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3D Printing Robotic Arm

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ABSTRACT

This project introduces the implementation of a low cost 3D printing Robotic Arm. Industrial Robotic Arms made up of several joints and actuated by motors are generally used in industrial field for lifting and manufacturing purposes. 3D printers are machines used for converting digital 3D model into physical 3D object. 3D object can be build by using Additive Manufacturing process. In AM process successive layers of material are laid one upon another and the process repeats until the final object is obtained. The additive process used in this project is Fused Filament Fabrication. By using this method it is able to print object more accurately and smoothly. FFF model uses thermoplastic filament that is wound on a coil and unreeled to supply material through cold end of an extrusion nozzle, which turns the flow on and off. The hot end of the extruder melts the material and can be moved in both horizontal and vertical directions. Both the movement of robotic arm and extruder is directed by a numerically controlled mechanism that is directly controlled by a computer-aided manufacturing software package. The model or part is produced by successively layering the thermoplastic material that is extruded from the nozzle. Movement of extruder is controlled by stepper motor. By combining industrial Robotic arm with 3D printing technology it is capable for increasing range of operation and it is comparatively more flexible than commercially available desktop 3D printers.

Keywords-- 3D printer, Robotic arm, Additive manufacturing, Fused Filament Fabrication, Extruder, Computer Aided Manufacturing, Nozzle

I. INTRODUCTION

3D printers are machines capable of making three-dimensional solid objects from a digital model by the process of additive manufacturing. In additive process successive +layers of material are laid down in different shapes to make the final object.3d printers are capable of generating successive layers, and therefore the final object under computer control.3D printer is said to be the catalyst for next industrial revolution. The 3D printer manufacturing industry is projected to have a huge growth in this decade. 3D printers can be used in a wide variety of fields, which itself increases its market potential. Industrial robotic arms are a versatile platform used in most manufacturing industries. Flexibility is the main quality of robotic arm that allows them to be utilized in so many different applications such as welding, painting, assembly, pick and place, product inspection, testing, and many more. The industrial robotic arm has a freedom in movement based on the number of serial links that have been connected. The main advantage of industrial robotic arm is their high degree of freedom. Because of this, the tip of a robotic arm has an increased level of freedom in its interaction with the work environment than that of a gantry machine conventionally used in 3D printers. This paper introduces the implementation of a low cost 3D printing Robotic Arm. Industrial Robotic Arms made up of several joints and actuated by motors are generally used in industrial field for lifting and manufacturing purposes. 3D printing exist by converting digital 3D model into physical three dimensional solid object. In this paper these two concepts are combined together. By using robotic arm platform for 3D printing, the area of printing can be increased by comparing with traditional 3D printers. This is possible due to the increased flexibility of the robotic arm. In this paper, additive manufacturing(AM) is the process used for three dimensional printing.. The additive process used in this paper is Fused Filament Fabrication (FFF). By using this method it is able to print object more accurately and smoothly. By combining industrial Robotic arm with 3D printing technology it is capable for increasing range of operation and it is comparatively more flexible than commercially available 3D printers.

II. LITERATURE REVIEW

3D printing is a fast growing technology discovered by Charles Hull in 1984. He invented stereolithography, a printing process that enables a tangible 3D object to be created from digital data. The technology is used to create a 3D model from a picture and allows users to test a design before investing in a larger manufacturing program. In 1992 3D printer was made by Hull's company called 3D systems.In1999 firstly 3D printing technology used in the medical field for manufacturing human bladder. In 2000 first miniature structure of human kidney was made using 3D printing. And in 2006 instead of sterieolithography new method called laser sintering method of additive layering is introduced. 3D printing is the process of making a three-dimensional solid object of virtually any shape from a digital model. Devices which perform 3D printing are called 3D printers. Mainly 3D objects can be manufactured by two processes, Additive process and Subtractive process. Subtractive manufacturing creates a product by removing sections from a block of material. The main disadvantage is that it generates waste through the excess material that is removed. It also got limited design capabilities Additive manufacturing creates a product through adding materials to the object. It adds material layer by layer until printing is finished. It also allows complex and intricate designs. Thus additive manufacturing is superior over the other for creating 3D objects. Here the additive mode of 3D printing is used and fused deposition modeling is the technique used. It is an additive manufacturing technology commonly used for modeling, prototyping, and production applications. The Fused Filament Fabrication (FFF) technology adopted in this paper belongs to this category.

III. METHODOLOGY

The first stage is to decide the robotic control system.Most 3D printers are controlled using G-code created using a slicing algorithm. The robot cannot execute G-code, so we brainstormed various solutions to the components that the robot control system required. Once prototype designs and plans for the individual components were completed, we analyzed the system as a whole. We ensured that each of the individual components could meet their requirements using a centralized power supply. For Gcode production we researched popular slicing programs before arriving at one that was reliable and free to use. For G-code translation program was written iteratively. New program features were written then thoroughly tested before additional features were begun.

Here we are using LPC2138 ARM processor as the controller section using Kiel software and A4988 is the stepper motor driver used for driving the stepper motors.

