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Self-Growing Biorobots with Nanotechnology Approach

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Abstract: ***Biorobotics is a field that is very exciting in the area of integration of many fields of natural science and engineering. Biorobotics can teach us more about the limits and nature of living beings too. One of the requirements of being alive is self-growth and self-organization. It is widely researched how this concept can be implemented into human-made robots. This review paper, it is thoroughly investigated how this concept can be realized with a nanotechnology approach as well as other possibilities for realizing this goal of self-growth.***

Keywords: Biorobotics, Nanotechnology, Self-growing robots

1. Introduction

Engineers have always been inspired by nature as they design products of the future. Biorobotics is one of the fields that gets the most inspiration from nature. It refers to the creation of physical replicas of biological systems, such as bioinspired and biomimetic robots.[1] Biorobotics examples that replicate animal movement have been constructed in many forms.

Plants have also been a fascinating subject to study, even though the animal movement is the primary source of inspiration. When considering the notion of a self-growing robot, plants' method of "growth" movement is quite remarkable. Self-growth in robotics has been investigated with many approaches. Besides being a science-fiction subject, it is a critical area of study. Various methods have been theorized to realize this phenomenon of self-growth. It is important because self-growing can give robots an incredible amount of adaptability

High-functioning robots are designed with advanced materials with elevated properties. For "self-growing" activities, nanotechnology can be helpful as it can manipulate the properties of materials. As the inner structure of the materials can be changed in an atomic manner, materials can develop advanced specialties.

2. Biorobotics

Bioinspired robotics is defined by an interdisciplinary approach that strives to improve the interaction between biologists and robotics experts. The interactive branches of biorobotics use a technique that differs dramatically from the classic "understanding by constructing" approach and this method involves building a robot and examining how it performs in controlled environments before drawing theoretical conclusions about live systems.[2] It is also very much of a question of materials science in this sense. Our general approach to building in new materials for the robotics components is in the means of "structure, property, process, and performance" in order. But while building biorobots or soft robots another approach such as "tailoring, modeling nanostructure, and multifunctionality" can be experimented with. Living creatures are complicated systems with a variety of desirable technical properties that have proven challenging to achieve using standard engineering method.[3] While machine builders are motivated by biology, examples of substantial biological discoveries spurred by the construction of robots are, at best stayed uncommon.[4] Therefore engineers will have to reject top-down forced design and reimagine their gadgets about natural complex systems. Manufacturing can be thought in a way through universal processes that allow self-assembly, self-regulation, and growth.

3. Self Growing and Organizing Robots

Self-growing action that mimics the living beings' lifecycle is the ultimate concept to discover. Our current robotics approaches have to be evolved or modified drastically to achieve self-growing. Self-growth or self-organization in robotics is mostly important because it can lead to excellent adaptation skills for robots in various environments. Also, it can help us understand the nature of living beings better too, and have a grasp of the subject of how humans evolve and grow. The concept of self-growing robots has been considered previously. It is convenient to think about additive manufacturing systems when thinking about the self-growth concept. This growth method is also relatively similar to what is "natural" in terms of how things grow. To enable the development and advancement of an exploratory tip, the robot uses the traditional technique of fused deposition modeling (FDM) and combines a bespoke three-dimensional (3D) printer.[5]

Some of the biomaterials that could be helpful in the additive growth of biorobots are enlightening concepts. Some biopolymers can be considered in this case. Even though cellulose, chitin, and pectin are three of the most prevalent natural materials on Earth, large-scale additive manufacturing with these biopolymers is restricted and often relies on expensive refining procedures or plastic additions.[6] Therefore in the case of biopolymers, there is more work to be done in the means of self-growth but results are hopeful.

Apart from biopolymers, there are other kinds of materials that can be helpful in self-growth based on additive manufacturing. This concept has also been discussed in terms of 3D self-assembled polydimethylsiloxane structures. Which is about bio-hybrid actuation as tailored flexible matrices and the use of a stress-induced rolling membrane is used to fabricate tailored layers arranged in a 3D architecture.[7]

Besides additive manufacturing methods, morphogenetic engineering has also been experimenting with self-growth and organization. Morphogenetic Engineering suggests a progressive transition toward biology through phases that might be referred to as "meta-designed development" (MDD) and "meta-designed evolution" (MDE)—stopping below pure undersigned evolution (UDE); so meta-designers will concentrate their efforts in MDD on developing local mechanisms that allow tiny agents or components to assemble, coalesce, grow, or construct structures on their own.[8]

Cellular Robotic System (CEBOT), which is one of the self-organizing robotic systems has been quite revolutionary in the area. The ability to link and separate cells easily, to ensure a holding force while coupled, and to communicate data across cells is a crucial requirement for cell design; therefore CEBOT has the potential to become a self-organizing universal manipulator thanks to the optimum structure determination approach and this communication system.[9] Unique properties such as dynamically changeable architecture, distributed intelligence, self-repairing ability, fault tolerance, and application in hostile and limited situations are possible thanks to the modular cell structure.[10]

With the exciting developments in additive manufacturing and morphogenetic engineering, there have been steps taken through the self-growing of self-organizing robots. This phenomenon can also be useful in self-repairing. But, above all, there may be another approach developed for self-growth with nanotechnology practices too.

