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Bio-Nanorobotics: The Milestone of Nanotechnology and Medicine

Ms.K.M.Poornima
Assistant Professor
Department of CA and SS
Sri Krishna Arts and Science College
Kuniamuthur, Coimbatore -641008, India.

Venkatraman.S
II M.Sc Software Systems
Department of CA and SS
Sri Krishna Arts and Science College
Kuniamuthur, Coimbatore -641008, India.

Andrews.J
II M.Sc Software Systems
Department of CA and SS
Sri Krishna Arts and Science College
Kuniamuthur, Coimbatore -641008, India.

Varun.P
II M.Sc Software Systems
Department of CA and SS
Sri Krishna Arts and Science College
Kuniamuthur, Coimbatore -641008, India.

Abstract: Nanorobotics is the emerging technology field creating machines or robots whose components are at or close to the scale of a nanometer (10−9 meters). More particularly, nanorobotics refers to the nanotechnology engineering regulation of designing and building nanorobots, with the devices ranging in size from about 0.1–10 micrometers and constructed of nanoscale or molecular components. This paper briefly describes about the Nanotechnology, and the Nanomachines that are very much important in the field of Nanorobotics. The scope of Nanorobotics and its application in the field of medicine have described.

Keywords: Nanorobotics, nanobots, nanoids, nanites, nanomachines, nanomites

I. INTRODUCTION

Nanotechnology is molecular manufacturing or, more simply, building the things with one atom or molecule at a time with programmed nanoscopic robot arms. A nanometer is one billionth of a meter (3 - 4 atoms wide). The trick is to manipulate the atoms individually and then placing them exactly where it is needed to produce the desired structure. These nanostructures typically exhibit the new properties or the behaviours due to the quantum mechanics. In 1959 Richard Feynman first pointed out some of the potential quantum benefits of miniaturization. A major advancement was the invention of molecular-beam epitaxy by Alfred Cho and John Arthur at Bell Laboratories in 1968 and its development in the 1970s, which has enabled the controlled deposition of single atomic layers. Scientists have made some progress at building some devices, including computer components, at nanoscales. Faster progress has been occurring in the incorporation of nanomaterials in many other products, such as stain-resistant coatings for clothes and invisible sunscreens.

Nanotechnology is very diverse and ranging from extensions of conventional device physics to completely hew approaches, from biological activities on the earth to space exploration.

II.NANOMACHINES

Nanomachines are largely in the research-and-development phase, but some primitive molecular machines and nanomotors are being tested. An example is a sensor having a switch approximately 1.5 nanometers across, capable of counting the specific molecules in a chemical sample. The names such as nanobots, nanoids, nanites, nanomachines or nanomites have also been used to describe these devices currently under research and development. The first useful applications of nanomachines is applied in medical technology, which could be used to identify and destroy the cancer cells. Another potential application is the detection of some toxic chemicals, and the measurement of their concentrations, in the environment. Rice University has demonstrated a single-molecule car developed by the chemical process and including buckyballs for wheels. It is actuated by controlling the environmental temperature and also by positioning a scanning tunneling microscope tip.

Another application is a robot that allows precision interactions with nanoscale objects, or can manipulate with nanoscale resolution. Such devices are more related to microscopy or scanning probe microscopy, instead of the description of nanorobots as molecular machine.

Figure 1. A Typical Nano Robot

Following the microscopy definition even a large apparatus such as an atomic force microscope can be considered a nanorobotic instrument when configured inorder to perform nanomanipulation. For this viewpoint,

macroscale robots or microrobots that can move with nanoscale precision can also be considered nanorobots

III. INTRODUCTION TO ROBOTISM

Robotics is a branch of technology that deals with the design, construction, function, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with the automated machines that can take the place of humans in dangerous environments or manufacturing processes, or be similar to humans in appearance, behavior, and/or cognition. Many of today's robots are inspired by nature causative to the field of bio-inspired robotics**[1]**.

A robot is nothing but a mechanical or virtual agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry**[10]**.

IV. ROBOTIC SURGERY

Robotic surgery is a computer-assisted surgery, and robotically-assisted surgery, that are terms for technological developments that use robotic systems to help in surgical procedures. Robotically-assisted surgery was developed to overcome the limitations of minimally-invasive surgery and to enhance the capabilities of surgeons performing open surgery.

