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4D-Printing

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Contents

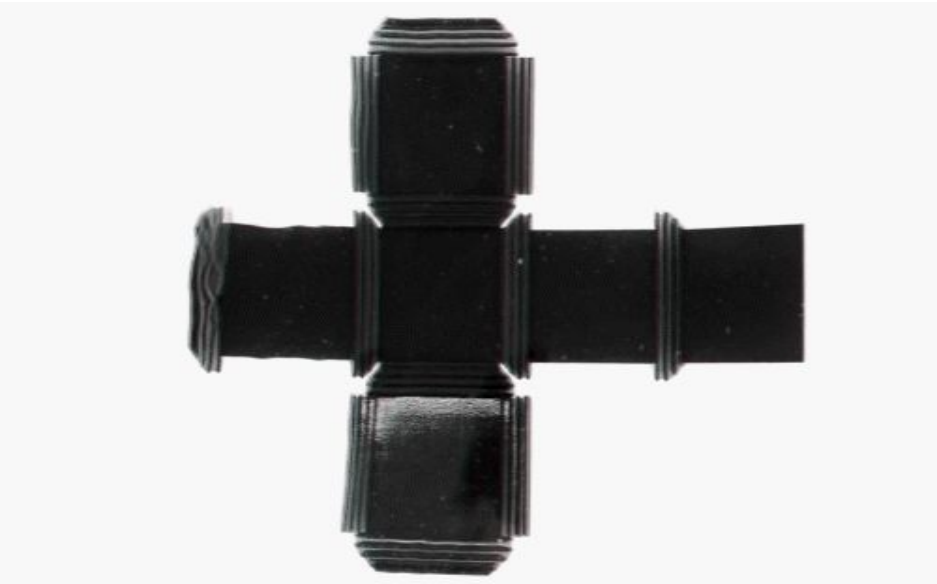
Glossary

The following are the must-know terms regarding 4D-Printing:

- 3D-printing – any of various processes in which material is joined or solidified under computer control to create a three-dimensional object, with material being added together;
- 4D-Printing – mostly same as 3D-printing, with an additional 4^{th} dimension being transformation over time;
- Programmable matter – special materials that have the ability to change their physical properties (shape, density, moduli, conductivity, optical properties, etc.) in a programmable fashion, based upon user input or autonomous sensing.

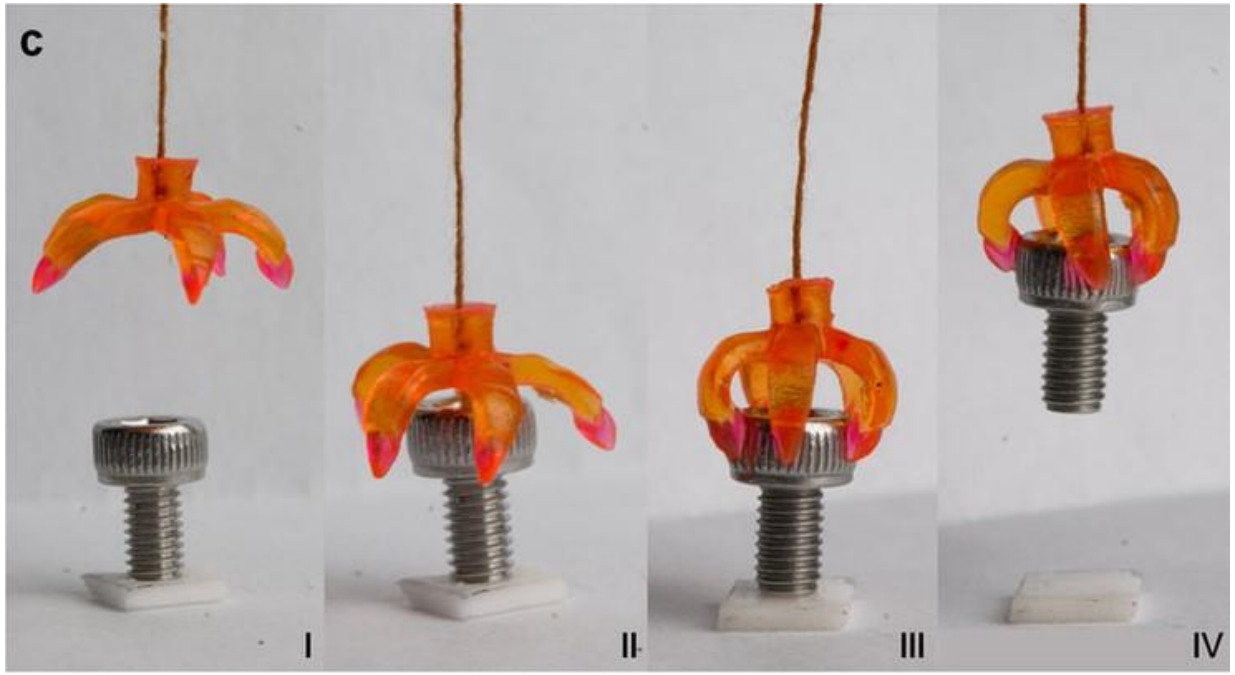
Technology in brief

3D printing, also known as “Additive Manufacturing”, turns digital blueprints to physical objects by building them layer by layer. 4D printing is based on this technology, but with one big difference: it uses special materials and sophisticated designs that are “programmed” to prompt your 3D print to change its shape. So, basically, 4D printing is a renovation of 3D printing wherein special materials to print objects that change shape post-production. A trigger may be water, heat, wind and other forms of energy.



A 4D-printed cube cutout changing its shape after contact with water

Technology in brief



A time-lapse of a gripper developed for grabbing and releasing an object.

The ability to change shape arises from the near infinite configurations at a micrometer resolution, creating solids with engineered molecular spatial distributions and thus allowing unprecedented multifunctional performance. 4D printing is a relatively new advance in biofabrication technology, rapidly emerging as a new paradigm in disciplines such as bioengineering, materials science, chemistry, and computer sciences

Methodology

Stereolithography is a 3D-printing technique that uses photopolymerization to bind substrate that has been laid layer upon layer, creating a polymeric network. As opposed to fused-deposition modeling, where the extruded material hardens immediately to form layers, 4D printing is fundamentally based in stereolithography, where in most cases ultraviolet light is used to cure the layered materials after the printing process has completed. Anisotropy is vital in engineering the direction and magnitude of transformations under a given condition, by arranging the micromaterials in a way so that there is an embedded directionality to the finished print.

State-of-the-Art and Open Issues

4D printing is a relatively new advancement in technology. As of now, it is most commonly applied in architecture and biomedical studies.

There are, however, some existing techniques/technologies that could potentially be applied and adjusted for 4D printing. They include Cell Traction Force, Electrical and Magnetic Smart Materials, as well as Commerce and transportation.

Industry Leaders & Startups

Since 4D printing is a relatively new advancement in technology, it’s not fully commercial yet.

At the moment, the industry leaders mostly are colleges such as MIT and University of Bayreuth.

Research teams are still developing new approaches and methods of using 4D-printing.

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That's all Folks!