photography, sculpting, and Landscape design, which took place in America. Much of the technology was not being developed until the mid-1980s. During this period, 3D printing was known as "RAPIDPROTOTYPING". Chuck Hull, of 3D Systems Corporation, manufactured the first usable 3D printer. Later in the 80's, Selective Laser Sintering (SLS) technology was synthesized by Dr. Deckard at the University of Texas during the commencement of project being done by Defense Advanced Research Projects Agency. In the 1990s, the technology was further improvised with the advancement of a method that uses UV light to solidify photopolymer, a highly viscous liquid material [3].In the 20th century, 3D printers were very expensive and were used to print a few number of products. Most of the printers were owned by scientists and electronics groupies for research and display. However advancements in the area of 3D printing have allowed for the design of products to no longer be limited by complex shapes or colors.

“The line between a physical object and a digital description of a physical object may begin to blur. With a 3D printer, having the bits is almost as proper as having the atoms”

As a technology, however, 3D printing has been around for some time, and commercial printers “have existed for years”.

Bradshaw et al. [5] confirm that the first patent was deposited in 1977. One reason for the recent nature of most of the literature is that prices for 3D printers have dropped sufficiently that individuals can now afford to purchase their own equipment.

The primary business Rapid prototyping framework, the SLA-1, was presented in 1987 The patent in regards to the FDM innovation was at initially issued to Stratasys in 1992. After a wasting with the stereo lithography process, EOS' R&D center was chiefly on the laser sintering (LS) process, which got reinforced step by step. Today, the EOS frameworks are all around perceived the world over for their gainful and subjective yield for mechanical prototyping and enthusiastic applications in the 3D printing part. The organization's metal laser sintering (MLS) procedure came about because of an undertaking with a bureau of Electrolux Finland, which was later obtained by the organization EOS in the year 1993.

3. BASIC CONCEPTS OF 3D PRINTING

A) Terminology

1) *ADDITIVE MANUFACTURING –*

Technology that createobjects through sequential layering.

2) *RAPID PROTOTYPING –*

Group of techniques used to quickly fabricate and scale model of a physical part or assemble using 3D computer aided design CAD data.

3) *SUBTRACTIVE PROCESS –*

Removal of material by methods such as cutting or drilling.

4) *STEREOLITHOGRAPHY –*

System for generating three dimensional objects by creating a cross-sectional pattern of the object to be formed.

B) Methodology

For printing any object in 3 dimensions, firstly the object must be sliced in the direction of one of the axis and in the plane parallel to remaining two axes. Then, at each plane, the list of points associated with object is saved along with plane number. This list of points and lines is known as ‘G-code’. This G-code is different for different machines and it depends on the capabilities and support.

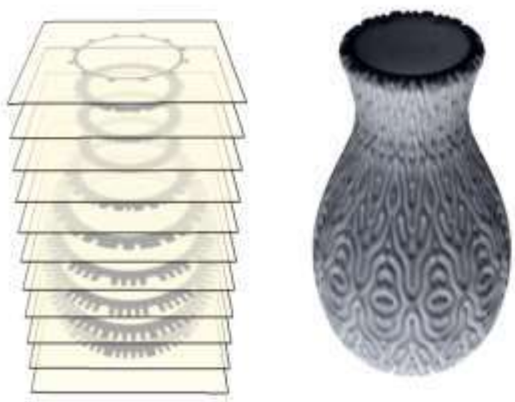

Fig. 1. Layered image of the object

Once the machine is provided with the point list, it starts the preparations for printing. It preheats the printing head and bed as per the requirement. Once done with preparations, the printing head is moved to each point in the list and the material is dropped there with the help of the nozzel. Once all the points in a layer are done, header moves along the slicing axis for printing all the points in next sliced layer.[2]

By this way, all the points of any object are covered and the object is printed.

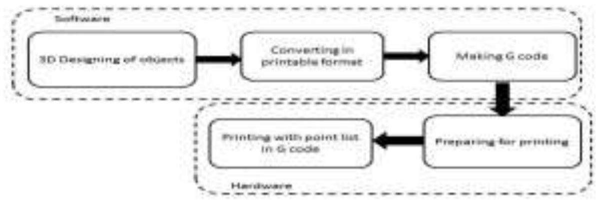

Fig . 2 . Flow chart

C) Work division

3D printer needs 3D designs to print. These designs are made with the help of software. This software also creates a printable version of the 3D models designed. The printable formats of 3D models can be converted into machine specific G-Code by other software. The hardware comes in picture once the G-Code is ready. Hardware unit then reads the G-Code and follows all the points in it. Maintaining the same precision in software and hardware is a huge challenge.

Duties of Software:

1. 3D designing.

2. Converting in printable format

3. Generating G code for printing.

Duties of hardware:

1. Preparing heater and bed according to material in use.

2. Keeping precision in printing.

3. Working with fastest possible speed with accuracy.

D) The software

1) Using one software we can do 3D – designing of objects and then covert it into printable format.
2) This is considered as step 1 in software development.
3) Using another software which is compatible we make the G- code for that particular printable format.
4) This is considered as the step 2 in software development.

