A Survey on Nanorobotics Technology

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Abstract— Nanorobotics is an upcoming technology field of creating robots whose components are at or close to the microscopic scale of a nanometer. To be more precise, Nanorobotics is the nanotechnology technique of building and forming designs of nanorobots. These robots range in size from 0.1-10 mm and get built in nanoscale (molecular component). The names nanorobots, Nanobots, nanoids, nanites, nanomachines or Nano-mites have also been used to describe these devices currently under research and development. Nanorobots get widely employed in the research & development (R & D) phases, but some first molecular robots get tested. In an example, a sensor having switch approx 1.5 nanometers across is capable of counting specific molecules in a chemical sample. The most useful applications of Nanobots are said to be in medical technology, which is used to identify and destroy cancer cells. The other potential example is the detection of toxic chemicals, and the measurement of their concentrations, in today's environment. The size of the Nanorobots is microscopic to be exact. Hence it is necessary for a large number of nanorobots to perform the microscopic and macroscopic tasks correctly together. These nanorobots move into large numbers i.e. swarms, both those incapable of carrying the replication and those capable of unconstrained reproduction in the natural environment.

Keywords--- Nanorobotics, Robotics, Nanobots, Nanorobots, Nanotechnology, Nanomedicine

I. INTRODUCTION

Nanorobotics is an upcoming frontier, a realm in which robots operate at scales of billionths of a meter [1]. Nanorobotics is the creation of functional materials, devices, and systems through control of matter on the nanometer scale. We can carry on the revolution in computer hardware right down to the level of molecular gates, switches, and wires that are unthinkable.

We have gotten better at it: we can make more things at lower cost and greater precision than ever before. However, at the molecular scale, we are still very crude, that is where nanotechnology comes in, at the molecular level.

Nanorobots are the next generation of nanomachines. Advanced nanorobots will be able to adapt, and sense to the environmental stimulus such as heat, light, sounds, textures of the surface, and chemicals perform complex calculations communicate, move and carry on the work together by conducting molecular assembly and to some extent repair or even reproduce themselves. Nanotechnology creates the science and application of objects on a level smaller than 100 nm. The final concept of nanotechnology [2] is the bottom-up creation of virtually any material object by carrying out the assembling of one molecule at a time. While nanotech processes occur at the scale of nanometers, the pieces of equipment or objects could be a result of the processes and can be much bigger. Huge-scale results happen when nanotechnology includes massive parallelism in which many simultaneous and synergistic nanoscale processes combine to produce a large-scale effect.

Many of the nanorobots have very limited processing power with no artificial intelligence as feared by most of us! They have a current processor that is handling up to thousand operations per sec. Hence, they have no threat issues whatsoever regarding Artificial Intelligence (AI) [11].

Most cellular repair Nanobots do not need more than 106-109 operations per sec of onboard computing capacity to do their work. It is a full 4-7 order of magnitude below correct human-equivalent computing at ten teraflops. Any faster computing capacity is only not required for most medical nanorobots.

There are multiple ways how this technology can be instrumental in the broad field of medicine. Specifically robotics, since the use of robots can enhance the way we handle the treatment of various diseases to a level where the life expectancy of our race can get increased [22].

