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DESIGN AND FABRICATION OF 3D PRINTER USING E-WASTE

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ABSTRACT:

*The application of additive fabrication has been progressively studied in construction. 3D printing is a manufacturing process which produces 3-Dimensional versions of objects using a collection of additive layered construction frames. The 3D Objects are created easily on a fast prototyping connected to a computer with blue prints for the objects. This can render physical object models which are engineered with a CAD program. PLA is employed as the base for creating impression. Most of its components are e-waste recycled. This printing technology derived from layer by layer producing technology. Extremely innovative, this technology has emerged as a versatile state of the art technology. This explores new markets and offers businesses seeking to improve manufacturing and other opportunities. This technology has the potential to revolutionize industries. It is utilized in various sectors such as industrial style, architectural engineer, construction, automation, medical industry aerospace etc***.**

Keywords: Additive fabrication, e-waste, recycled, PLA, Fast prototyping.

1. INTRODUCTION:

The invention of stereo lithography by Charles Hull leads to the history of 3d printing. Bill Clington created first stereo lithography system to produce complex parts, layer by layer construction, in the standard fraction of time. A 3D printer is a specific category of industrial robot capable of performing an additive process under computer control. 3D printing is a method that creates solid 3D object digitally of any form from a digital model. Since it can instantly print parts or an entire product based on a 3D graphic design, it is a revolutionary way for professionals and hobbyists to create a 3D printer. In recent years, 3D printing has been developed to create a 3D printer for education. The product prices are still fairly expensive relative to other educational products. In this project, we are trying to develop the product based on the recycled electronic components, making the product affordable for most educational institutions. The second reason that we are designing the project in this way is to increase people's awareness of e-waste safety. As per the U.S. Electronic Waste Agency is rising about 3 times faster than any other waste, as about 300 to 400 million devices are discarded out of the garbage. The problem comes with rising computer and printer processing powers and capabilities each year. Since outdated electronics are no longer viable in companies and institutions, they pose a threat to the safety and productivity of society as a whole. In particular, e-waste accounts for about 70 per cent of America's toxic waste, causing severe contamination of American soils. A 3D printer, for example, requires valuable high power stepper motors which would otherwise be thrown into a landfill. Thus, designing 3D printers with e-waste can both cut the cost of the product and protect the environment in which we live.

2. PRIMARY DESIGN ANALYSIS

2.1 3D PRINTING METHODOLIGIES

3D printing also known as Additive Manufacturing where software tools are used to develop an object model, and the printer creates the object by adding successive layers of material until the object is shaped. The object can be developed using various printing materials that includes plastics, powders, filaments, and paper. The following is the overview of some of the printing technologies.

(i) Stereo Lithography (SL)

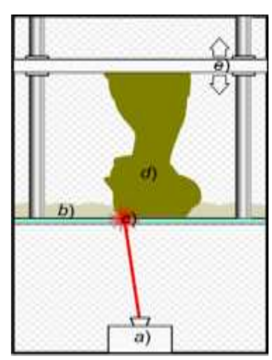


Fig-1: SL Process

SLA, along with fused deposition modeling (FDM) and selective laser sintering (SLS), is one of three key technologies introduced in 3D printing. It is a member of the field of resin 3D printing. A related technique is called digital light processing (DLP), which is typically combined with SLA. It is a kind of evolution of the SLA process, using a projector screen rather than a laser. Schematic representation of Stereo lithography (a) selectively illuminating the transparent bottom (c) of a tank (b) filled with a liquid photo-polymerizing resin. The solidified resin (d) is progressively pulled up by lifting platform (e).

(ii) Digital Light Processing (DLP)

DLP (Digital Light Processing) is a process similar to stereo lithography because it is a form of 3D printing that deals with photopolymers. The main difference here is the source of light.

