

Open Source IOT Based 3-D Printer

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ABSTRACT

IOT stands for Internet of Things consisting of physical devices having sensing elements, actuators, and their network connectivity that enables these devices to acquire process and exchange the data. 3D printer works on additive process in which material adds up layer by layer to form 3-D objects. As the technology is getting advance engineers are switching to additive manufacturing or 3D printing technique that can print models in various colours, scale, and materials in 3-Dimensional just by giving digital inputs. 3D printing and IOT are two new as well as important technologies, which plays an important role in direct or indirect ways to industries and also in our everyday life. The objective of this paper is to make an IOT based 3D printer which will show the remote monitoring of 3D printer including the speed, bed temperature, and can provide feature to stop or resume the printing. Also we can send the G-code without connecting 3D printer to any computer via wire or by means of storage device.

Keywords: IoT, 3D printing, sensors, bed temperature

INTRODUCTION

When any machine is controlled by any computer for automation by means of executing pre-programmed sequences, the machine is termed as computer numerical control (CNC) which is a revolutionary idea for industries as earlier machine were controlled manually by means of lever or wheels [1]. The input in the form of accurate dimensions of the object or design is given into the software which is programmed using the universal language that is CNC working along with the G-code.

Much of the research has been done in the field of manufacturing with the coming up of CNC technology. This further gets advanced in getting more easy operation and compact design which results the new innovation of adopted manufacturing. The new technology worked in the same manner as CNC milling machine however there is a difference unlike CNC milling machine additive technology uses the concept of addition of materials to form a 3-D object. In recent times, many of the engineers have relied upon additive manufacturing or 3D printing. Which can enable them to print models in various colours, scale, and materials in 3-Dimensional just by giving digital

inputs. 3-D printers are becoming more and more intertwined with day to day operations like medical, education, industries etc[2][3].

The internet of thing (IOT) and 3D printing are two new technologies, which progressively impact a lot of the industries and also our day to day life [4]. Internet of Things consisting of physical devices having sensing elements, actuators, and their network connectivity that enables these devices to acquire process and exchange the data. With the help of internet of things, existing network infrastructure can be remotely controlled, creating opportunities for further integration of the physical world into automated system hence resulting into improved efficiency, accuracy, reliability and economic benefit.

The overall objective of this paper is to develop an open source, IOT based 3-D printer which will be able to collect and exchange data. With the help of internet of things, we can have remote control across existing network which will be able to fetch the data related to temperature of hot bed, speed, how much time will require to finish the job or to send G-code. The paper is divided into 4 sections- first explaining the methodology and hardware, second includes the comparative analysis of existing trends, third includes the applications and results and fourth depicts the conclusion.

OTHER 3D PRINTING SCENARIOS AND TREND ANALYSES

We shall present some other futures oriented analyses related to the future of manufacturing and 3D printing. First we present technological foresight results, which are based on Delphi expert panels [5]. TechCast Project published first public results in 1998; latest results were published in 2013 [6]. When we analysed the futures of manufacturing three fields of technology, require our special attention. These fields are: 1 information technology 2 manufacturing and robotics 3 medicine and biogenesis. Figure 2 presents a visualisation of the results of the TechCast results. There are also critical fields for 3D printing. Manufacturing and robotics are marked by bold frames. Medicine and biogenetics are marked with grey shade. Horizontal variable year indicates most likely year of maturity in that technology field.

METHODOLOGY

The 3-D printer was manufactured with aluminium body by using linear bearing as they are more precise and light weight and use belt drive system for moving the extruders as well as the hot bed with the help of the Nema 17 Bipolar stepper motor having torque of 4.2 Kg-cm. The IOT platform was used to exchange the data is PTC Thing Worx Technology Platform. We have used this platform because of the availability of complete set of IOT tools and features that can support the IOT application we require.

