RESEARCH ARTICLE OPEN ACCESS

Revolutionizing 3D Printer Into 4D Printer

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Abstract:

This paper aims to revolutionize the current status of 3D printer. The motive of this paper is to enlighten about adding integrated behavior to 3D printing object. Paper also illustrate the different application in real world where add this feature will enhance the efficiency and durability of model.

Keywords --- 3D printer , 4D printing , Material and application of 4D printing

INTRODUCTION :

In this era of technology human are more dependent on machine in the field of manufacturing which is making their production of goods easier. The brute force assembly technology takes a more time. To reduce the time taken by earlier technology, intelligent physical material can be programmed to build themselves.

The 3 D Printer technology has revolutionized the manufacturing industry by his advent. This technology was introduced 1980. In today's world 3D object can be manufactured very easily by computer aided design tool and 3D printer. This technology is wildly used in various fields such as fabrication of clothes, sensor, bio - hybrid robot. 3D Printer is wildly used in research, manufacturing and can be used by an individual for fabricating different object.

With the rise of many smart technology manufacturing is becoming faster and reliable. Now a days smart material is used for shape recovery, actuator and sensor.

The smart material is equipped with external stimuli. The behavior of 4th dimension is induced in 3D printed object. After the 3D object is printed, shape morphing is main characteristics of 4D printing. So the device for manufacturing 4D printer and 3D printer are same but we have to change the materials which can get affected by surrounding condition or external stimuli. So the self changing material would cater the need in future. Researches are going on regarding the 3 D printer self folding structure. Meta materials, can be morphed according to their environment which can make up entire new class of 3D printer.

METHODOLOGY

Today at micron and nanoscale the unprecedented revolution is happening. This is ability to program physical and biological material to change shape and properties and to compute outside of silicon base matter.

There is even a software tool called as CadNano that allows us to design three dimensional shape like nano-robot, drug delivery system and use DNA to self assemble those functional structure . But if we look at the human scale there is massive problem that on being addressed by those nano-scale technology if we look at construction and manufacturing. There is inefficiency as more energy is consumed and excessive labor techniques .Let's take an example of water pipes. We have fixed the capacity of water pipes and fixed flow rate. If any natural disaster

occurs and pipes get damaged which are under ground or in case the demand is changed then in that circumstances the entire pipe is to be excavated from underground and replaced by other pipes .So in intelligent material we are going to combine two different thing . Firstly a nano-scale is programmable adaptive material. It does not mean that programmable material, automated machine are replacing humans. These material can build themselves and they are known as self assembly .

Self assembly is a process by which disorder parts can build an ordered structure through local interaction. So for local interaction we can fuse simple ingredients.

The material and geometry [the first ingredients] is to be tightly coupled with energy source. The energy can be a passive energy such as heating, shaking, pneumatics, gravity, magnetics. There is a need of smartly designed interaction. Those interaction would allow the stag to from one stage to another.

FUTURE SCOPE

The multi-material 3D printing can give rise to 4D printing. So we can deposit multi-material and self transformation can occur from one shape to another shape directly on their own. This is like robotics without wire and motor. So the 4D printing can be used in near future .In extreme environmental scenario it is difficult to build as per current construction techniques. So the construction work during such scenario is lacking the efficiency and producing large amount of waste materials which is dangerous for environment. This way of production is also expensive as compared to it's successor. In infrastructure if the water pipe can expand or contract or change the rate of flow according to surrounding condition then it can reduce risk of damaging of water pipe by a large percentage.

Types of intelligent material

1) Shape memory material
2) Thermo-responsive SMMS.
3) Self assembly / Self actuating

SHAPE MEMORY MATERIAL

These materials on certain external stimulus changes their shape. Polymers such as nitinol has the property of quasi-plastic which on severely deform can regain its original shape after a certain stimuli. The stimuli can be in the form of heating or cooling. For most of the material, when the object is subjected to cooling, the internal energy of the atoms reduces which tends to bring contraction in the object. When the object is heated, there is a rise in the internal energy, resulting in expansion of the object. These material has reversible phenomenon i.e., if the condition are reversed the object would come back in its original shape / form. The stimulus can be in the form of thermal responsive, photo responsive, chemical responsive and mechanical responsive.