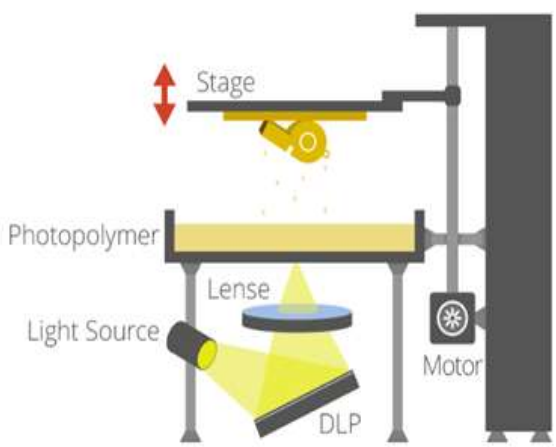


Fig-2: DLP

DLP uses a more generic light source, such as an arc lamp with a liquid crystal display panel that is applied in a single pass to the entire surface of the photopolymer resin vat, typically speeds up than SL. As SL, DLP also manufactures highly accurate parts with excellent resolution, but its differences also include the same support structures and post-curing specifications. Nevertheless, one benefit of DLP over SL is that it only requires a shallow vat of resin to facilitate the process, usually resulting in less waste and lower running costs.

(iii) Fused Deposition Modeling (FDM)

Through this technology, objects are made using thermoplastics. They are developed by heating a thermoplastic filament up to its melting point and by extruding the thermoplastic layer by layer. It is possible to use different methods to build complex structures.

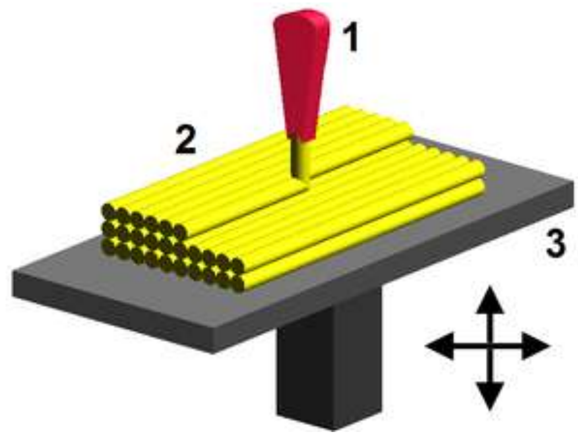


Fig-3: FDM 1-Nozzle ejecting molten material, 2-Deposited material, 3-Controlled movable table

(iv)Selective Laser Sintering (SLS)

SLS resembles mostly of Stereo Lithography. It utilizes powdered material stored in a container. For each layer, a layer of powdered material is placed on top of the previous layer using roller and then the powdered material is sintered to build the object that has to be formed by laser according to a certain pattern. The part of the non-sintered coated substance will be used to include the supportive framework and this content can be discarded until the object has been formed for re-use.

(v)Selective Laser Melting (SLM) and Electronic Beam Melting (EBM)

The SLM process is strongly analogous to the SLS pattern. In comparison to the SLS process where the powdered material is sintered, the SLM process often contains a complete melting of the powdered material.

The process Electronic Beam Melting (EBM) is similar to SLM, too. Here instead of using a high-powered laser, an electron beam is required. The electron beam completely fuses a metal powder to shape the target. The process is slower and more expensive than with SLM, with a greater limitation on the materials available.

2.2 E-WASTE

The materials required for the design process have been considered as the starting point. Several designs on 3D printers have been studied. The concept of the proposed 3D Metal Printer was taken from many open source online platforms and improved. The newest and most recent 3D printer design is Prusa i3. This printer has many exciting features and is considered the best most effective all-round printer. The materials from electronic waste were found to be the nice choice for constructing a 3D printer at low value. For the basement aluminium composite sheets is getting used in this model. They are flat panels with two thin coil-coated aluminium sheets bonded to a non-aluminium core. The aluminum L-angle is taken to be a supportive stand for the x and z motion drivers. The foremost vital thing to be noticed is that the three movements of the axis were developed individually. The stepper motors taken from old DVD drives and floppy drives power these motions. Thus the big evolution from the e-wastes was made to make the program cost-effective.

3. SYSTEM ARCHITECTURE

In the planned system, the following components are chosen for manufacturing process. Beginning with the basement support aluminum material is used. On the hardware side Arduino mega, Ramps, Stepper drive, Extruder, Hotend, PTFE tube, SMPS, PLA, thermistor, old DVD writer and floppy drive were used. In the software side CURA, CAD are used. The following gives the subsequent description on every part used for this module.

3.1 HARDWARE:

STEPPER MOTOR

The stepper motors used here needs 12volt power supply and are from recycled e-waste. Totally the design need three stepper motor among that two are from DVD-drivers. One is for X-axis movement (right and left) and the other one is for Y-axis movement (forward and backward). The dismantlement of motors ought to be done very carefully for better result.

