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UNIVERSAL DELTA 3D PRINTER

[1]Aadish Agrawal, [2]Snehil Srivastava
[1,2] School of Electronics Engineering VIT University, Vellore India
[1]aadishagrawal@gmail.com [2]snehilsrivastava54@gmail.com

Abstract— **3d printing is a thriving technology trending today among science community. Lots of research is being done to use the technology to its full potential. 3D printing will continue to provide low- cost effective solutions in various sectors. Our project focuses on Delta 3D printer. The project mainly aims at manufacturing plastic objects by successively placing layer on layer. The designing for hardware is performed in Solid works. We have developed the algorithm for the movement of the extruder with the help of which we can develop the desired 3D model. We have developed the Arduino code in order to control the movement of the extruder. We wish to construct a universal 3D printer. Many techniques are employed to print 3D objects like Stereo lithography (SLA), Digital Light processing, Fused Deposition modeling, etc. By universal we mean that most of the techniques to print 3D objects can be integrated in one prototype so that a standard is established. We also wish to make the machine cost effective so as to provide it to the benefit of the people.**

Index terms- **Deposition modelling, 3D PRINTER, technology.**

I. INTRODUCTION

3d printing mainly uses additive fusing technology where a 3 dimensional object is created by successively placing down layers. Here 3D objects are created in a quick manner on a reasonably sized machine connected to a computer which stores blueprint designs of the object. 3D printing concept of custom manufacturing is stirring to everyone. The technology has proved its mettle as it is both cost effective and also saves time of production of objects. The basic principles involved are materials cartridges, flexibility of output and translation of code into a visible pattern. Hideo Kodama of Nayoga Municipal Industrial Research Institute is generally regarded to have printed the first solid object from a digital design. However the first prototype using 3D printing technology was developed by Charles Hull in 1983. And with that the advent of the technology began. The process involves mainly three steps: Modelling, printing and finishing. The first involves designing blueprints for the object and provide them as input to 3D scanner with software like CAM, CAD, etc. Through the different Technologies, the blueprint is then used to create the object where the materials like thermoplastics, etc. are used. The finishing is mainly done through polymers or processes like chemical vaporization, painting, etc. 3D printing is an additive process, as it adds one layer over another. This is better than subtractive processes as there is considerable wastage removal. Secondly, the entire process is digitalized without requiring much manual calculation. Thus maintaining the continuum from laser scanning through building information modelling through digital construction. Also, this technology can be used at Nano and micron levels too

II. APPLICATION

It is used in a variety of industries including jewelry, footwear, industrial design, architecture, engineering and construction, automotive, aerospace, Healthcare industries, education and consumer products.

A..Healthcare*:* The technology is being used to manufacture artificial organs to help the physically handicapped. The technology is also being researched upon for manufacturing tissues to cure diseases like arthritis.

B. Automotive*:* The technology is being harnessed in the industry for manufacturing automotive parts. This makes the production simpler as it saves time and cost of labor. The first 3D printed car, Strati is already developed by Local Motors in 2014.

C. Aerospac*e:* Light weight engines are coming in use for airplanes which are produced using 3D printing. This will not only be cost effective but also enhance the performance of the engines. It will also reduce the assembly cost of the components.

D. Construction*:* The technology is already in use in the Netherlands. Low cost housing can be effectively provided to the poor living in the slums. The technology can also be used to produce furniture necessary to provide proper living standards to the poor and needy. Also the Housing agenda can help in settling victims of natural calamities.

E. Education*:* Teaching using 3D printer gives a mindset of better learning as it contributes to
Students' boldness to design, increasing their confidence and imagination. Introducing 3D printing in education is different compared to other technologies. It will encourage the experimentation in their learning.

F. *Consumer:* footwear made by 3D printing methods would be lighter and more flexible so enhancing the wearer's performance. 3D printercan also be used for manufacturing clothes as it can print clothes according to the consumer's demands. 3D printing of consumer product is also cost effective as it reduces labor charge and increase mass production.

III. TYPES OF 3D PRINTING

A. Stereo lithography - Stereo lithographic 3D printers (known as SLAs or stereo lithography apparatus) position a perforated platform just below the surface of a vat of liquid photo curable polymer. A UV laser beam then traces the first slice of an object on the surface of this liquid, causing a very thin layer of photopolymer to harden. The perforated platform is then lowered very slightly and another slice is traced out and hardened by the laser. Another slice is then created, and then another, until a complete object has been printed and can be removed from the vat of photopolymer, drained of excess liquid, and cured.