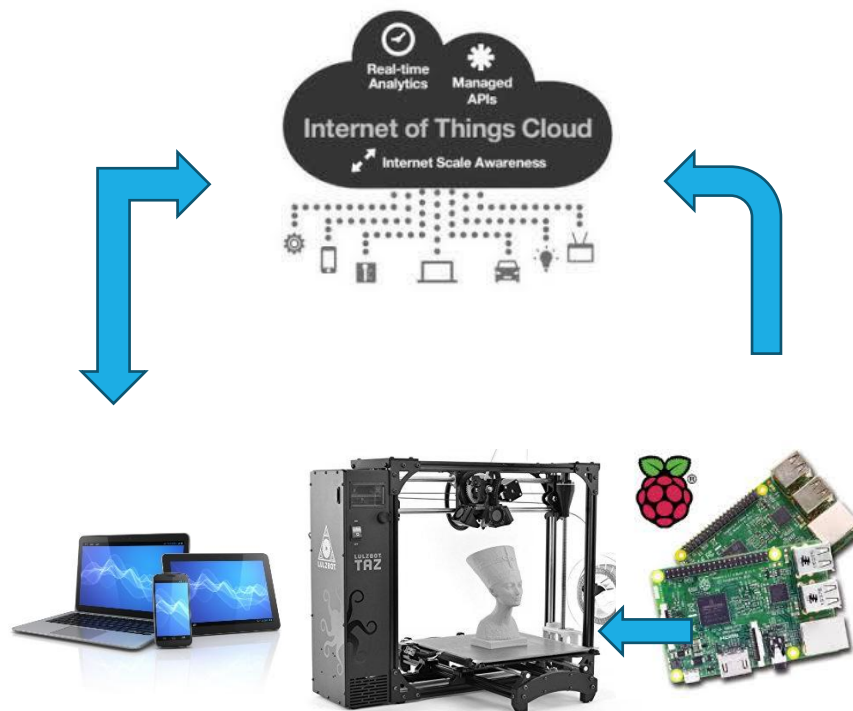


Figure 1: Block Diagram of the System

We have use Raspberry Pie 3 model B as the processing boardin this project as it provides better connectivity. It has on board Wi-Fi and Bluetooth. The operating system is Raspbian Jessie which will connect to internet as well as to the 3-D printer and makes a compatible IOT application in ThingsWorx composer which will be responsible to exchange the data from 3-D printer to user via protocols and give the features to monitor and to control the machine in remote network. Composer is an integrated development environment (IDE) that is used for IOT application creation. With the help of composerwe can achieve both the data modelling and user interface development building aspects

Arduino Rambo 1.2G is being used to control the stepper motor. Arduino Rambo 1.2 G is a microcontroller based board for 3-D printer. It integrates the stepper motor, hotbed, extruder, fan driver, and thermometry all in one. It will receive the data from raspberry pie as it has IoT connectivity where data will be enter or receive by the user.

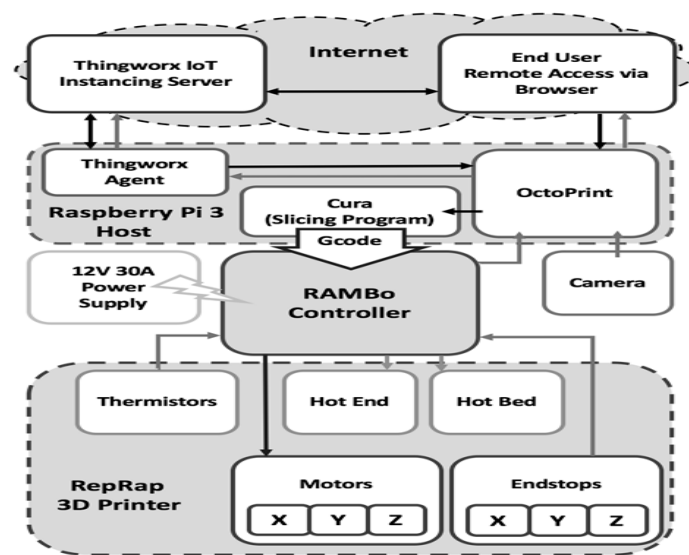


Figure 2: Flowchart of the system

HARDWARE

Mechanical setup

Design:

This 3-D printer is 3 axis having total 5 Nema-17 stepper motor one for hot bed, one for extruder, one for horizontal and two for vertical axis. Whole body is made up aluminium for light weight and for grater strength. It has work space of $10 \times 10 \times 15 \text{ cm}^3$ and having belt system for movement of extruder and hotbed.