Fig-4: Motors from DVD/CD drive

The other one is from the floppy drive which is also an e-waste. The stepper motor used in this is employed for the Z-axis movement (up and down) and it is connected along with hot end.

The stepper motor is a brushless DC electric motor which splits the whole revolution into many equivalent phases. The motor direction may then be guided to move and maintain each of these measures without any sensing elements of the input location as long as the motor is specifically built for the role in terms of torque and rpm.

NEMA-17 STEPPER MOTOR

In this purpose a compact DVD drive stepper motor is just not efficient enough to be used as an extruder motor so a large NEMA 17 motor was purchased. The motor is part of a direct drive extruder in the MK7/MK8 model that's made up entirely of 3D printed components. The extruder is placed on the panel, and a PTFE duct leads the filament into the hot end positioned in the travelling carriage of the printer.

Fig-5: Stepper Motor

Mounting the extruder motor remotely holds the mass off the axes, which may also be too hard for the thin, recycled stepper drive motors during this situation. NEMA 17-size hybrid bipolar stepping motor has a 1.8° step angle (200 steps/ revolution). Each phase draws 1.7A at 2.8 V, allowing for a holding torque of 3.7 kg-cm (51 oz-in). These motors are used where precise position management is desirable and the cost or complexity of a feedback control system is unwarranted.

Extrusion is a method used to make objects of a cross-sectional settled profile. A substance is forced or pulled through a die of the cross-sectional profile it desires. The two main advantages of this method over the process of manufacturing are its ability to form very complex cross-sections and to work with brittle materials. Because the material just comes up against compression and shear stress. Extrusion products are generally called "extruders." The primary way to produce wire, board, bar and tube is to draw metal.

STEPPER DRIVE

A stepper driver is a processor chip that acts as a mediator between a stepper motor and the controller. It rearranges the indications for the stepper engines to be sent, to enable it to operate. Once and a while the stepper drivers are on separate circuit boards and are connected to the controller. The steppers are on small circuit sheets here and there which are directly connected to the controller itself. The controller can have space for no but less four of the microscopic circuit sheets (one for each stepper engine) for this case.

Fig-6: Stepper Drive

This stepper motor driver enables you to monitor bipolar stepper motors with an output drive strength of upto 35V and 2A in complete, fifth, fourth, eighth, and sixteenth phase modes. The interpreter is the key to creating the A4988 simple to implement. Simply input one pulse at the phase input, drives one micro step of the motor. There are no step sequence tables, high-frequency control lines, or complex programming interfaces. The A4988 design is suitable for applications where a classy microchip is either inaccessible or overloaded.

HOT END

The "Hot end" is the active part of the 3D printer where the filament is melted. This permits the liquid plastic to flee the little nozzle to create a thin and inexpensive plastic dab which will adhere to the substrate on which it is laid.

Fig-7: Hot end

The hot end consists of either a melting zone or two-hole chamber. The cold end pushes the filament through one hole into the hot-end heating chamber. The molded plastic exits through the other hole at the tip of the heating chamber. The hole in the tip (nozzle) is between 0.01 mm and 1.0 mm in diameter and has a standard size of 0.4 mm for current generation extruders. The heating is carried out by a cartridge with induction coil just outside the barrel's end. The necessary heat is used to produce about 150 to 250 degrees centigrade with typical temperatures in order of 20W. A thermistor is normally mounted near the nozzle for feedback control of the nozzle temperature, and a thermocouple may serve as an acceptable control hardware. It requires high temperature metal.

THERMISTOR

The temperature of the hot end is measured using a thermistor. The temperature of the Heated Bed is often measured by a Second Thermistor. They are the resistors that vary with the difference in temperature as regards safety. Great characteristics of the thermistor in its working extent are an expected precisely defined safety confidence at each temperature. The reduction or increase is dependent on the form of thermistor per Kelvin degree, which is called its coefficient. Positive warm coefficient PTC will increase as negative coefficients NTC will decrease in temperature expansion safety.

ARDUINO MEGA

The Arduino Super is a Board based on the ATmega2560 microcontroller. It has 54 digital input / output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (serial hardware ports), a 16 MHz crystal oscillator, a USB interface, a control socket, an ICSP header, and a reset key. It contains everything required to support the microcontroller.

