A New Generation Fast, Economical, Environment and User Friendly Three Dimensional (3-D) Printer

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Abstract – **As we move ahead towards 21ˢᵗ century, the era of 3D printing technology will be a boon for the human race. 3D printing is the process of which you can form any solid shape from its digital model. Doesn't it sound interesting? 3D printing as a widely emergent technology is being widely considered as the most significant technological break-through of the 21ˢᵗ century. 3D printing will change the way we purchase goods, personalize items and manufacture products. In today's world, time and money hold the utmost importance but these are the only two major issues with the 3-D printer. My research paper will try to solve this purpose by giving a great concept and several ideas to increase its overall production time and making it more economical for customers and eco-friendly for the environment. Apart from figuring out ways to increase production time and make the 3-D printer more economical, the research paper also focuses on the required previous work and the ongoing work in the field of a 3D printer. It will also provide insights of 3D scanning. A 3D model which can be scanned and then printed would save a lot of time and money instead of simulation programs.**

Keywords – 3-D printer, time, economical, additive manufacturing, rapid prototyping, stereolithography

I. INTRODUCTION

Have you ever wanted to control how the things you use look, feel and function? Imagine being able to think of a design for a screwdriver and then make that screwdriver right away. Maybe you want to make a plastic mask for your party or perhaps you need to replace the broken part of your bike. There is a type of machine that allows you to quickly create objects like this. 3-D printers use designs made on computers to make three-dimensional objects right before your eyes. You can control the size, shape and even the material of the objects.

3D printing is a popular and rapidly expanding field. Additionally, the uses for 3D printers are growing every day. 3D printing can be used to prototype, create replacement parts and even versatile in printing prosthetics and medical implants. It will have a growing impact on the world, as more and more people gain access to this amazing machine.

Reference [1] defines 3-D printing also known as additive manufacturing or rapid prototyping as building 3d objects using plastic filament, resin or other material from a digital design. The creation of the 3D object is achieved by building it up layer by layer, rather than machining it away, the way you would be making something from a block of wood, or squirting something into a mould, as you would for injection - moulded plastic parts.

Its flexibility and the sheer magic of seeing something built from nothing have captured people's imagination, and it is clear that surprising applications will continue to pop up for years to come.

3-D printers are the new breed of the old printers that we use today. Futurologists such as Jeremy Rifkin believe that 3-D printing signals the beginning of a third industrial revolution, succeeding the production line assembly that dominated manufacturing started in late 19ᵗʰ century. Using the power of the internet, it may eventually be possible to send a blueprint of any product to any place in the world to be replicated by the 3-D printer with "elemental inks" capable of being combined into any material substance of any desired form. [2]

Let us imagine our lives a few years from now when 3-D printers would dominate almost every industry. Let's take a look at the food industry. Sell your food recipes online, give a print command to one of your favorite recipes and you get a freshly printed 100% edible ready to eat dish or a food item. Taking a serious look at the usage of the 3-D printer in the food industry, patients that are advised certain types of food can get their desired food printed. Diabetic patients suffering from high blood pressure need a specific type of food. The 3-D printer can print every type of food that you require at your home, within a few minutes, without actually cooking. The tedious preparation part while cooking usually discourages people to cook. But with the emergence of the 3-D printer in the food industry, all these problems can be solved. One such printer is available and that is "FOODINI". Promoting cooking with fresh ingredients, FOODINI manages the difficult time-consuming parts that often discourages people from creating homemade food. [3] [4] [5]

Presently different 3-D printers like object 500 Connex3 of Stratasys, 3-D systems, Voxeljet, Exvive 3D of Organovo, CLIP technology 3D printers Carbon 3-D etc. are available. None of them is complete in itself. Further, production time is the issue with everyone except the CLIP 3D printing technology of Carbon 3D but CLIP loses in terms of the economical factor. Major and common problem in all of them are that they need the G-Code in order to run and so 3D modeling is necessary. My research paper solves this problem by integrating 3D scanner and required software that will create G-code of a live object just by scanning it. Therefore, saving overall production time in replicating the object you already have. [6] [7] [8] [9]