Bearings:

Bearings are the most important part of a machinethat is used to reduce its frictional resistance for any kind of motion it will be in- Rotational or Linear. Here linear bearings are used to reduce linear friction through the pipe supports.

Supports:

It is very crucial for a machine to rotate its router in all the axes while under operation. The movement of the rotorneedto besmooth and idealaccordingto the specificationsgiven through the user commands. This router movement is given by belt which is connected to stepper motor but the support given herewith nickelled pipe with 8mm diameter.

Electrical and Electronic parts:

Microcontroller:

Without the microcontroller it is not possible to control the motion of the machine. Here we have used board withArduino RAMBO 1.2G microcontroller and Raspberry Pie 3 model B processing board for making a link between IOT application and the printer.

Motor drivers:

Many motor driving ICs are available to run a stepper motor. H-bridge based motor drivers are mainly considered for their less cost and easy to use. But these are not compatible for CNC or 3-D printing type of applications because micro stepping capability is required. This is the reason these drivers are not supported by the software. Hence Polulu drivers are being used which is inbuilt in the Arduino Rambo 1.2G.

Stepper motors:

The DC motors that move in discrete steps are known as Stepper motors. They have multiple coils-Phases that are organised in groups. The motor will rotate one step at a time by energizing each phase in sequence. Bipolar stepper motors are more preferred as they have higher torque capacity. In this paper NEMA 17 batch motors have been used because of their advantage of being not too expensive but very effective in their position.

Power source:

The power given to the shield decides the torque of the stepper motors. So, a power supply of 18 V and 2.5 A rating is given to three individual stepper motors and their drivers. A 20 V 4A transformer controlled by some ICs is used to generate a regulated output.

RESULT

In 3-D printer the Raspberry Pie 3 model B having operating system Raspbian Jessie acting as the host which is used to control the printer and collects the physical parameters like temperature, speed and time remaining to complete. This parameter will send to client which is for the IOT application with the help of protocols. In RAMBO 1.2 G we have also installed the LCD of Adafruit TFT display this data can also be transfer through protocols and we can check the status of printer on run time with the help of IOT application apart from that we can also pause or resume the job with the help of user interference of application. If we want to see the run time process we can also installed the camera which will transfer the live video to application. The IOT application interference is shown in fig where we have feature like video to see the printing on run time, can adjust the rpm of fan also can change the temperature of hot bed and nozzle. This interface can access to multiple device may be it is your smart phone or your laptop just u can make a g-code file by putting the dimension of the work piece and save, with the help of this IOT application we can send the G-code to the printer and able control and monitor the printer wirelessly with the help of internet of things.