E) The hardware

The hardware consists of central controller for handling all the events and driving different parts of printer. The printer has following electrically moving parts and sensors

1. 3 Stepper motors, 1 for each axis.

2. A printing head

3. A filament roll and feeder

4. Printing bed with heating facility.

5. Temperature Sensor

6. Limit switches

Stepper motors are used to move the header in the direction of the particular axis. Stepper motors are used for fine precision. Printing head is the actual printing part having a heater. The printing head heats up and extrudes the material provided by feeder. Feeder assembly continuously takes the printing material from its roll and feeds it to the printing head. Temperature sensors are used for PID controller to control the temperature of bed and printing head. Limit switches are implemented for detection of extreme point in any direction. It is of most importance as when the printer starts up, the position of head may be different than home. Hence we need limit switches to bring it back to home[5].

Hardware unit also consist of drivers required to drive the motors and heaters. Drivers are required as actuators and heaters consume a lot of power and need higher current and voltages that microcontroller cannot handle.

F) Important components and explanation

Hardware part also have a 12V 30A DC power supply for powering up the heaters and motors. Power supply is SMPS and isolated type.

Central Controller - Central controller is the brain of the system. It controls all the actions. The Sensors provide information about current status of the system and the work to be done is provided through the serial interface. It is hardcoded to perform a specific set of operations for the specific commands and sensor conditions. It also drives a LCD display to display the system working point and status.

For our system we are using 16F877A microcontroller from Microchip to drive the system. It is chosen for following features it provides,

- In built 10 bit precision ADC
- In built USART
- Two 16 bit timers
- CMOS outputs
- High speed operations at low cost
- Robust
- Easy market availability
- Cheaper solution

X, Y and Z motor Drivers - The motor drivers are used for driving the high power motors with very low power control signals. The Driving power is consumed directly from the source while the control is provided from this interface to the stepper motors. The Stepper motors used are having 5Kg of torque and need 2.5A of peak current. As the controller circuit cannot provide this current, we need drivers. X Y and Z motors are used to drive the system in these directions precisely. The Speed of the motors can be controlled by using the PWM signal to the driver, and direction can be changed just by inverting the direction pin. The 3pin_header provided for it is having A PWM pin, A Direction pin and A Common Ground pin.[4]

*The X Y and Z Limit_*- Sensors Limit sensors are the limit switches attached to the ends of the axis to indicate the end of the printing area. They cut the power supply to the motors and also indicate to the central controller that the printing header is reached at the extremity. It is just a switch pressed when header reaches at end, and released when header moves in again.

*Heater Drivers_*- Heater Drivers are used to drive heaters in plate and extruder. The Nicrome wire is used as the resistive heating element. The heating temperature is controlled by using the PWM from the central controller while the heating current is provided by the heater drivers. The heater in the base plate is use to keep the base warm for best results and extruder heater is used to melt the filament.

Temperature Sensors - The temperature sensors are used to detect the current temperature value. The central controller adjusts the PWM signal according to these values. The sensor used to extruder and plate are RTD PT500 sensors as the temperatures in this portions are going above 200 degree Celsius. The sensor employed at the circuit is a LM35 sensor used to detect any extra heating component in the circuit to avoid any accidents.
Filament Detector - This sensor is used to detect if the filament is available or not. This sensor plays very important role to avoid overheating of the header and also saves the energy by cutting off the heating when the filament is not available.

The PC interface - The PC interface is the source of information to the system. The commands and directions are provided by the PC software to the system. The system is connected with the computer via serial RS232 interface at the baud rate of 115200 bits per seconds. This speed is required as system needs to know the next point of operation in the 3d space. The communication from the computer to the system follows a specific sequence to avoid loss of data or the invalid commands. The printer hardware does not have memory. Hence the PC software needs to be connected to the system continuously to print. This is a disadvantage over the existing systems, but it is very effective to reduce the cost and overall complexity of the system hardware.

4. PROBLEM DEFINITION AND PROPOSED WORK

1) PROBLEM DEFINITION – To develop a 3D printer in an affordable budget with high precision which has its application in biomedical field to prints organs such as tooth, bone and such smaller objects.

2) PROPOSED WORK - 3D printer is a very innovative technology to print any object in 3 Dimentional format. Nowadays, 3D printing is used in every field such as educational, smart phone, space manufacturing and artificial jewellery. Apart from this it is widely used in medical field for printing many parts of the body such as tooth, bone and etc using plastic as a material with moderate complexity and very good finishing taking medical applications to a very next level.

In the proposed work, we will be using 16F877A microcontroller as the central controller which will be controlling all the actions and it will be the brain of the system. It will be connected series interface with sensors and other components. It will also drive the LCD display.

To drive high power motors, we will connect them to motor drivers. The driving power is consumed directly from the source while the control is provided from this interface to the stepper motors.