B. Fused Deposition Modelling - Here a hot thermoplastic is extruded from a temperature- controlled print head to produce fairly robust objects to a high degree of accuracy.

C. Selective laser sintering (sls) - this builds objects by using a laser to selectively fuse together successive layers of a cocktail of powdered wax, ceramic, metal, nylon or one of a range of other materials.

D. Multi-jet modelling (mjm)- this again builds up objects from successive layers of powder, with an inkjet-like print head used to spray on a binder solution that glues only the required granules together.

IV. PROPOSAL

The main objective of this project is to design a 3D printer that can be manufactured at a low cost and make it universal as different types of printing techniques can be used. This Printer can also be manufactured without use of high-end materials that are not readily available which is very positive point as anyone with good knowledge can be able to make these type of 3D printer. The making of the 3D printer will not only encompass the design of the printer itself, but also a derivation of its movement algorithm based on trigonometric functions and implementing the logic in hardware for printing desired 3D design. There are many kinds of 3D printer that are currently present in the market but our project focuses on Delta 3D type.The delta 3D printer has 3 column A,B,C where each column has a carriage that runs up and down. Each carriage connects to extruder platform which is aligned parallel to the bottom surface of 3D printer called bed. These delta 3D printer consists of 3 stepper motors for the movement of extruder(printing head), microcontroller(Arduino Uno) which will be used for controlling motors in order to print model with accurate shape and size, motor shield to provide accurate power supply to motors, delta 3D printer hardware model ,thermoplastic(PLA) which will be used as printing material which has melting point of 150-260 degree Celsius and can solidify at room temperature, a container which will used to store molten thermoplastic and burner which will provide required temperature for melting PLA. A Delta style 3D printer is different from Cartesian printers in a number of ways. Cartesian printers use discrete motors for its movements along the 3 axis of motion (i.e.- x, y and z axis) A typical Cartesian printer uses 1 motor for motion in the x direction, 1 motor for the y and 2 for z direction. A Delta printer on the other hand does not operate in such a discrete fashion. It uses 3 stepper motors which move together to give motion to the extruder platform. Given the large number of individual entities to be designed, each entity was approached separately. The model to be manufactured is built one layer at a time. A layer of thermoplastic (poly lactic acid) is automatically deposited in the 3D printer bed. The molten thermoplastic comes from container to extruder and gets deposited on bed via nozzle that is present at the middle of extruder for printing accurate shape of the model. The layer solidifies immediately as thermoplastic cools down at room temperature. Also water wash will be given continuously via sprinkler for increasing speed of cooling down process. The extruder (printing head) will move according to the instruction given for the deposition of another layer of printing material in position on the 3D printer bed. Cooling down process will work simultaneously in order to make model rigid with accurate shape. This sequence occurs one layer at a time until the model is completed. The benefit of this project is that we have used material which is easily accessible to the common man and will be able to design this type of 3D printer as obtaining high end materials is difficult. However accessibility is considered more
. important than accuracy here. The printer is designed in such a way that it acts as a neutral extruder i.e. it will be compatible with different types of printing techniques the user may want to use techniques like fused deposition modelling, stereo lithography etc. which makes our project universal as we can use different types of 3D printing

mechanisms using same 3D printer model with only changing the extruder part.

V. WORKING

This project consists of 3 parts:

A. This part consists of giving input of the required design we want to print by making it in solid works and placing it in the 3D design of our hardware (3D printer) in solid works. Using solid works we will be able to get coordinate values of different Cartesian points in the Cartesian plane of 3D printer bed in which designed model is placed which will be further required for algorithm. The output of the solid works will be Cartesian points of the model that is going to printed which will be further used in the algorithm.

B. Part 2 consists of algorithm which is implemented in MATLAB whose input will be the coordinate point that we got from solid works and using these algorithm MATLAB will continuously provide distance of each carriage from 3D printer bed for each Cartesian point. These values will further used by stepper motors in order to determine number of steps required for the accurate movement of extruder.