Both time and money in today's world have a huge significance. Now since time is money the second effort of my research paper will be making 3-D printers more economical. This can be done by making 3-D printer smart enough to replicate their own parts. This concept can be very useful in making it economical (First implemented by RepRap, an open source community). Further, the filament rolls or the plastic rolls that will be used for creating the replicated parts can be made by integrating or adding a device that recycles old material to create filament or plastic rolls that will be used in making replicated 3-D printer. [10] [11] [12] [13] [14] [15]

There are three major steps to make a real object using 3D printer (which is called as overall production time). They are -:

- Designing 3-D model
- Slicing 3-D model using various slicing software that will create G-code
- Calibrating printer
- Printing object

My research paper will explain the advantages of combining these three steps and using alternatives to make the process of printing fast and efficient. The research paper will be guiding you through the various efforts and technologies used in making a 3-D printer. This will include giving eye shots of advantages and disadvantages of combining three technologies.

Final research efforts, therefore, include

- Various efforts and technologies used in reducing overall production time 3-D printer.
- Confirming Advantages of combining all the steps of additive manufacturing.
- Explaining and confirming the ideas in making 3-D Printer economical.

Section 2 gives the contribution of various people in the field of making 3D printer fast and economical for customers. Section 3 explains the methodology to create a 3D printer that is both fast and economical .
Section 4 presents results from the above research and study. Section 5 is the conclusion part gained from the research. It will also give a detail information on future work.

II. RELATED WORK

This section will brief you on the prior work in making 3D printers fast and economical. Furthermore, details on the ongoing work is also provided in this section.

A. Seed - 1981

Several additive manufacturing methods were available in 1980's but the idea of 3-D printing first came into the limelight when Hideo Kodama of Nagoya Municipal Industrial Research Institute invented two additive manufacturing fabricating methods of the three-dimensional plastic model. This gave rise to the idea of printing 3-D objects using a device that is now called as the 3-D printer. [16] [17]

B. Sapling – July 16, 1984

Alain Le Méhauté, Olivier de Witte, and Jean Claude André filed their patent for the stereolithographic process, a process which is the foundation of 3-D printing technology. Three weeks and 2 days later Chuck Hull filed his own patent for the same. He created the first prototype of 3-D printer in the same year which was later accepted by 3D printing software and digital slicing software. [16] [17] [18]

C. Plant – 1990

In 1990, 3D printers started emerging more than just a nebulous idea. In the same year Fused deposition modeling (FDM) was commercialized by Stratasys company. But the patented technology acted as a hurdle to be used by others, before its expiration date. After the expiration of the patented period, many open source communities opened up, one of them being RepRap. This was the first stride in price dropping factor of 3D printers. This has led to two orders of magnitude price drop since the creation of this technology. [16]

D. Tree - 2000 to Present

Up until 2005, 3D printers were fully developed but were operational only at the industrial level. They were also costly and proprietary. In 2006 first two DIY 3D printers Fab@Home and other was the RepRap were influenced by the idea of Altair 8800 one of the first DIY computer kit, released in 1975. DIY concept in 3D printers was a smart step taken by these companies to eliminate the high price factor. Now the 3-D printer's DIY kits were launched and were affordable to everyone. This was the second stride towards making 3D printers economical. [19]

During 2006 RepRap, an Open source community thought of a great idea which was to create a part of the 3-D printer using a 3-D printer. On September 13, 2006, the RepRap 0.2 prototype successfully printed the first part of itself. On February 9, 2008, RepRap 1.0 "Darwin" successfully created half of its parts. This was the best and 3rd stride in making it economical. [12]

During 2014, the cost of filament used by 3D to make 3D objects shot up. Due to an adulation of 3D printers, a new idea was introduced, Filament Recyclebot that could use old plastic bottles, shampoo bottles etc. to create a filament. The filament could then be used to manufacture 3D objects that were both feasible and eco-friendly. Later in 2015, filament makers like Filabot, Filafab, Filastruder etc. came into light. In 2016, Redetec introduced Protocycler that has an extraordinary mix flow technology that can extrude 5ft/min using waste plastic. Protocycler is currently available for pre-order. This marked the 4th stride in making 3D printers economical. [13] [14] [15] [20] [21] [22] [23]

