International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 09 | September - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

FUSED LAYER MODELING 3D PRINTING MACHINE

Naveen M *1, Rajath HG*2 Prashanth S*3

*1PG Student, Department of Mechanical Engineering, GMIT, Bharathinagar, Mandya, India.

*2 Assistant professor, Department of Mechanical Engineering, GMIT, Bharathinagara, Mandya, India

*2 Associate professor, Department of Mechanical Engineering, GMIT, Bharathinagara, Mandya, India

Abstract

The study aimed to deepen understanding of additive manufacturing, covering techniques, benefits, trends, and challenges. This knowledge was applied to refine a commercial 3D printer prototype and establish guidelines for practical 3D design. Key aspects included additive manufacturing principles, prototyping, and design, with data collected through model assessments and 3D design processes. An analysis of 3D printing's evolution revealed its extensive impact on society, economy, geopolitics, security, and the environment. A comparative evaluation of existing 3D printing solutions considered costs, technical specs, strengths, and limitations, likening its transformative potential to past technological revolutions. The goal is to enhance 3D printer models through in-depth literature review, identifying areas for improvement and commercialization readiness.

INTRODUCTION

3D printing is a versatile process that creates three-dimensional objects by layering material under computer control. It's used in rapid prototyping and additive manufacturing, enabling diverse shapes. Various technologies like SLA and FDM are employed, distinct from traditional machining and molding. Starting with a digital 3D model, slicing it into layers, and translating it into machine instructions (G-code), 3D printers add material layer by layer. Processes vary, from desktop FDM printers using melted plastic to industrial SLS machines with lasers for metals and plastics. Prints take 4 to 18 hours and often require post-processing. Delta printers differ, offering speed and height advantages but fewer options and support than Cartesian printers. Consider your needs when choosing one.

TECHNOLOGIES

Various technologies for layer-by-layer part fabrication are diverse and evolving. They cater to different materials, speed, and strength needs. Some are established for prototyping, while others are becoming viable for production. Ongoing development yields new methods. These additive fabrication methods are categorized based on the materials they use.

Liquid-based processes: The initial category of 3D printers utilizes a process called photo polymerization. These printers create object layers by selectively solidifying a liquid resin, known as photopolymer, which hardens upon exposure to laser or other light sources. Some of these printers operate within a tank of liquid, while others extrude a single resin layer and use ultraviolet light to solidify it before adding the next layer. A subset of these printers can mix various photopolymers in a single print job, enabling the production of objects composed of multiple materials.

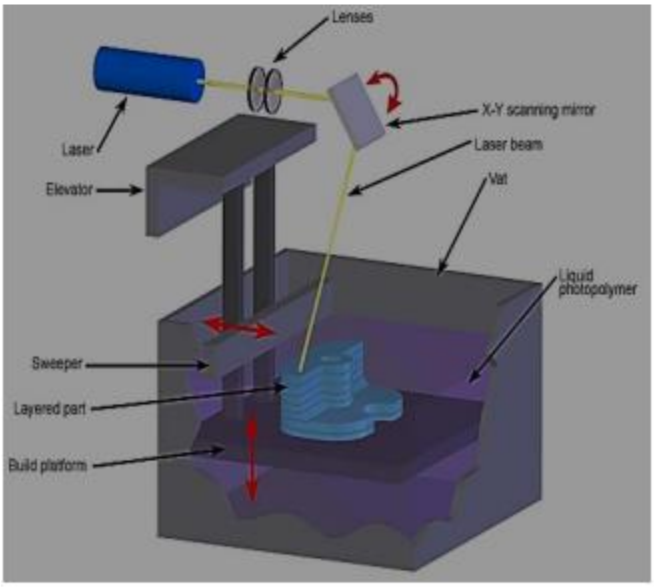
Powder-based processes: The second, expansive category of 3D printing hardware constructs objects by selectively bonding successive layers of extremely fine powder. This process, known as powder adhesion or granular material binding, can be achieved in several ways. One method involves jetting an adhesive onto each powder layer, while another employs a laser or heat source to fuse the powder granules together. Some technologies melt and fuse the granules of powdered material as they are deposited onto a surface. Powder adhesion methods are already widely used in 3D printing, accommodating a diverse range of materials including nylon, bio-plastics, ceramics, wax, bronze, stainless steel, cobalt chrome, and titanium.

Solid-based processes: Another category of 3D printers constructs objects by extruding a molten or semi-liquid material from a print head nozzle. This often involves extruding molten thermoplastic, which solidifies rapidly after leaving the print head. Some extrusion-based 3D printers produce objects by extruding molten metal, while others use this method to 3D print culinary creations like chocolate or cake frosting (icing). There are even specialized 3D printers that extrude materials like concrete or clay, making them suitable for architectural and construction applications.

Paper based processes: The last category of 3D printers operates on a lamination principle. In this method, consecutive layers of cut paper, metal, or plastic are adhered together to form a solid object. When paper sheets are the chosen material, they are cut using blades or lasers and then bonded together with adhesive. In some cases, multiple inks are sprayed onto the paper sheets during the printing process to produce affordable, full-color 3D printed objects.