C. Part 3 consists of programming of microcontroller for the movement of extruder by getting MATLAB output that is distance of each carriage from bed. Using these values microcontroller will calculate the required displacement and the direction carriage should move according to which it will give command to stepper motor to rotate for specified number of steps to achieve the required displacement for precise movement of extruder which will lead to printing in very accurate manner.

VI. TECHNICAL DETAILS

1) Hardware Description:

Delta 3D printer consists of 3 columns (3 pairs of support rods) which will provide the rigid support structure forming the backbone of the printer. This structure must be perfectly rigid and must not face any deformation due to the weight of the motors as well as the hanging structure. There will be top and bottom plates made up of hard plywood which are identical to each other. The top plate has a hole at its center while the bottom does not. This hole has no structural significance apart from to create a path for the wire to be extruded or the pipe that supplies the printing material to the extruder. Each column consists of one carriage which is connected via bearings so that the carriage can slide up and down freely. The carriage is connected to extruder platform via connector which has same length for all the three columns.

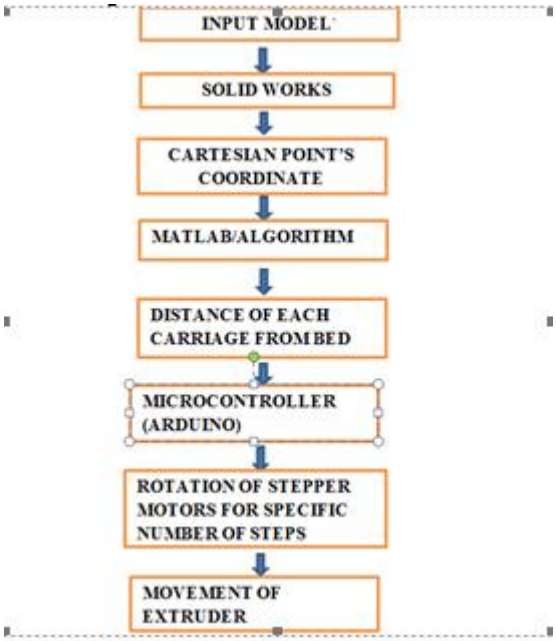

Fig 1. Flowchart of working of 3D printer

2) Hardware Designing*:*

Many designing software are available which enable us to design objects virtually. The vital advantage of these software is that we can check the feasibility of the designing objects. Working with virtual objects before realising them as objects helps us in reducing the wastage of material because of wrong designing. Solid works is one of the designing software where we can make 2D drawings, 3D objects and can assemble 3D objects available

Procedure for making 3D objects**: -** Firstly we have to select the 3D drawing option in solid works. Then we have to make 2D sketch of required shape with accurate dimensions. The 2D sketch will then be extruded to make the required 3D object. Once we are done with designing of all the required 3D objects we can assemble them to make the entire structure using the MATE option.