Thermo responsive Shape memory materials

In Thermo-responsive shape memory material totally depend upon temperature acting as a stimuli. There are two ways by which the stimuli can be given i.e., temporary deformation and permanent deformation. Here the material memory remembers two different shapes corresponding to two different stimuli i.e., heating or cooling.

Thermally induced Shape Memory Materials

When a photo triggered actuation is introduced over cinnamic acid which is mixed with polymeric network then it serves as a molecular change/ molecular switch. When the wavelength of ultraviolet rays are greater than 260nm , then cinnamic groups gets cross-linked which in turn fix the temporary shape covalently. When the wavelength of Ultraviolet radiation is less than 260 nm, the cleaved shape fixing is formed due to formation of covalent bonds. So a polyester urethanes containing pendant cinnamamide moieties and crystalline poly(L,L – lactide) hard and amorphous poly(ε - caprolactone) soft segment can be developed into a biodegradable light sensitive Shape memory materials. On the other hand there are many disadvantages of using thermally induced shape memory materials. The materials are exposed to limited light out of which only a small percentage enters a polymers bulk. The material takes huge time to change their shape and they have low shape fixity (20%-55%).

Hydrophilic elements

There are many hydrophilic elements which gets their stimuli via water. When the materials are kept in water, the hydrogen bonds weakens due to the presence of water molecules. The cellulose nano-whiskers and thermoplastic polyurethane can show the shape memory effect phenomenon. When the material is dipped in water the hydrogen bonds gets weaker than water molecules. The hydrogen is present between nano-whiskers. This helps in deformation of nano-whiskers . If we want the original shape of nano-whiskers subsequent drying is needed. So in this way the water acts as a stimuli for cellulose nano-whiskers and thermoplastic polyurethane.

Self –actuating / Self – assembly materials

In case of self assembly two successive layers of different properties or different stimuli response are layered one upon the other and built together. The object can get stimuli from the environment or by humans. So with respect to time the object ‘s shape gets changed either physically or chemically . For Ex. B – sheet structures are formed when ionic self – complementary peptides are put in aqueous solution with two distinct surfaces. The property of first surface should be hydrophilic in nature while the property of second surface should be hydrophobic in nature .So , when the ionic self complementary peptide are put in water the hydrophilic layer will absorb the water while hydrophobic layer will repeal the water. The components possessing the property of hydrophilic will bulge while the components possessing the property of hydrophobic layer will shrink. This in turn will change the shape of the object. The amount of water retained or absorbed will be proportional to each other respectively. The peptide consists of 16 amino acids. The size of each amino acids is nearly 5nm. They are arranged in alternating non-polar pattern and polar pattern . The β- sheet structure and strands are formed by peptides. So there is continuous one polar and one non-polar molecule undergoing self-assembly to form nano-fibres consisting of non polar residues. They undergo drastic conformation changes under external stimuli between alpha helix and beta helix strand or β-sheet .

APPLICATIONS :

There is a wide application of 3 D Printer which can be used in day-to-day life.

1. The shape changing material can be used in Space Shuttle or Space Satellite. The material at zero gravity can transform itself in to and fro motion continuously then peristaltic movement would occur which will help progration of space shuttle.

2. With the help of programmable intelligent material there is a scope of changing the width of the pipeline which would help in changing the flow rate of water, volume of water flowing through pipe line could be changed.
3. The 4 D Printed object can be used in making the building which uses the intelligent material to transform according to the environmental conditions.
4. The class of hydrophilic elements can be used in the ships. The hydrophilic layering could be done inside the ship's outer-case. It would help the ships if there is any crack in the base of the ship. The hydrophilic element will absorb the incoming water in turn increasing its size till the water stops flowing inside the ship.