BLOCK DIAGRAM

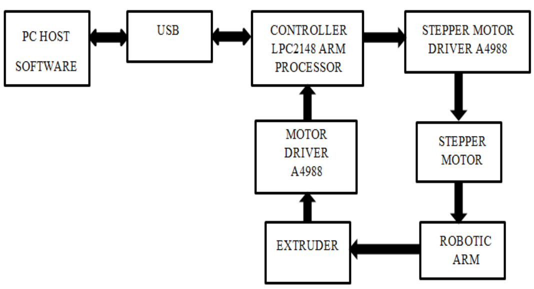

Fig.1 Block Diagram

The G code for the image, to be printed is generated by the software's in the pc. This G Code file then given to the controller section by connecting a USB to PC. The controller converts the G Codes into machine familiar language. Controller generates pulses for driving the stepper motor according to the G Code. A4988 stepper motor driver is used for driving the stepper motor. Here four stepper motors are used. Three of them for X ,Y, Z movement and one for extruder. At the end of the robotic arm an extruder is connected. The motor moves the arm and the extruder connected at the tip of the arm in various trajectories of image. Through the nozzle present at the tip of the extruder is providing the material for printing. The stepper motor connected to the extruder allow the movement of printing material.A4988 stepper motor driver is used for driving this stepper motor.

IV. STEPS IN 3D PRINTING

Fig.2 Steps in 3D printing

There are various steps involved in creating a 3D object from a digital model and a number of softwares are used for this purpose. The above figure explains various steps in creating a 3D object from a CAD model. In the first step the CAD model of the object to be printed is created using a CAD software. The output of CAD software is converted into codes for 3D

Printer using a slicing software. The codes generated by slicing software are used by printer to create the object.

A. Computer Aided Design (CAD)

Before slicing it is important to consider the way a digital model is obtained as an STL file. There are many different possibilities to model objects, such as 3D scanning, taking measurements for a full-scale replica . Furthermore by taking a video or a series of pictures all around an object it is feasible to feed those into a program like Autodesk Memento and create a 3D model. The easiest way is to download existing models from online platforms i.e. Grab CAD or similar ones. As a consequence that all of these methods are making use of a computer, which leads to the fact that this entire process is called Computer Aided Design (CAD).

B. SLIC3R

Slic3r is a tool which translates digital 3D models into instructions that are familiar with 3D printer. It slices the model into various horizontal layers and generates suitable paths to fill them. Slic3r also generate code for tool path to create each layer. These codes are called G-codes. It is one of the commonly used numerical control language.Slic3r has a tool, called Plater, which allows one or more models to be loaded and arranged before being sliced. Once we acquired a model, drag it onto the Plater window to load it into Slic3r.

C. STL format

STL means Stereolithography and can be exported into most CAD software suites. It is a file format native to the stereolithography CAD software created by

3D Systems .STL has several after the fact back acronyms such as "Standard Tessellation Language". This file format is supported by many other softwares and it is widely used in applications like rapid prototyping,3D printing and computer-aided manufacturing .STL files describes only the surface geometry of a three-dimensional object without indicating its color, texture or other common CAD model attributes. The STL format specifies both ASCII and binary. Binary files are more common, since they are more compact. An STL file represents a raw unstructured triangulated surface by the unit normal and vertices of the triangles using a three-dimensional Cartesian coordinate system.

D. G-code

Most 3D printers includes three axes, an extruder, a hot end and a heated bed. Therefore it includes four motors and two heated elements to control. With an STL file the printer is not yet able to control the requested moves. Hence, a G-code is introduced to transfer the required movements to the tools of the printer.

G-code, which has many variants, is the common name for the most widely used numerical control (NC) programming language. This language is mainly used in computer-aided manufacturing to control automated machine tools. G-code is sometimes called G programming language The G programming language provides ever information the printer needs to know to print the desired object, including the speed and path of moving the axes. In addition it has to supply information about the temperature of the heated elements and speed of extruding the filament.

V. ALGORITHM

The Fig 3 shows algorithm determines the conversion of G-codes. From the G codes each lines are captured. First capture the G-code and if \n or \r is present then it will be the end of the line. Then check for the presence of any symbols like,'(',')',';' etc then neglect the Gcode. And then check the condition of alphabets. If it is lower case then convert it into upper case. Make the position of X,Y and Z axis to its minimum position and then capture the index number of each axis.

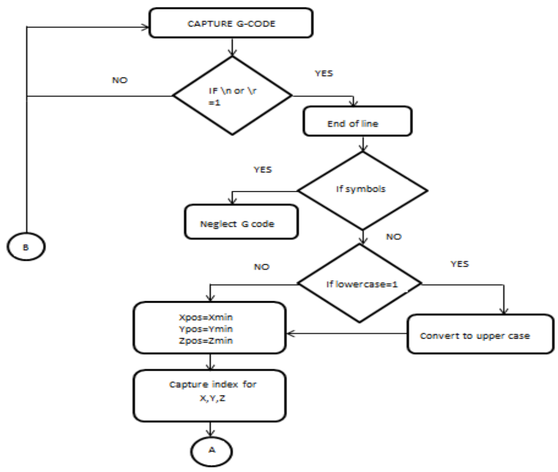

Fig.3 Algorithm part 1

In Fig:4, if the index of X axis is zero then check the index of Y. If it is a non-zero value then new position is attained by adding index number of X with current position of X. If index of Y is non zero value, then new position of Y axis is attained by adding the index number of Y axis with current position. Then finally check the index number of Z axis, if it is non zero then new position of Z axis is obtained by adding the index number with current position of Z axis. Finally three axis got the current position and moves three motors accordingly. Then again capture the next line of G Code for the next movement.