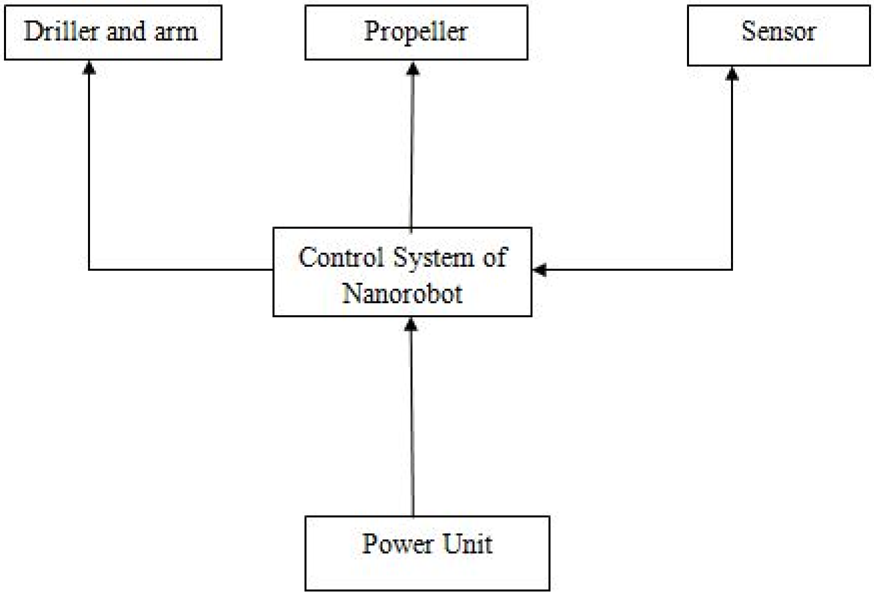

Fig 1. Block Diagram of Nanobot

II. LITERATURE SURVEY

A. ROBOTICS

Robotics is the technology that focuses on the design, construction, operation, and application of robots. Transactions are such as the use of computer systems for their control, the response of the sensors, and information operating. These technologies show us that the automated robots that take the position of the humans in hazardous surroundings or manufacturing processes or resemble humans in appearance, behavior, and cognition. Many of today's robots get boosted by the action that contributes to the vast area of bio-inspired robotics [5].

The concept of creating robots that can operate autonomously dates back to classical, but the findings are into the functionality, and potential uses of robots did not grow substantially until the 20th century. Throughout history, robotics has often been seen to mimic human behavior, and often manage tasks in a similar fashion. In the current world, robotics is a quickly expanding field, as technological advances continue to design research and build new robots that serve various purposes practically. Many robots carry out military jobs that are dangerous to people such as defusing bombs, mines and exploring shipwrecks.

Currently mostly, (lead-acid) batteries are used as a power source. Many different types of cells can get utilized as the energy source for these robots. They vary from the lead acid batteries which are very safe and have a relatively long life but are heavy to the silver-cadmium batteries that are much tinier in size and currently are very expensive. To design a battery powered robot we need to take into account factors such as safety, cycle lifetime and weight. Generators, often some internal combustion engine, can also be used [6].

B. NANOTECHNOLOGY

Nanotechnology is engineering at the smaller groups of atom level. It is a term for a particular range of technologies, techniques, and processes that add the control of matter at the atomic scale [1]. The nanotechnology gives better future for human life in various fields. In future nanotechnology provides economy, eco-friendly and efficient technology which removes all difficult predicaments which are seen by us in today's world. Nanotechnology is the exciting new technology of making things small, light and cheap; nanotechnology-based manufacturing is a technique derived from processing and rearranging of atoms to fabricate custom products [2].

The nanotechnology applications have three different categories nanosystems, nanomaterials, and nanoelectronics. The impact of the nanotechnology occurred in computing and data storage, materials and production, therapeutic area, power and surrounding, transportation, national security and space exploration. There are many applications of nanotechnology which are exciting in our life such as nanopowder, nanotubes, membrane filter, and quantum computers.

Nanotechnology does not get attached to any factory or market. Typically, it enables a set of technologies which across all market sectors and scientific practices. It is distinguished by the size of the materials being developed and used, not by the processes gets used, or products get manufactured. Nanoscience is an inherent multidisciplinary. It displays the conventional boundaries between physics, chemistry, biology, mathematics, information technology, and engineering [4].

Atoms along with molecules get stuck with each other because they have complementary shapes that form locks with each other or charges that create the attraction. Presently like with electromagnets, a positively charged atom molecule will hold to a negatively charged molecule. As millions of these particles are pieced together by nanomachines, a particular item will begin to take the shape and size. The aim of the little production is to control the atoms individually and place them in a pattern or trend that produces the desired structure.

C. NANOROBOTICS

Nanorobots are the result of a combination of two technologies: Robotics and Nanotechnology. A nanorobot is an atomic machine that is designed to operate a particular operation continuously and with accuracy at nanoscale dimensions, which are the dimensions of a few nanometers (nm) or less, where 1 nm = 10-9 meter. Nanorobots have certain applications in the assembly and maintenance of highly complex systems. Nanorobots probably work at the atomic level to build devices, machines, or circuits, a process known as nuclear production (molecular manufacturing). Nanobots will also produce replicas of themselves to replace worn-out units, a procedure called self-reproduction [5].

Nanorobots are of particular interest to researchers in the medical field. It has given rise to the area of nanomedicine. It gets suggested that a group of nanorobots serves as antibodies or antiviral agents in patients with vulnerable immune systems, or having diseases that do not get cured quickly by the usual measures. There are multiple other potential medical applications which include the repairing of the harmed tissue, removing the obstruction affected by the plaques in the arteries, and perhaps the reconstruction of the entire body organs by replacing them [6].

A major merit of nanorobots is their durability. In a theoretical world, they can stay operational for many years or centuries. Nanoscale systems can also work much quicker than their large-scale counterparts. These nanoscale systems have displacements that are small. They allow mechanically as well electrically occurring events to take place in lesser time at a given speed.