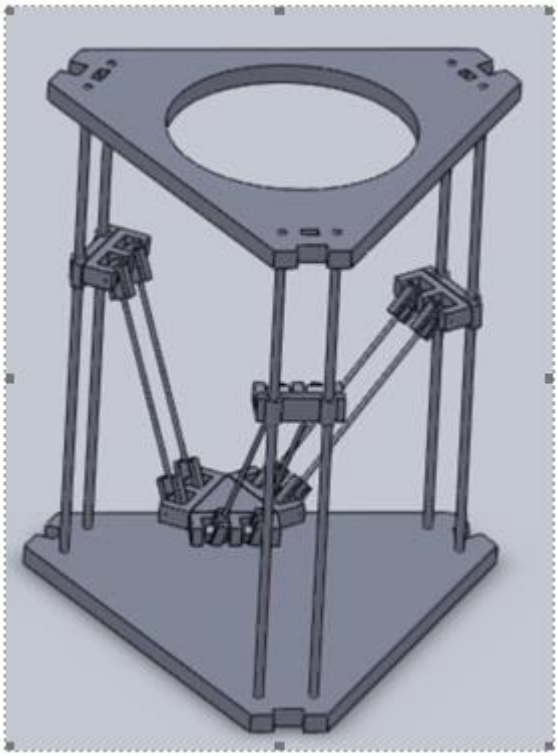

Fig 2. Final assembled structure

3) Algorithm

The movement of the extruder is peculiar in delta printers. The formula for movement of extruder varies from printer to printer depending on base size, dimensions of different parts of the 3D printer, hanging mechanism for arm lengths etc. Thus a method based on trigonometric functions must be derived. In this section we are going to give brief details of the algorithm for the movement of the extruder in a précised manner. This algorithm has utilized the concept of Cartesian plane with the origin as the center of bed for getting final output that is distance of each carriage from bed for each Cartesian point in the model of 3D printer. Basically this algorithm focused on relating the center point of extruder platform with the height of each carriage. The derived algorithm can be used for calculating the different heights of each carriage for every change in X, Y, Z value or Cartesian point of extruder value that is using this algorithm we can calculate the height of each carriage for the desired point in the Cartesian point where extruder platform wants to move which will result in precise movement of extruder. This will give us the desired 3D model.

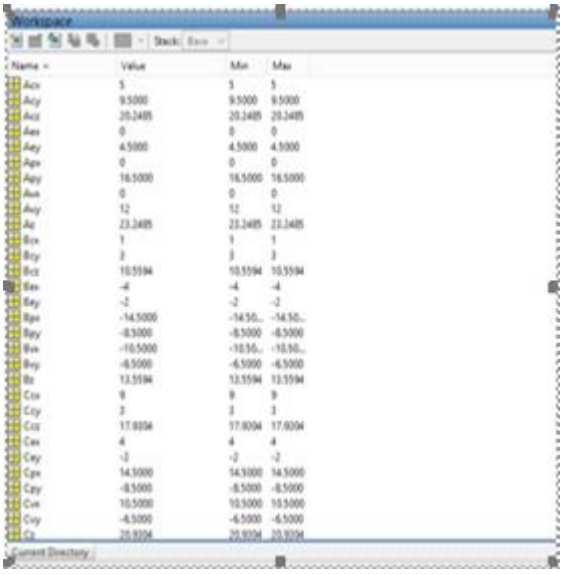

Fig 3. Final calculation of algorithm

4) Electronic components' interfacing Here we are using two Arduino Uno microcontroller in order to control 3 stepper motors which are brushless DC motor which divide a full rotation into a number of equal steps for getting the precise movement of extruder to get the desired 3D model. We have also used motor shield in order to provide proper torque to stepper motor such that it can easily be able to move extruder. Power supply is also used in these project to give the required power to motor shield which will be able to provide the desired torque for the stepper motors. In this section we are taking input distance of each carriage from bottom surface of 3D printer which will further subtracted by previous distance of each carriage which will provide displacement of carriage and according to this displacement value microcontroller will give command to stepper motor to rotate specific number of steps and in clockwise or anticlockwise direction. All the three motors are synchronized with each other to get accurate movement of extruder.

5) Printing material

In order to print a 3D model, we chose thermoplastic Poly Lactic Acid which has properties perfectly matching to the requirements of this project as it solidifies at room temperature due to its melting point of around 160 to 170 degree Celsius. Thus it will solidify at room temperature and we can make the desired design simply by melting it down using proper heating mechanism and further print it via nozzle which after coming down to room temperature will solidify and we will get required 3D model.

6) *Printing mechanism*

In this project we are using fused filament mechanism for printing that uses a continuous filament of a thermoplastic poly lactic acid. The filament is fed from a large coil through a

moving heated extruder head and molten material come out through head's nozzle and is deposited on the bed. Extrusion in 3D printing using material involves hot end and cold end where working of cold end part is to pull and feed the material from the spool and further push it towards the hot end. The hot end part is used to melt the filament and allow molten PLA to exit from the small nozzle.

VII. FUTURE PROSPECTS

The technology is becoming vital today as it has ushered us into a new era of technological advancement. In 2014 itself, the industrial evaluation of the technology in various sectors is around $4.5 billion. The standard we want to establish is to make our printer universal. By universal we want to embed every major 3D printing technique which is available in the market as mentioned above in "types of 3D printing." Section. We are suggesting that in order to make it universal, the extruder can be set neutral i.e. the extruder can be changed in accordance with the technique the user wants to implement and referring that we can change the settings on the heat bed. The bed is placed in order to sustain the impact from the extruder. Processes like slicing, modelling can be adjusted in the laying out of the material. We also want to implement internet of things in the prototype. We will connect the prototype wirelessly using either Bluetooth of Wi- Fi module which will help us to send the instructions from a distance to the printer and the prototype will develop the object accordingly.

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