VI. RESULT AND DISCUSSION

Here we are exploring the possibilities of integrating 3D printing technology with robotic arm is used for both prototyping and distributed manufacturing with applications in architecture, construction, industrial design, automotive, aerospace, military, engineering, civil engineering, dental and medical industries, biotech (human tissue replacement), fashion, footwear, jewellery, eyewear, education, geographic information systems, food, and many other fields. Successfully developed the mechanical structure of the robotic arm and interfaced robotic arm with LPC2148 ARM processor. Generated G-codes of various figures and converted those codes to controller familiar language.

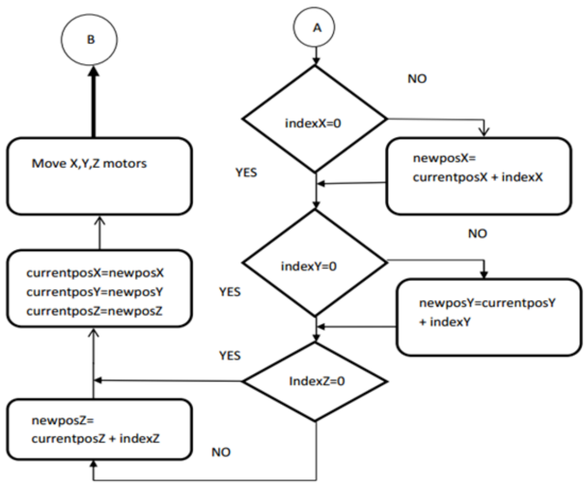

Fig.4 Algorithm part 2

Designed the PCB board with controller section and the motor drivers, A4988 stepper motor driver is used. The commercially available 3D printers usually have a printing area of dimension about 200mm x 200mm x 100mm.Inorder to increase the area of printing and to print tiny curves more flexible structure is required. This is where the importance of 3D printing robotic arm exist. This is low cost, simple mechanical design and these features makes it suitable for households, educational applications and hobbyist purposes. For printing wide range of materials are used including plastics, resins, metals, ceramics and more. Even concrete are also using as printing material now a days. The most popular material. used is plastic and most of style printers print objects using plastic, however some of the higher-end printers are capable of printing using many different materials. The printing material used here is PLA material, PLA is probably the easiest material to work with when you first start 3D printing. It is an environmentally friendly material that is very safe to use, as it is a biodegradable thermoplastic that has been derived from renewable resources such as corn starch and sugar canes. So it is not a harmful for nature and it generates only negligible waste. And it is easy to use ,no skilled person is needed.

VII. CONCLUSION

Successfully developed the mechanical structure of the robotic arm and interfaced with the ARM processor. Developed G-codes for various figures and successfully translated to controller familiar language. Thus by combining the highly flexible robotic arm structure with 3D printing technology it is able to increase the printing area and can print tiny curves easily.

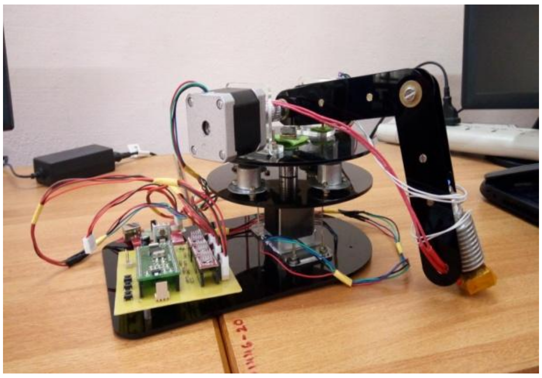

Figure 5 Working model

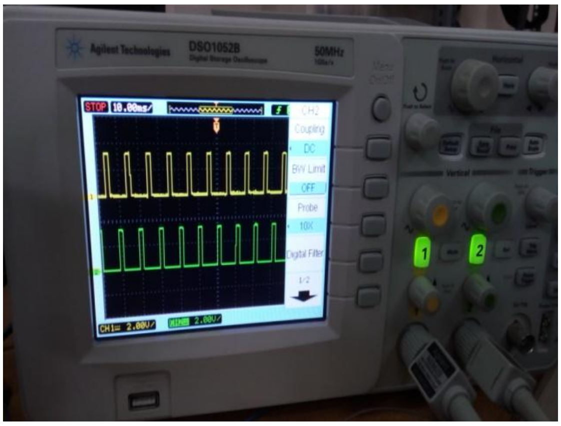

Figure 6 Stepper motor driving signal

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