Fig- 8: Arduino Mega

Attach it to a device with a USB cord, or power it with an AC-to-DC converter or battery to start it. Never be afraid of accidental discharge, either since the Mega also contains a plastic base plate to protect it. The Arduino MEGA 2560 is designed for projects that require more I/O lines, more sketch memory and more RAM. With 54 digital I/O pins, 16 analog inputs and a larger space for your sketch it is the recommended board for 3D printers and robotics projects.

RAMPS

Ramps are Arduino Mega 2560's best-opted shield, Ramps have become the most popular, most-used 3D Printer hardware from 2012 up to the present date. It shares hardware ideas with numerous different gadgets (stepper motor, thermistor, radiator MOSFETs, etc.). RAMPS 1.4 version is the one that is easy to access and most efficient for the Arduino board's performance and stability.

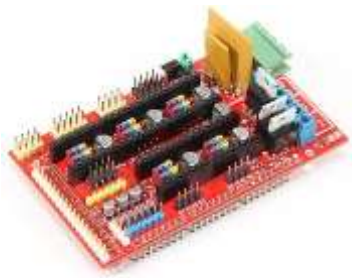


Fig-9: RAMPS Board

RAMPS 1.4 is probably the most widely used electronics for 3D printers. It can monitor up to 5 stepper motors with 1/16 stepping accuracy and interface with a hotend, heat bed, ventilator (or second hotend), LCD controller, 12V (or 24V with correct modification) power supply, up to three thermistors and up to six end stoppers.

PTFE TUBE

Fluoro polymer tubing, also referred to as tubing, is a transparent, chemically inert and non-toxic material with an unmatched chemical resistance and a surface that really enhances the flow to the PTFE (PolyTetraFluoroEthylene) tube.

PLA MATERIAL

PLA is a biodegradable thermoplastic derived from renewable resources such as cornstarch, cane sugar, tapioca roots or even starch potatoes. Compared to all other petrochemical plastics such as ABS or PVA, this makes PLA the most environmentally friendly option in the 3D printing domain. For example, PLA is used in both medical suturing and surgical implants because it has the potential to degrade into the body's harmless lactic acid.

SMPS

A switched-mode power supply is an electronic power supply that integrates a switching regulator for efficient processing of electrical power. unlike a linear power supply, a switching-mode supply transfer transistor constantly switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, reducing waste energy. Switching regulators are used as substitutes for linear regulators when they require greater performance, smaller size or lighter weight.

3.2 SOFTWARE:

CAD

CAD (Computer Aided Design) is computer software used to design and record the design process for a product. CAD is used for the product development and optimization. Although it is very flexible, CAD is used extensively in the design of the tools and equipment used both in the manufacturing process and in the construction domain. CAD helps design engineers to lay out, print and save their work for future editing on a computer screen and to improve it.

CURA

Cura is an open source 3D printer slicing application. It was developed to manage the program by David Braam who was later employed by Ultimaker, a manufacturer of 3D printers. Cura is available under the LGPLv3 license. Cura was originally released under Open Source Affero General Public License version 3, but was changed to LGPLv3 on 28 September 2017.Ultimaker Cura is used by more than one million users worldwide, performs 1.4 million print jobs per week and is the popular 3D printing software for Ultimaker 3D printers, but can also be used with other printers.

Fig-10: CURA Setup

3.3 DESIGN FLOW

The prcedural flow goes on as given in the flow chart.

1. Design of CAD CAM model in designing software like AUTOCAD

2. Transfer of the CAD file to SLICER software to be divided and broken down in form of G codes which can be compatible foe further operational processes.