Limit sensors are used as the limit switches to indicate the end of the printing area. We also use the filament detector sensor to detect if filament is available or not. **NICROME** wire is used as the resistive heating element.

Temperature sensors are used to detect the current temperature value.

Finally, PC interface is the source of information to the system. The commands and direction are provided by the PC software to the system. The system will be connected with the computer via serial RS232 interface at the band rate of 115200 bits per second.

Hardware part also have a 12V 30A DC power supply for powering up the heaters and motors. Power supply is SMPS and isolated type.

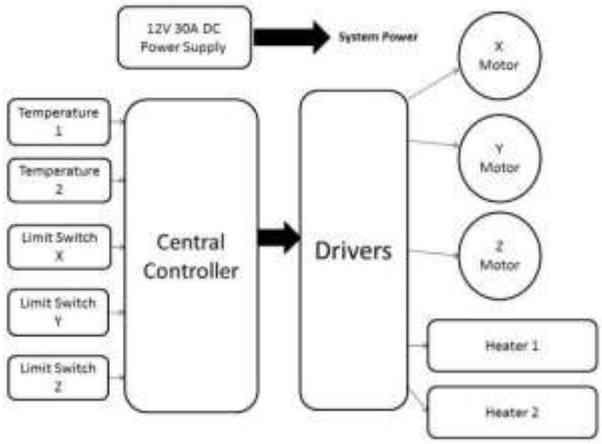

Fig. 3. Block diagram

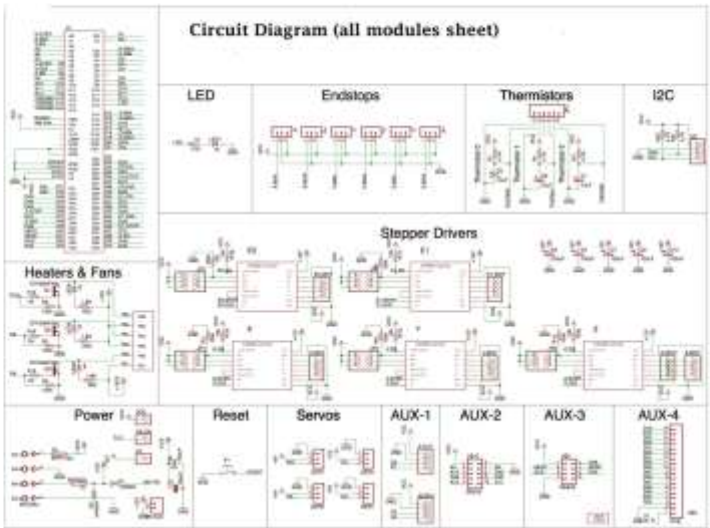

Fig. 4 Circuit diagram

We observed some results after printing our biological structures. Our main objective was to print the tooth. Results are as follows

5. CONCLUSION

As 3D printer is a very useful device it should be analysed with the advantages, disadvantages and how the device can change the society and engineering etc in mind. The nature of 3D printer is creating a part layer by layer, instead of subtractive methods of manufacturing lead themselves to lower the cost in raw material. Instead of starting the printer with a big chunk of plastic and carving away the surface in order to produce the product. Additive manufacturing only "prints" what is required and where it is required. 3D printing is the ultimate just-in-time method of manufacturing. Just have a 3D printer which is waiting to print your order. Additive manufacturing takes your design to a whole new level because undercuts, complex geometry and thin walled parts are very difficult to manufacture using traditional methods. In addition, the mathematics behind 3D printing is simpler than subtractive methods. This mathematical difference is hard to explain but it is the fundamental reason why 3D printing is superior to all other manufacturing techniques. It always better to keep things simple and additive manufacturing is simple by its nature. With so many potential benefits of 3D printing, there is no surprise that this method is making its way in industries and quickly becoming a very favourite tool of progressive marketers. Comparing the numerous advantages, applications and future scope, we can conclude that 3D printer and its technology are able to create a next industrial revolution.

6. REFERENCES

[1] Dipayan Dey,Souvik Mondal2,Arijit Kumar Barik "3-Axis CNC Router Modifiable to 3D Printer" International Journal of Innovative Research in Science, Engineering and Technology Vol. 5, Issue 9, September 2016

[2] Siddharth Bhandari,B Regina "International Journal of Computer Science and Information Technology Research" Vol. 2, Issue 2, pp: (378-380), Month: April-June 2014

[3] Medhavi Kamran, Abhishek Saxena “A Comprehensive study on 3D printing technology, MIT International journal of mechanical engineering, Vol. 6, No.2, August 2016

[4] Charlie Wapner, “Toward a more printed union library 3D printing democratizes creation, December 2015.

[5] Bob Hayward, David Moschella, Jon Schreiber, Simon Wardley, Howard Smith, “3D printing and the future of manufacturing” CSE, the rise of 3D printing.

[6] Desai, Deven R. and Magliocca, Gerard N. ‘Patents, meet napster: 3D printing and the digitization of things’, Vol. 102, Issue 6.