3D PRINTING TECHNOLOGIES

Stereo-lithography (SLA): Stereo lithography (SLA), introduced by 3D Systems in 1988, stands as the foremost rapid prototyping technology. It excels at producing intricate and precise polymer parts. In SLA, objects take shape layer by layer through a laser tracing a liquid photopolymer's surface within a vat. The material solidifies wherever the laser touches, and the platform descends by the layer thickness. Each new layer bonds to the previous, forming a complete 3D object. Objects with complex geometries require support structures. After printing, excess polymer is removed, and curing may be done in a UV oven. Final finishing involves removing supports and refining surfaces for a polished result.



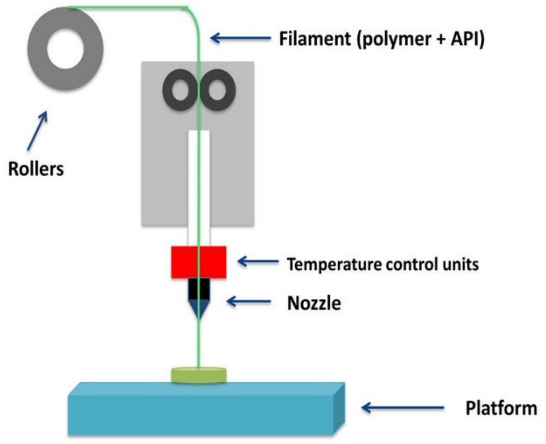
Stereo lithography

Fused Layer Modeling (FLM): Fused Layer Modeling (FLM), pioneered by Scott Crump and later adopted by Stratasys Ltd. in the 1980s, is a 3D printing technology known for its use of production-grade thermoplastic materials to create functional prototypes, concept models, and manufacturing aids. FLM is celebrated for its precision and impressive strength-to-weight ratio.

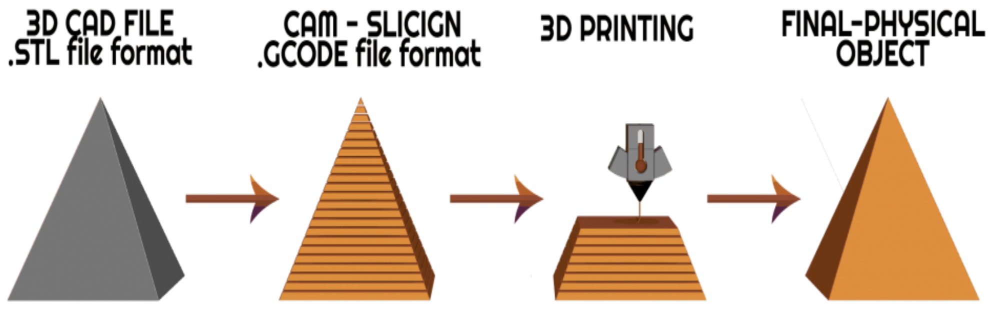
To initiate FLM printing, users first slice 3D CAD data (the 3D model) into multiple layers using specialized software. The sliced data is then sent to the printer, which constructs the object layer by layer on a build platform.

This process involves heating and extruding the thermoplastic filament through a nozzle onto the base. Additionally, the printer can extrude support materials, which dissolve after printing to aid upper layers.

The printing time for FLM depends on the object's size and complexity, and post-printing, the finished object requires cleaning to address any visible imperfections in raw FLM parts.



Fused layer Modelling (FLM)



3D PRINTING MACHINE

Cartesian configuration: Cartesian 3D printers derive their name from their use of the X, Y, and Z axes in a coordinate system to control movement in three dimensions. Typically, in Cartesian 3D printers with a heated bed, the bed moves primarily in the Z axis while the extruder moves along the X and Y axes, allowing it to move in four directions on a gantry.

In contrast, printers like the Printrbot Simple take a slightly different approach. Instead of moving the print head exclusively in the XY space, one of the axes is altered by moving the entire print bed itself. This design simplifies maintenance but may sacrifice some printing speed.

In summary, Cartesian 3D printers with heated beds and designs like the Printrbot Simple offer different methods for achieving 3D printing, each with its own set of advantages and trade-offs, including considerations related to ease of maintenance and printing speed.

Cartesian configuration

Delta configuration: Delta 3D printers are distinct with a circular print bed and an extruder suspended by three arms in a triangular arrangement, giving them the "Delta" name. Designed for speed, they offer the advantage of a stationary print bed, ideal for specific print jobs.

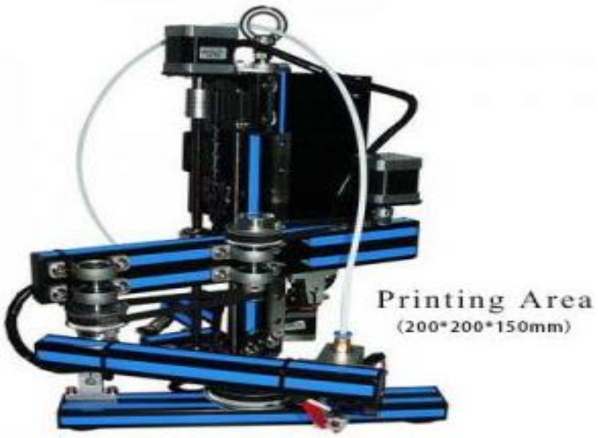
The Delta configuration has several advantages. Lightweight moving components enable swift and precise printing, but constant motion may risk print detachment and inaccuracies, especially in taller prints. Delta printers shine in crafting tall objects like vases due to their fixed platform, and their inherent height permits larger builds in the vertical dimension, which can be easily scaled up.

