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Editorial

4D printing and its potential applications in the healthcare sector

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The things that may self-transform in shape or function in response to a predefined stimulus, such as osmotic pressure, heat, electricity, ultraviolet radiation, or other energy sources, are referred to as four-dimensional printing, or 4D printing, things. The "time" dimension is a new dimension in 4D printing. The time required to finish printing is not included in this. As a substitute, it symbolizes the passage of time as things change shape and is mentioned as the main contrast between 4D and 3D printing. Put otherwise, "3D printing and time" is what 4D printing refers to. The revolution in 4D printing has to start with a certain trigger. This may incorporate additional elements including light, heat, humidity, and electrical fields. In this instance, special materials are utilized to react to certain stimuli. When stimuli are applied, these materials' programmable features may take shape. One of the key benefits of 4D printing technology over 3D printing, according to Choi et al.[1] (2015), is the capacity to construct dynamic structures employing intelligent materials. This approach has significant promise for printing biological tissues and organs since they have a dynamic structure (Haleem et al., 2019).[2]

The healthcare sciences have a lot of prospects thanks to 4D printing technology. The following are some potential applications for 4D printing in the medical field:

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Implants with intelligence: Smart implants that can alter their form or characteristics in response to certain stimuli, such pH or temperature, may be made via 4D printing. This may lessen the possibility of infection or rejection and increase the implant's biocompatibility.

Tissue engineering: Structures resembling the intricate three-dimensional structure of tissues and organs may be produced using 4D printing and used in tissue engineering or regenerative medicine. Researchers are able to build buildings that can expand and adjust to their surroundings by using smart materials that have the ability to alter over time in terms of form or qualities.

Drug delivery systems: By using 4D printing, it is possible to develop drug delivery systems that distribute medications gradually and under control. Drug delivery systems that are triggered to release medications at specified times or places in the body may be created by researchers utilizing smart materials that can react to specific stimuli, such as temperature or pH.

Surgical instruments: Through the use of 4D printing, surgical instruments and equipment that may alter in form or property during surgery can be produced, potentially improving surgical results and lowering the chance of problems.

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Healthcare Uses 4D Printers

Examples of 4D printers that are either in development by academic institutions or presently on the commercial market. Here are few instances:

Stratasys J750 Digital Anatomy Printer: This printer prints anatomical models with a variety of textures and characteristics that mimic human tissue by using PolyJet technology (Sparks et al., 2021).[3] Additionally, models that alter over time in response to certain stimuli may be printed with this printer.

Rapid liquid printing technique developed by the MIT Self-Assembly Lab allows for the production of large-scale things with dynamic features. It works by using a robotic arm to deposit liquid ingredients in a three-dimensional environment (Sparrman et al., 2019).[4] With time, the printed items' characteristics or form may alter in reaction to certain stimuli.

3D printer HP Jet Fusion 5200 Series: This printer prints things with a variety of attributes, including as color, texture, and conductivity, using Multi Jet Fusion technology (Robar et al.[5], 2022; Mehdipour et al., 2021).[6] Moreover, items that gradually change in form or attribute in reaction to certain stimuli may be printed with the printer.

The 4D Lab at the University of Illinois at Urbana-Champaign is home to a number of 4D printers that can print materials with a variety of dynamic characteristics, such as hydrogels, liquid crystal elastomers, and shape-memory polymers (Muthukumar et al., 2015).[7] A vast array of cutting-edge instruments and gadgets, such as soft robotics and medical implants, may be made using the printers.

All things considered, 4D printing technology is a quickly developing industry, with several cutting-edge printers being created and used by businesses and researchers worldwide. Additive manufacturing, which is the technique of making 3D things by piling materials on top of one other, is the primary technology used in 4D printing. But by using "smart materials"—materials that may alter over time in response to certain stimuli like moisture, light, or temperature—4D printing goes beyond conventional 3D printing.

Conflict of Interest

None.

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