In the case of robotically-assisted minimally-invasive surgery, instead of directly moving the instruments, the surgeon uses one of five methods to control the instruments; either a straight telemanipulator or through computer control. A telemanipulator is a distant manipulator that allows the surgeon to perform the normal movements associated with the surgery whilst the robotic arms carry out those movements using end-effectors and manipulators to execute the actual surgery on the patient. In computer-controlled systems the surgeon uses a computer to control the robotic arms and its end-effectors, though these systems can also still use telemanipulators for their input. One advantage of using the computerised method is that the surgeon does not have to be present, but can be anywhere in the world, leading to the possibility for remote surgery**[2]**.

In the case of enhanced open surgery, autonomous instruments (in familiar configurations) replace traditional steel tools, performing certain actions (such as rib spreading) with much smoother, feedback-controlled motions than could be achieved by a human hand. The main object of such smart instruments is to reduce or eliminate the tissue trauma conventionally associated with open surgery without requiring more than a few minutes' training on the part of surgeons. This approach seeks to improve open surgeries, particularly cardio-thoracic, that have so far not benefited from minimally-invasive techniques.

V. NANOROBOTICS IN MEDICINE

Nanorobots are theoretical microscopic devices measured on the scale of nanometers (1nm equals one millionth of 1 millimeter). When fully realized from the hypothetical stage, they would work at the atomic, molecular and cellular level to perform tasks in both the medical and industrial fields.

A few generations from now someone diagnosed with cancer might be offered a new alternative to chemotherapy, the traditional treatment of radiation that kills not just cancer cells but healthy human cells as well, causing hair loss, fatigue, nausea, depression, and a host of other symptoms. A doctor practicing nanomedicine would offer the patient an injection of a special type of nanorobot that would seek out cancer cells and destroy them, dispelling the disease at the source, leaving healthy cells untouched. The extent of the hardship to the patient would essentially be a prick to the arm. A person undergoing a nanorobotic treatment could expect to have no awareness of the molecular devices working inside them, other than rapid betterment of their health.

Nanomedicine's nanorobots are so tiny that they can easily pass through the human body. Scientists report the exterior of a nanorobot will likely be constructed of carbon atoms in a diamondoid structured because of its inert properties and strength. Super-smooth surfaces will lower the likelihood of triggering the body's immune system, allowing the nanorobots to go about their business unimpeded. Glucose or natural body sugars and oxygen might be a source for propulsion, and the nanorobot will have other biochemical or molecular parts depending on its task.

VI. NUBOTS

Nubot is an abbreviation for "nucleic acid robot." Nubots are organic molecular machines at the nanoscale. Nucleic acids direct the course of protein synthesis, thereby regulating all cell activities. Their transmission from one generation to the next is the basis of heredity.

The two main types, DNA and RNA, are the composition of similar materials but differ in structure and function. Both are long chains of repeating nucleotides. The chain of purines and pyrimidines (bases)—adenine (A), guanine (G), cytosine (C), and either thymine (T; in DNA) or uracil (U; in RNA)—in the nucleotides, in groups of three (triplets, or codons), constitutes the genetic code[3].

DNA structure can provide means to assemble 2D and 3D nanomechanical devices. DNA based machines can be activated using the small molecules, proteins and other molecules of DNA.

Figure 2. A Nubot

Biological circuit gates, which are based on DNA materials have been engineered as molecular machines to allow in-vitro drug delivery for targeted health problems.

Such material based systems would work similar to that of the smart biomaterial drug system delivery, while not allowing precise in vivo teleoperation of such engineered prototypes.

VII. ABILTIES OF NANOROBOTS

Since Nanorobots are capable of actuation, sensing, signaling, information processing, intelligence, some of the characteristics abilities that a Nanorobot should possess are**[4]**:

- ***a. Swarm Intelligence:*** Decentralization and distributive Intelligence.
- ***b. Cooperative behavior:*** Emergent and evolutionary behavior.
- ***c. Self Assembly and Replication:*** Assemblage at nano scale and nano maintenance.
- ***d. Nano Information Processing and Programmability:*** for programming and controlling nanobots.
- ***e. Nano to Macro world interface architecture:*** an architecture enabling instant access to the nanorobots and its control and maintence.