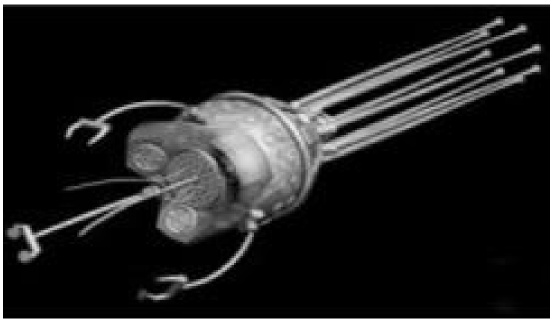

Fig 2. Nanorobot Structure

III. METHODOLOGY

A. THE BASIC TECHNOLOGY

Nanotechnology is relatively straightforward while learning about it, but to develop this universal technology into a nanorobot is more complicated than it seems.

Till date, the researchers have made excellent progress but have not officially released a finished product related to nanorobot that works entirely in a mechanical mode.

Many of the nanobot’s prototypes perform quite well in some ways but are definite biological in their true nature, while the greatest goal and perfect definition of a nanorobot are to have the molecular entity made entirely out of electromechanical components. Nanorobots are primarily a modified machine version of a bacteria. They are built to function on the same scale as both bacteria as well as the common viruses so that they can communicate directly and fight them [7].

Ideal nanobot consists of a transport process, an internal processing unit and a fuel unit of some kind that enables it to work. The biggest problem rises around the fuel cell. The fuel cell, since most conventional forms of robotic propulsion, can’t be forced to become smaller in size that is nanoscale with the current technology. The researchers have succeeded in reducing a robot to five or six mm, but this size still technically qualifies it as a macro-robot [9].

Since the best possible option in creating a nanorobot is to use another nanorobot, but the only problem lies are in getting started. Humans can perform one nano-operation at a time, but the thousands of varied applications required to construct a free and independent robot would be exceedingly too long and slow for us to execute at hand does not matter how high-tech the laboratory is. So it becomes necessary to create a whole set of specialized machine devices to speed up the procedure of nanorobots building construction and designing [10].

B. HARDWARE

The perfect nanorobot consists of a transporting device, an internal processor and a fuel system of some kind that allows it to function [8]. The main difficulty arises from this fuel cell since most conventional forms of robotic propulsion cannot be reduced to a nanoscale with current technology. The researchers have succeeded in cutting down a robot to five or six mm, but this size still technically makes it a large-scale robot (macro).

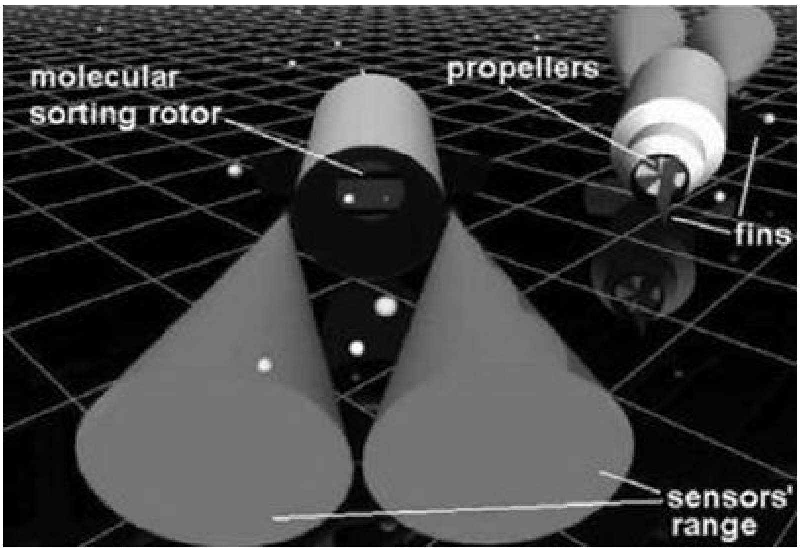

Fig 3. Nanorobot Design and Components

1) NANOSENSOR

It is a biological, chemical, or surgical sensory point that is deployed to deliver necessary information about nanoparticles to the large-scale world. Their use primarily adds up various medicinal objectives and gateways for the construction of other nanoproducts, such as computer chips that work at nanoscale systems. Therapeutic purposes of nanosensor mostly revolve around the capable nanosensor to accurately identify particular cells or the places in the body those are in desperate need [12]. By counting the changes that occur in the certain parameters such as concentration, volume, speed, velocity, gravitation, displacement, pressure, temperature of cells in a body, electrical and magnetic forces, the nanosensor might be able to differentiate between the individual cells and also recognize them.