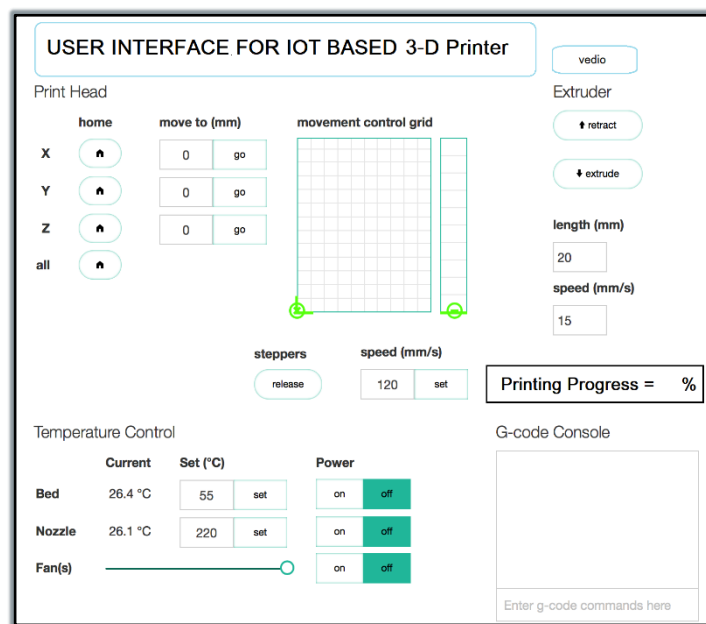


Figure 3: 3-D printer User Interface

APPLICATIONS

1. Shelter

One of the basic necessities of human beings is Shelter. 3D printing has an important application in this field. The building construction field is amongst the last fields where human labours are given preferences over robots. Although a large population is still under scarcity of food and shelter yet these fields remain labour intensive instead of being automated. Keeping in view a large number of risks that can be foreseen in traditional building methods like hazardous working conditions, costly and time laboriousness. 3D printing of buildings can give a possible solution to these issues by the creating automatically different types of buildings much faster and in a reliable manner. This technology was first come into existence after the research at University of Southern California.

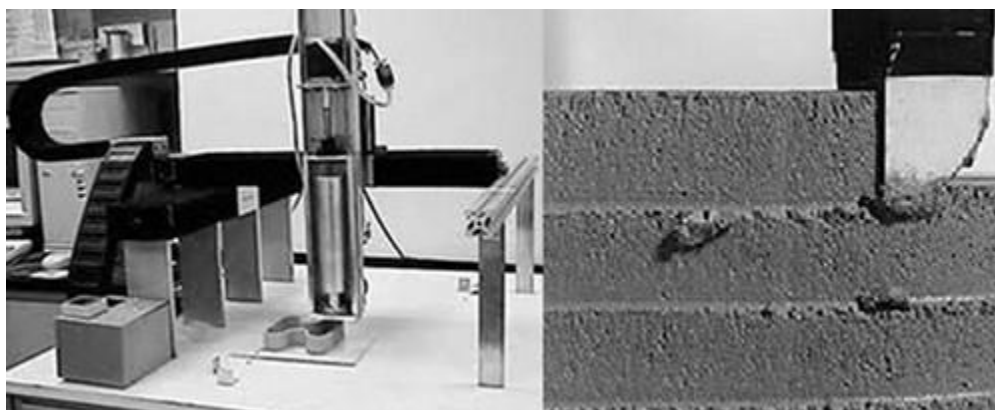


Figure 4: 3-D printing Application in Shelter

The technology is being used in different types of housings schemes with applications in every kind of custom designer homes, large scale infrastructure projects, and short-term housing projects. This technology can also help engineers to work in the high labour intensive areas for constructing difficult and typical geometries like DOME geometry.

2. Bio-Organ printing

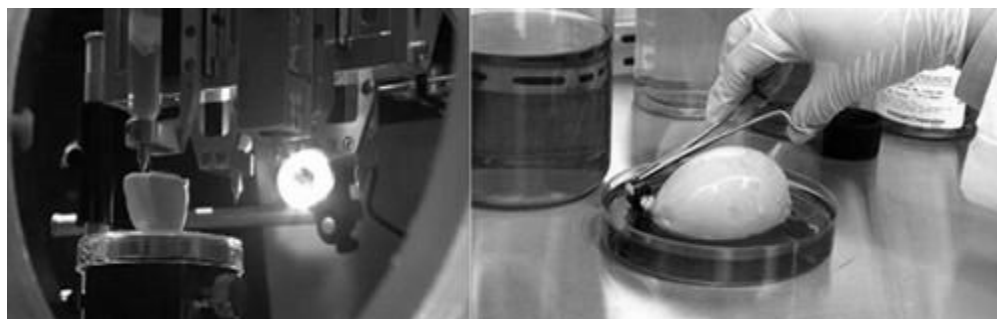


Figure 5: Bio printing machine (left), Bio-printed model (right)

Regeneration of tissues and organ is an implausible ability in plants, mammals and vertebrates unlike in humans which have limitations in this. It is a whole new field of science that provides the regeneration of new tissues or a complete organ from multiplication of cells. The cells are taken into 3-D containment that not only provides the 3-D proliferation but also required nutrients for their growth [7].