There were several 3D printers based on the stereolithography but the poor quality, rugged side and slow speed lead to lagging emergence of this revolutionary technology until February 10, 2014 when patent for the Continuous Liquid Interface Production (CLIP) technology was filed by EiPi Systems, Inc as applicant with the following individuals titled as 'inventors': Joseph M. DeSimone, Alexander Ermoshkin, Nikita Ermoshkin and Edward T. Samsuski. Later Carbon 3D. Inc created the CLIP based 3D printer M1, which is 100 times faster than the pioneer technologies and can print an object in around 15 minutes with great quality and smooth surfaces. Numerous technologies existed but speed remained an unsolvable problem. New technologies were introduced but the alterations in the production time were minimal. CLIP is the pioneering technology that reduced the production time onto a scale of 100 to 1. Therefore, CLIP technology is considered the first stride in reducing the production time of 3D printers. [24] [9].

In 2016 several 3D printing companies launched their All in One (AIO) 3D printers. They include FLUX Delta of FLUX Inc, ZEUS of AIO Robotics, Da Vinci of XYZ printing etc. These printers save the overall production time by scanning the real object to create G-code which is comprehensible by 3D printers instead of making a 3D model of the object. This has been the second stride to increase the production time of the 3D printers as a whole lot of time was wasted in creating a 3D model of the object and to create the 3D model one should have a command on AutoCAD, blender etc. [25] [26] [27]

This was the brief of the prior work to reduce the overall production time of a 3D printer and making it economical for users as well as making it easy to use but the above references are for either speedy or economical 3D printer. My research paper will give a theory to create 3D printers which are both fast processing and economical.

In Section 3 i have given a proposed methodology of my research in which I have given a theory to reduce the overall production time of a 3D printer and making it economical to buy as well as for printing objects through it. While making it the environmental factor is also take care of and so it is made eco-friendly. I have also provided the cost approximation in my proposed methodology and list of material required to build it.

III. PROPOSED METHODOLOGY

My proposed methodology for reducing the overall production time of a 3D printer and making it economical at the same time is based on ensuring the possibilities of combining the filament recycling hardware and 3D scanner with the 3D printer. Thereafter, integrating them with a 3D scanning software and a slicer that will create G-code for the 3D printer to work.

After this we will confirm the advantages, price factor and speed factor.

We will use **RepRap snappy** as a 3D printer

Advantages for choosing this model

- Open source

- Uses very few non-printed parts (therefore easy for self-replication)

- Design does not need belts, pulleys, metal rails, and almost no screws outside of the motors or extruder hot-end.

- Can be made under 300$.

Specifications

- Around 57 different parts can be printed.

- Non-printed parts: motors, electronics, glass build plate, 2 ACME threaded rods, one 686 bearing.

- Printing size: build area of about 7.5" x 7.5" x 7.5" or 19cm x 19cm x 19cm.

- Material cost : US 85$.

- Cost: under 200$ (after using filament from recycling bot else cost will be under 300$).

- Precision: about 0.05mm XY, 0.01mm Z.

- Speed: 100mm/sec (printing)

Bill of materials

ELECTRONICS			
Qty	Description	cost	Where found
1	Power supply, 120W (300W w/ Heated Bed)	~20$	Amazon.com
1	Controller electronics (RAMPS1.4+2560+Polo-lus)	~42$	Amazon.com
3	Mechanical microswitch end-stops and wiring.	~5$	Amazon.com
5	NEMA17 Stepper Motors, $)mm Length, !m cable	~65$	Amazon.com
1	J-Head Extruder hot end w/heater, a thermistor.	~32$	Amazon.com
2	40mm 12v 2-pin cooling, 10mm thick	~4$	Amazon.com
1m	wire, dual conductor,gauge	~1$	Amazon.com

HARDWARE			
Qty	Description	Cost	Where Found
2	ACME threaded rod, 3/8" -8 x 12"	~18$	Mcmaster.com
1	Extruder Drive Gear	~4$	Amazon.com
1	686 Bearing	~1$	Amazon.com
1	Borosilicate glass build platform (213 x 200mm)	~22$	Amazon.com
4	Mini binder clips	~3$	Amazon.com

Total cost will be around 217$ excluding shipping charges and labor.