3. Syncing the G codes in CURA which will decide and direct the steeper motors used in the model of 3D printer.

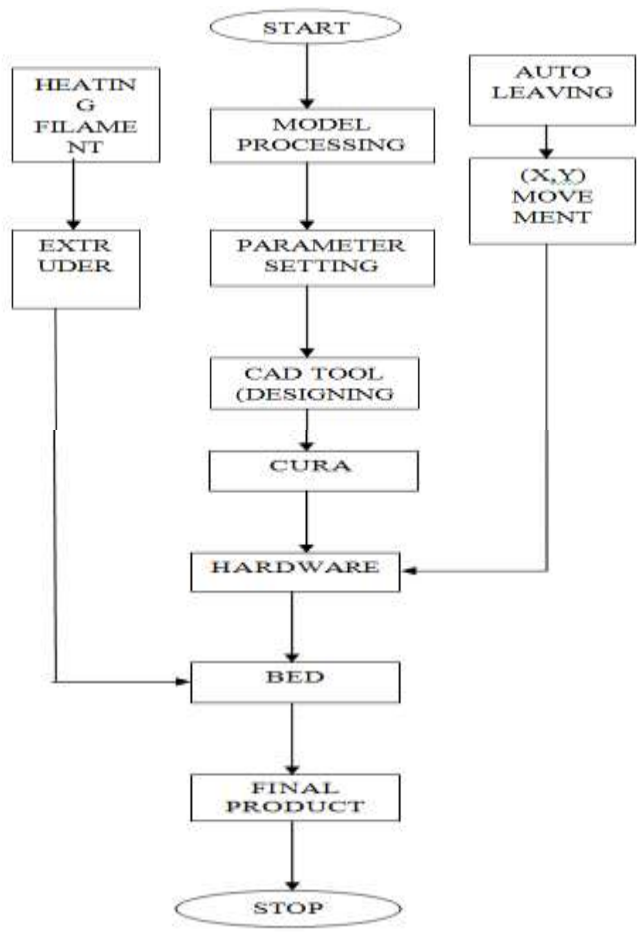
4. G codes defining the direction of stepper motor will direct the motors in X<Y and Z direction for the specifically assigned stepper motors for each directional axis.

5. Movement of the stepper thus ensures the movement of heat bed and extruder in the stated direction as the motors. This transfer of motion takes place through threaded rods.

6. Extruder containing polymer base will deposit the polymer on the heat bed in the shape and direction prescribed with respect to the G codes.

7. Fan for additional cooling effect of the polymer ensures reduction in the operational.

The following flow chart gives the procedurals for the 3D printing process.



4. RESULT AND DISCUSSION

The effective print speeds are a result of combining several elements:

1. **The filament feed**: The system responsible for delivering filament to the hot end, usually composed of a motor and grabbing mechanism (a pinch wheel) to push the filament. 2.**The hot end and nozzle**: Where the plastic filament is heated very quickly to the appropriate temperature for extrusion. 3.**The motion system**: Where the nozzle is moved quickly about on the build plane to effect deposition of the polymer material.

These three factors must be in balance for successful 3D printing. The graph shown below gives the amount of material built for the core temperature and filament feed rate.

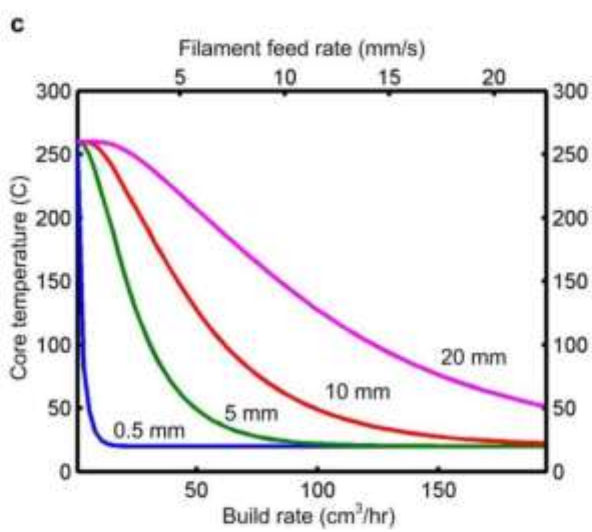


Chart-1: Characteristics of filament feed rate vs core temperature vs build rate

The Melt Flow Index (MFI) is specified by ISO standard 1131-1 as "the molten polymer mass, in grams, which flows in 10 minutes through a capillary of a certain diameter." A filament's MFI is frequently quoted as one of the main factors that determine the performance of a FDM printing operation. The MFI is closely correlated with the thermal viscosity of filament materials at a certain temperature of printing.