VIII. BACTERIA-BASED INJECTION

This approach proposes the use of biological microorganisms, like the bacterium Escherichia coli. This type of injecting the machine into the body is not too harmful.This model uses a flagellum for propulsion purposes. .After injecting the machine into the body, its movements are monitored carefully. Electromagnetic fields normally control the motion of this kind of biological integrated device. **[5]**

IX. NANOMEDICINE

Potential applications for nanorobotics in medicine include early diagnosis and targeted drug-delivery for cancer,biomedical instrumentation, surgery, pharmacokinetics monitoring of diabetes, and health care. **[6]**

In such plans, future medical nanotechnology is expected to employ nanorobots injected into the patient to perform work at a cellular level. Such nanorobots intended for use in medicine should be non-replicating, as replication would needlessly increase device complexity, reduce reliability, and interfere with the medical mission.

Nanotechnology provides a wide range of new technologies for developing customized solutions that optimize the delivery of pharmaceutical products. Today, harmful side effects of treatments such as chemotherapy are commonly a result of drug delivery methods that don't pinpoint their intended target cells accurately. It is possible able to attach special RNA strands, measuring nearly 10 nm in diameter, to nano-particles, filling them with a chemotherapy drug. These RNA strands are attracted to cancer cells. When the nanoparticle encounters a cancer cell, it adheres to it, and releases the drug into the cancer cell. This directed method of drug delivery has great potential for treating cancer patients while avoiding negative effects (commonly associated with improper drug delivery).

Another useful application of nanorobots is assisting in the repair of tissue cells alongside white blood cells. The recruitment of inflammatory cells or white blood cells (which include neutrophils, lymphocytes, monocytes and mast cells) to the affected area is the first response of tissues to injury. Because of their small size nanorobots could attach themselves to the surface of recruited white cells, to squeeze their way out through the walls of blood vessels and arrive at the injury site, where they can assist in the tissue repair process. Certain substances could possibly be utilized to accelerate the recovery.

The science behind this mechanism is quite complex. Passage of cells across the blood endothelium, a process known as transmigration, is a mechanism involving engagement of cell surface receptors to adhesion molecules, active force exertion and dilation of the vessel walls and physical deformation of the migrating cells. By attaching themselves to migrating inflammatory cells, the robots can in effect “hitch a ride” across the blood vessels, bypassing the need for a complex transmigration mechanism of their own.

X. CHALLENGES FACED

The Major challenge in Nanotechnology, especially Nanorobotics, is that we need to study more about the properties of materials at nanoscale. Since the elements behave differently as nanoscale than when they are in bulk, there is a concern that some of the nanoparticles could be toxic. The design of nanoscale components is very complex. The major challenge in the Nanotechnology is up scaling from the laboratory work to industrial scale manufacturing. **[7][9]**

XI. FUTURE SCOPE OF NANOROBOTICS [8]

The potential of Nanorobotics is huge and can lead to miniaturization in wider areas such as space systems, medical diagnostic equipment and drug delivery systems along with the surgeries. An intense research is going on the field of Nanotechnology and Nanorobotics especially in the fields of medicine and space technologies. Nanotechnology in conjugation with the available microelectronic techniques offers new possibilities of system integration. Clear example of this kind is the integrated optics and integrated fluidics. It also offers new technologies for antennas thus opening new doors for the field of Communications. Research is going on in the field of space science for deploying a network of sensors to search large areas of planets such as Mars for the traces of water or any other chemicals.

XII. CONCLUSION

The field of Nanotechnology, especially Nanorobotic, can create a new revolution in the present world and can change the future of this world. It is in the hands of the future engineers and the scientists to use it in a creative manner. Research should be encouraged in the field of Nanotechnology and Nanorobotics, which can create many miracles in the current Science and Technology.

All of the current developments in technology directs human a step closer to nanorobots production.Nanorobots can theoretically destroy all common diseases of the future world, thereby ending much of the pain and suffering.Although research in nanorobots is in its preliminary stages, the potential of such technology is endless.

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