Reference [28] [29] [30] [31] gives all the steps and codes to make RepRap snappy.

For 3D scanner, we will use **Sarduscan,** a DIY 3D scanner.

Advantages of choosing this 3D scanner

- Simple to design and build.
- Cheap (30$ or 12$ if u have a computer webcam).
- Evolutive
- Provide a complete solution.
- The scanner is a totally open source and open hardware.

Bill of material

HARDWARE			
Qty	Description	Cost	From Where
12	M3 (16 and 20 mm)	~1$	ebay.com
12	M4 (12 and 20 mm)	~1$	ebay.com
1	Arduino nano	~4$	ebay.com
1	Chinese stepper motor (28BYJ-48) and controller (ULN2003)	~5$	ebay.com
1-4	Line laser 5v	~2.5/piece	ebay.com
1	Hercules HD Twist	~15$	ebay.com

Total cost will be around 26$ (1 laser) to 35$ (for 4 lasers) excluding shipping charges and labor.

Reference [32] [33] gives all the steps and codes to make Sarduscan 3D scanner.

Now for producing filament from the waste we will use any DIY Filament extruder, I will use a filament extruder called **Filament Factory.**

Advantages of choosing this model

- Open source.
- Readily available parts.
- Very cheap in term of the price factor.
- Easy to build.

Bill of materials

HARDWARE			
Qty	Description	Cost	Where Found
1	Wiper motor	~5.5$	Junkyard.com

1	Motor controller 20A	~3$	ebay.com
1	Power supply 12V, 240W+	~4$	ebay.com
2	Fans (80mm)12V	~4$	ebay.com
1	Fitting ¾" US	~1$	ebay.com
1	Water tap extension- ¾"	~3$	ebay.com
1	End cap ½"	~0.2$	ebay.com
1	Faucet mounted filter – ½" diameter	~10$	ebay.com
3	Steel angle	~22$	ebay.com
1	Axial ball thrust bearing	~5$	ebay.com
2	10mm threaded rod	~4$	ebay.com
1	Insulation	~16$	ebay.com
1	PTFE tape	~0.5$	ebay.com
1	Heat resistant tape	~1$	ebay.com
3	Rocker switches	~5$	ebay.com
1	Wooden board 100cm x 10cm x 2cm	-	-
2	Sockets	~2$	ebay.com
-	Wires (two colors)	~1$	Amazon.com
-	Several screws	~1$	Amazon.com
1	Auger bit(diameter=16mm ; length = 460mm)	~10$	ebay.com
1	PID temperature controller DC 12V version	~13$	ebay.com
1	K-type thermocouple	~10$	ebay.com

Total cost will be around 120$ to 130$ excluding shipping charges and labor.

Reference [34] gives all the steps and codes to make filament factory, a filament extruder.

In my methodology I have proposed an idea to combine the 3D scanner and the filament factory with the 3D printer to form a single unit. This will let the user to create filament from the waste plastic that can be directly used to create 3D model. For example if user wants create a 3D model, he will firstly put the waste plastic in the machine, and the machine will directly use that waste plastic to create a 3D model. This will make 3D printing economical and eco-friendly. The model will be cheap because it will be created using waste plastic. Moreover, the 3D model will be eco-friendly because plastic is being recycled.

For software, we will use **Blender** for 3D CAD design (if the real object is absent) else we will 3D scan the object using **Sarduscan.** Then for 3D slicing, we will use a freeware slicer, **Slic3r.** This will slice 3D model to thousands and lacs of 2D figures for the 3D printer to print in a layer by layer manner. For 3D scanner, we will use ReconstructMe (freeware)**.**

Reference [35] [36] [37] [38] [39] gives the links and tutorials for the above software.

Our total cost of 3D printer cum 3D Scanner cum filament maker is around 380$ to 400$.

Our 3D printer solves the problem by saving the overall production time through the scanner attached to the printer by directly scanning the object instead of making a 3D model. It is also user-friendly as you don't need to learn 3D modelling (point valid only in the case if a real object whose copy is to be made is present.). It is economical as the filament cost that was earlier 20$ to 30$ per kg will now reduce to 1$ to 2$ at max, which will be the cost of electricity consumed. My proposed model of 3D printer is eco-friendly as it uses waste plastic bottles to produce filaments.