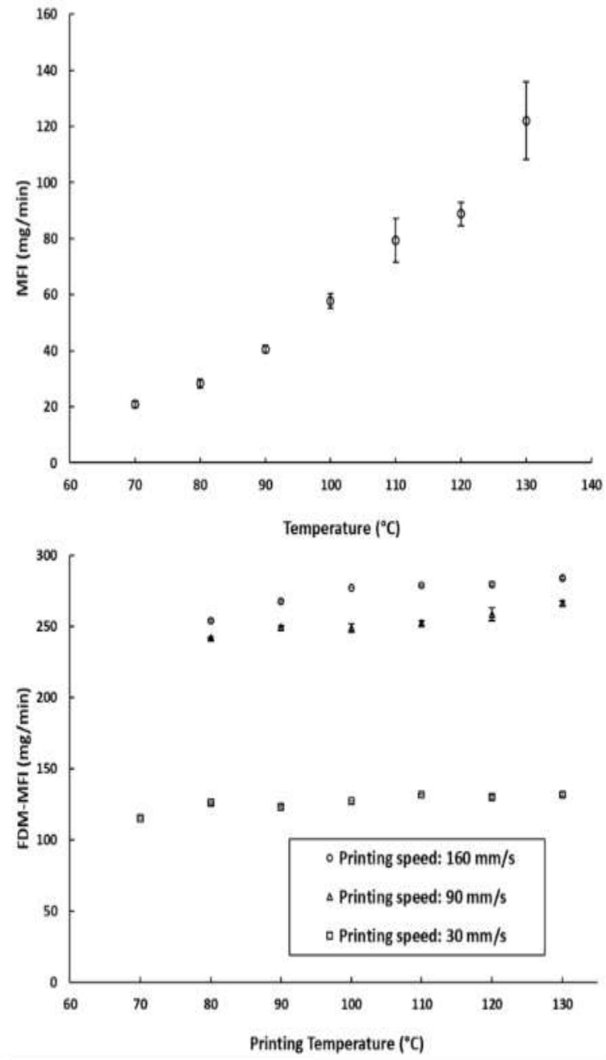


Chart-2: Characteristics of printing temperature vs MFI-FDM

(a) The measured MFI values of the PCL filaments at completely different temperatures (the arrow indicates the manufacturer counseled printing temperatures) (b) FDM-MFI of the PCL filaments measured at different printing speeds across different printing temperatures

MFI measurements (which define the volume of PCL deposited due to its melt flow) were then contrasted with the quantity deposited in FDM printing (referred to as FDM-MFI) (b). By giving the theological temperature dependency shown in the MFI experiments (a) when printed using FDM (b) there was a very low temperature dependency on the deposition speeds. This implies that the shift inside the melt flow of the filament is not very good to have a noticeable effect on the quantity of fabric being deposited by the print head over the changing appropriate printing temperatures. The only outcome was shown at 70 degree C, while a printing speed of

30mm/s was purely possible. This results in the hypothesis that, given the running speed is adequate to enable free flow of the compound melt, the contribution of operating temperature to the fabric's printability is not of primary importance.

5. RESULT

The outcome of this project was to make a successfully completed portable 3D Printer. The frame style is made robust and compact victimisation sectional aluminum. The choice of the various parts for the fabric is economical. Mechanism management is easy because of fewer engines, and sensible synchronization will be accomplished using this new 3D printer technique.

6. APPLICATIONS

3d printing earned its own place in the production method of social unit merchandise, significant devices, the automotive industry, the aerospace and aviation industries, the food business, electronic products, field of study models, fossil or ancient artifact restoration, gift items and imaginative 3D modeling as art form, toys, instruments and equipment, fashion designs such as shoes, suits, jewelry or museum souvenirs, etc already. It is used in the medical field for the development of custom prosthetics, orthotics, or implants. It is also used for the printing of laboratory equipment and as a research tool for the printing of biomaterials. It is commonly used on anatomic 3D-printed structures of patients for simulated surgeries.

7. FUTURE SCOPE

The futurologist Jeremy Rifki believed that 3D printing marked the beginning of a new industrial revolution replacing the assembly of production lines that dominated manufacturing from the late 19th century onwards. The scope for 3-d printing in the medical field is emerging day by day, the ultimate goal is printing transplant organ.

8. CONCLUSION

3D printers are gaining quality and becoming a necessity in instructional establishments and industries. The reason why we choose to make a 3D printer from e-waste is principally because of the fact that electronics with perfectly components are thrown out in our daily lives due to technology advancements. Therefore making a suitable solution to make it cost-efficient and eco-friendly. The 3D printer will not be a learning experience for the ideal person and cheaper, it will also be an answer to the e-waste dilemma that we face in today's world.

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