3D printing of human tissues and organs has been a revolutionary step in the healthcare industry. It not only increases the average life span of humans but also improves their quality of life. The longer waits of months or years by the organ recipients for a donor will be over now. There will be less issues of incompatibility because of the mismatching of correct blood type consequently organ transplant rejection can be abolished. This will also put a check on illegal trafficking of human organs. The people who have lost their limbs in wars and accidents will be able to gain their mobility once again. 3D Bio-printing can have extraordinary consequences on regenerative medicine and quality of life simultaneously.

3. Dental implants

Since many years now, dental industry is using artificial materials for dentures, orthodontics, implants, and crown like operations. As these parts are subjectively designed separately hence this process is expensive and time consuming. The direct and indirect 3D printing, namely printing the actual parts or a mould, has been proven to be a cheaper and faster alternative to conventional techniques[8].

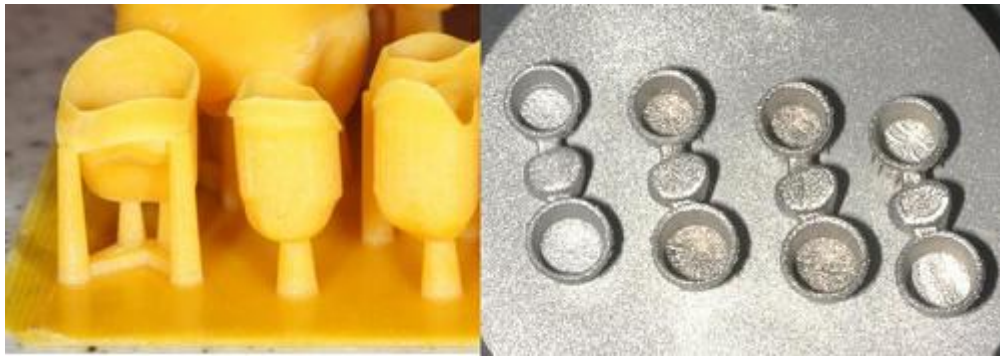


Figure 6: Dental Industry and 3-D Printing

4. Education

The education system can be revolutionised through the 3-D printing technology and will help in the overall development of the students. 3-D printing technology will provide the new learning experience to the students by making them capable to realise their idea and concepts. Many affordable 3-D printers are available for educational purposes for design and fabrication of student projects.



Figure 7: 3-D printing technology (left), 3-D printed ornaments (right)

5. Creativity

Human being is a social animal. Having been using its mind and creativity to express itself is its prime function. Regarding this 3D printing can be helpful in creating the structures and objects having precise and intricate geometries which are very rare, expensive, or impossible to be manufactured using traditional manufacturing methods. Figure 13 shows two such ordinary customised designs that are highly rare and intricate[9].



Figure 8: Stiletto heel in Eiffel tower form (1), Minute design ring

CONCLUSION

This IOT based 3-D printer has number of application and it will save more time to print number of objects as compare to ordinary printer. We can access and send G-code file wirelessly from anywhere in remote network. It is one more step towards making our 3-D printer smarter and IoT use will help to connect to other devices in future and print by its own without any kind of human input. Additive manufacturing and IoT forms an advance combination of technology as both are in the forefront in today's trend. Digital manufacturing has enabled us to convert the digital model into reality. 3D printing enables us to design limitless complex geometries. Prototypes and short series productions can easily be fabricated using it. This has made it easy for us to find the solutions in different fields like Automotive, Medical, Aerospace, Consumer, and many other products.

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