IV. RESULT

This section sums up the results that are obtained from online comparisons and observations made by the experimentation of the above work.

Since the beginning of 3D printing in 1980's, various endeavors have been made to improve the technology of 3D printers listed as: improved designs, reducing the prolonged production time, making this technology more economical for users. However, despite the great efforts, 3D printing technology either served to be economical or fast. No prior concepts or ideas have been able to bring about the qualities of being economical, fast. eco-friendly and a user friendly experience in a 3D printer.

In 2010, several open source communities opened up soon after the 3D printers market boomed. The open source communities came up with brilliant ideas to make 3D printing technology cost effective. Before this period, 3D printers were widely used in industries. My research paper contributes to the 3D printing technology in a similar way. I analyzed their concepts only to come up with a better solution in the development of 3D printers. I presume that this modern and innovative technology will revolutionize the world.

My 3D printer is a value for money model that merely costs approximately $380-$400. Filament rolls that once used to cost $20-$30 have now reduced to approximately $0.5 per kg (same

price as that of electricity). [40] [41] They've also become environment-friendly. I could marginally reduce the production time of a 3D printer by adding 3D scanner to it.

In 2016, various companies added a 3D scanning inbuilt feature in their 3D printers. Some of them are available for pre-order. [25] [26] [27].

The 3D printer is a great idea that turned into reality. Complexity, price factor, production time, the high cost of filament are the causes of the prolonged development of this technology. Due to this, people are missing out on this revolutionizing technology. I have proposed a method to develop a 3D printer model, taking care of all the factors stated above.

V. CONCLUSION AND FUTURE WORK

My paper has proposed a revolutionary and futuristic 3D printer model. The work done in creating this 3D printer is described in detail and the result is then put forward.

The primary goal of this research paper was to propose a revolutionary design for 3D printer that can save your time, money and make it eco-friendly at the same time. To achieve my primary goal, we analyzed various efforts and technologies that were used in reducing overall production time of the 3D printer. Further, we confirmed various advantages of combining all the steps of 3D printing or additive manufacturing. At last, we explained and confirmed the ideas in making a 3-D Printer economical. At last, we presented our model by ensuring and explaining the advantages of the model.

The discussion done in section two, gives clarity to a 3D printer model. On the modification of prior studies and observations, I have proposed a method to develop a 3D printer model that emphasizes on maximizing the benefits and minimizing the drawbacks of this technology so as to, push the growth of this revolutionary technology.

Section three explains the methodology used to make 3D printer including the details of making it, parts used, availability, the price of each part and every technical detail with the proper references are provided.

Section four described the result of research. A number of conclusions have been made. It is found that every 3D printer available in the market is somewhere incomplete in itself, some are fast some are economical, some are eco-friendly but none of them is all of the above. My 3D printer is economical, eco-friendly, fast overall production time. My idea of improving the above factors in 3D printer that I represented in my proposed methodology has a lot of scope in future and will contribute to the fast growth of this revolutionary thing. I believe that 3D printer will change the way we create objects, food, buildings etc. 3D printing can contribute in any field whether it is a medical field or engineering or business or anything. 3D printing will benefit the mankind to a great extent.

The idea of 3D printing was limited earlier due to many hurdles but with the passage of time all hurdles are crossed and it's rising.

In future, it can be applicable to outer space research centres like NASA where astronauts can print anything they want in the space instead of bringing it with them. It can be very useful.

It can be applicable to medical industry where 3D food printers will take care of the diabetic patients by providing them with the 3D printed food that will have the right amount of sugar and calorie. 3D printer can help in developing live organ using a tissue. One such 3D printer is currently present. [8]

It can be applicable in construction. One such 3D printed building is made in Dubai. [42] This is happening now but with very low pace. But in future, it will change the dimension of this industry.

It can be a boon for education. Students can see a live 3D model of any machine or a part of the machine rather than a 3D model on a 2D screen. They will easily learn assembly of the machine. Any innovative idea in students' mind (changing design of hammer or pencil box) can turn into reality with this machine.

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