Their construction is simpler with fewer parts, reducing maintenance and costs. However, they must be taller than the maximum build volume they can accommodate due to their arm structure.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 09 | September - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Delta 3D Printer

SCARA configuration: The Selective Compliance for Assembly Purposes (SCARA) robotic arm is characterized by three degrees of independence, driven by three servo motors. These degrees of freedom enable the SCARA robot to execute one vertical and two horizontal motions. In the context of 3D printing, a feeding system is integrated into the SCARA robotic arm, positioned at its rear and extended at its extremity. This configuration enables the SCARA robot to effectively engage in various aspects of the 3D printing process, such as material feeding or manipulation of the printer's components. The SCARA robotic system proves to be a versatile and precise choice for various industrial applications, including 3D printing, thanks to its distinctive design and motion capabilities.

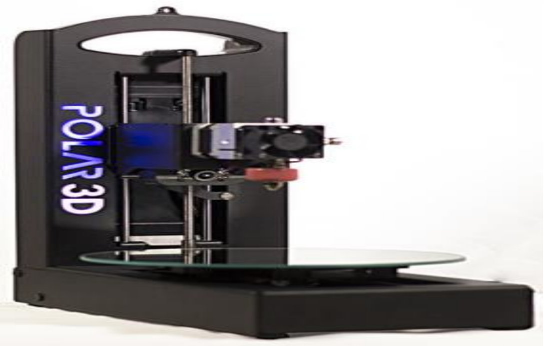


SCARA configuration

Polar configuration: The category being discussed here is the polar coordinate system used in 3D printers. Unlike the Cartesian configuration, which relies on a square grid, the polar configuration uses a circular grid to describe points. In a polar setup, the printer typically consists of a rotating bed and a print head capable of vertical movement.

The primary advantage of a polar configuration 3D printer is its ability to operate effectively with only two stepper motors, as opposed to the three or more motors required in other configurations. This simplifies the printer's design, reduces complexity, and potentially makes it more cost-effective and easier to maintain.

In summary, polar configuration 3D printers employ a circular coordinate system, offering benefits such as a rotating bed and the capacity to function with fewer stepper motors. These characteristics could make them an attractive choice for specific applications within the 3D printing realm.



Polar configuration

CONCLUSION

This study aimed to develop a portable and cost-effective 3D printer with a robust frame design using affordable materials. It simplified bed leveling with a single vertical motor and proximity sensor, ensuring precision down to microns. Unlike some printers, it avoided layer distortion at high speeds by streamlining controls, reducing motors, and improving synchronization. The research's driving force was affordability, achieving cost savings of 10-15%. Seamless integration of 3D design and printing software resulted in prints closely matching design specifications with nearly 100% accuracy. In conclusion, the researchers successfully created an economical, accurate, and portable 3D printer, expanding access to 3D printing technology for various applications.

REFERENCES

[1] In July 2018, Charlie CL Wang authored "Delta DLP 3-D Printing of Large Models," Volume 15, Issue 3.

[2] Betina Madeira Schmitt's work titled "A Comparative Study of Cartesian and Delta 3D Printers on Producing PLA Parts" was published in Volume 20, Supplementary Issue 2 in 2017 from São Carlos.

[3] S.H. Kochesfahani's contribution can be found in the book "Advanced Research in Virtual and Rapid Prototyping" (CRC Press, 2017), spanning pages 25 to 30.

[4] In January 2016, the "Santa Catarina Delta 3D Printer" was featured in the Journal of Industrial Design and Engineering Graphics, Volume 11, Issue 1.

[5] Ricardo Celi's work from 2015 centers on "Design and Construction of a 3D Printer implemented through a Delta Robot."

[6] The collaborative effort of Jeff Huygens, Naveen Kini, Madhukar Korupolu, Joung Lee, Eric Ng, and Yang Seok Ki, titled "Disruptive Medicine Using 3D Printing," was dated April 28, 2016.

[7] David H. Freedman authored "Layer by Layer," which appeared in Technology Review, Volume 115, Issue 1 in 2012.

[8] "Rapid Prototyping: Principles and Applications" authored by Chee Kai Chua, Kah Fai Leong, and C. Chu Sing Lim was published by World Scientific in 2010.

[9] Hideo Kodama's contribution titled "Automatic Method for Fabricating a Three-Dimensional Plastic Model with Photo Hardening Polymer" was published in Review of Scientific Instruments, Volume 52, Issue 11, in November 1981.

[10] A. Ramya 3D PRINTING TECHNOLOGIES IN VARIOUS APPLICATIONS Volume 7, Issue 3, May–June 2016, pp.396–409.