4. Nanotechnology Approach

Nanotechnology is a fascinating field that allows us to understand the nature of materials on an atomic scale. It allows us to manipulate the internal structure of materials. How atoms behave characterizes the material. There is a question of whether this area of study can be used for "self-growth" as we talked about previously. How robots can benefit from growing with a nanotechnology approach should be thought of in terms of how nature builds every structure. In building with nanotechnology the solution is that the statue will have to construct itself. We must develop a technique to coerce, or persuade, billions of tiny particles to self-assemble into the technology and we won't be able to help them; therefore, they must accomplish it on their own. This leads us to self-growing technologies. Nothing is built in this manner by humans. However, if you look around, you'll notice that nature constructs everything in this manner. Everything is constructed from the ground up.[11] Therefore, we can think that nanotechnology and the self-growth concept are similar in their core.

The potential of self-assembly for nanotechnology has motivated a variety of research initiatives in molecular biology and biophysics targeted at better understanding self-assembly processes such as protein folding and the use of templates to generate geometrical restrictions.[12] It has opened the ways to think about creating biological or soft machines or robots. A robot that is made of materials that are similar to living beings or which is made of already living organisms can achieve a self-growing behavior.

Richard Jones claims that biological machines use Brownian motion and that "a separate aspect of the physics that causes issues in one sort of design may be used to advantage in a design that is correctly optimized for this different reality; therefore, Nano engineers will have to make use of features of the nanoscale that pose challenges for the traditional machine.[13]

The biological machines concept opens up new avenues of thought for self-growing biorobots. When thinking about self-growth tissue generation of the biorobots is very important. Probably, self-growth actualization is going to be done by tissue growing. As we have previously stated, in these machines it is highly possible to use biological materials. Natural tissues have the potential to self-strengthen through biological development, in which new building blocks are carried into the tissues and connected to pre-existing microstructures, whereas manufactured materials are often static.[14]

In the concept of tissue generation, nanotechnology can be helpful. Scaffolds are materials that have been created to contribute to the development of new functional tissues by causing desired cellular interactions. And the materials that are used in tissue scaffolds are most biocompatible. The fabrication of tissue scaffolds using nanofibers is one of the most important uses of nanotechnology in tissue regeneration.[15] The patterning of implantable surfaces with nanotopography is perhaps one of the most sophisticated applications of nanotechnology in tissue engineering.[16] When all of this is considered, it is possible to say with tissue engineering using biocompatible polymers, self-growing biorobots can benefit from nanotechnology.

5. Nanorobotics

As an evolving field of technology that creates machines or robots that contain parts at or close to a one-nanometer scale, nanorobotics can be helpful in self-growing biorobots too. There are several approaches to achieving this goal.

At the moment, the most exciting approach for nanorobot actuation is produced by the process of remote force fields, mediated by responsive nanoparticles or other nanoscale materials, and nanotechnology will add value to the redesign of larger robotic devices, in addition to driving the design and development of functional micro and nanorobot components.[17] These intelligent nanorobots can be thought of as components of larger biorobots. They may be able to heal a damaged area, grow or change shape with future developments. There is also the possibility of remotely being able to control or observe closely biorobots that contain nanorobots. Because nanobots can be merged with all types of tools, such as cameras, nanolasers, and nano chemicals.[18]

There is another newly invented concept here. 0.039 inches wide. Xenobots are not nanobots, but they can also be inspiring in this area as they are programmable organisms. The observed activities that have been documented include organizing microplastics, self-healing, and chemical communication with pheromones. Xenobots are multilayer heart and skin tissue robots made from frog stem cells.[19] There is a big possibility that they can be helpful in self-growing activity in the future.

6. Usage of Hydrogel

As various biomaterials are thought to be candidate materials for biorobotics, the hydrogel is also one of the most appropriate ones. Because of their similarity to biological tissues, hydrogels, which are cross-linked polymer networks infiltrated with water, have been intensively researched in tissue engineering and biomedicine.20

Highlighting DNA nanotechnology as a concept here can be enlightening. A novel form of a responsive hydrogel (Dgel) whose overall shape is dynamically regulated by DNA hybridization induced double crosslinking may be generated by integrating molecularly designed DNA sequences into a polymeric network. The Dgel is used in conjunction with a 3D printing technique to quickly produce modular macroscopic objects with programmable reconfiguration and directed movement that can even replicate the complicated motions of human hands as the first step toward production.21

7. Conclusion

Biorobotics is a promising area of study with the possibility of teaching us about the nature of living as well as benefiting the advancement of technology with the possibility of adaptable and intelligent robots. As stated previously, self-growth is very interesting to know about and investigate. Self-growth can be realized with the advancement of technologies such as additive manufacturing and morphogenetic engineering. But also, it might be possible to realize this goal with nanotechnology. This can be done with nanorobots that are part of a larger system. It can also be realized with the DNA nanotechnology concept with hydrogel or other types of biocompatible materials. Both the concepts of 3D printing and nanotechnology seem to be promising in this area. Further research may be able to make it available for engineers to build self-growing biorobots that will achieve various tasks.

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