2) MOLECULAR SORTING ROTOR

These are a class of nanomechanical tools capable of binding or releasing molecules from or to the solution and transporting these bound molecules against significant gradients.

3) FINS

They are a surface used for stability and to produce lift or thrust or to steer while moving in water, air, or other fluid media. A Nanorobot can travel with the help of this tool known as Fins.

C. NANOROBOT NAVIGATION

There are three primary considerations researchers need to concentrate on when looking at nanorobots moving through the body [13]. Namely, they are navigation, power and how the nanorobots will travel through the blood vessels. These get divided into two categories which are:

1) External navigation systems.

And,

2) Onboard systems.

1) EXTERNAL NAVIGATION SYSTEMS

External systems for navigation are one of the ways to use ultrasonic signals for the detection of the nanobot's locality and direct it to the right place. The ultrasonic waves would either pass through the body or reflect back to the origin of the signals or do both. The nanobot could give out pulses of ultrasonic waves, which could be detected using specialized equipment with ultrasonic devices (sensor) [14].

Using a Magnetic Resonance Imaging (MRI) machine, doctors could track and position a nanorobot by the detection of its magnetic field. Doctors may also track nanorobots by injecting a radioactive dye into the patient's bloodstream. Other ways of identifying the nanorobot include using X-rays, radio waves, microwaves or heat.

2) ONBOARD SYSTEMS

Onboard systems or internal devices mainly sensors, may also play a significant part in navigation. A nanorobot with chemical sensors will help in the detection and follow the trail of specific chemicals to reach the right destination [15]. A spectroscopic device would allow the nanorobot to take samples of surrounding tissue, analyze them and move a track of the correct sequence of chemicals.

D. POWER SOURCES

There are mainly two sources of energy used for nanorobots internal energy sources and external sources of energy.

1) INTERNAL POWER SOURCES

A nanorobot could utilize the patient's body temperature to create power, but there would need to be a gradient of heat to manage it. Energy generation would be a conclusion of the See Beck effect. A capacitor which has a better power to weight ratio also gets used.

2) EXTERNAL POWER SOURCES

External sources of energy include systems where the nanorobot is either tethered to the outside world or gets manipulated without a physical chain. Tethered systems would need a cable between the nanorobot and the power source. The wire would need to be strong enough, but it would also need to move without any force through the human body without causing harm [16]. A physical chain could supply power either by electricity or optically. Experimenting within Montreal, can either control the nanorobot directly or induce an electrical current in a closed conducting loop in the robot.

E. PROCEDURE

The common idea behind Nanorobotics is to manipulate objects at the scale of nanometers. Nanorobots might function at the atomic or molecular level to build devices, machines, or circuits, a process known as molecular manufacturing.

Two approaches we got to follow in the implementation of a nanorobot are:

1) BIOCHIPS

The first approach is the biochip that supports a possible way to produce nanorobots for necessary medical applications, such as for surgical instrumentation, cure, and delivering the medicines [17]. This process for producing on nanotechnology scale is currently in practice in the electronics business. So, practical nanorobots should get combined into nanoelectronics devices, which will support teleoperation and advanced capabilities for medical instrumentation.

2) SELF RECONFIGURABLE MODULAR ROBOTS

The second approach is self-reconfigurable modular robots also known as Fractal robots [18]. Self-reconfiguring robots are also able to change their shape deliberately by rearranging the connectivity of their parts, to adjust to new situations, perform new operations, or recover from harm.

IV. BENEFITS OF NANOROBOTICS TECHNOLOGY

Nanorobotics initiates the path towards new manufacturing routes, more efficient, performance and intelligent materials, towards the new construction of structures and associated maintenance and monitoring systems [11].

A. SPACE TECHNOLOGY

Space technology has two applications of Nanorobotics:

1) Swarms

And,

2) Space colonization

1) SWARMS

Swarms are just like the nanorobots that work in unison such as bees. They hypothetically operate with flexibility cloth material and being composed of what is called Bucky Tubes. This material will act as strong as diamond. If a nanocomputer gets included to nanomachine, a bright cloth gets discovered. The gorgeous fabric could be used to keep astronauts from bouncing around in their airship while they sleep, a difficulty that affects when autopilot computer fires course correction rockets [19]. This cloth-like item will be capable of offsetting the unexpected movements and steadily traveling the astronauts to their location.

2) SPACE COLONIZATION

Nanorobots can get utilized in carrying out design projects in hostile environments. For example, with a handful of duplicating robots, using local material and local power, it is conceivable that space surroundings can be entirely built by remote control so that habitats may need only to show up their suitcases.

Colonization of space can get done, and a group of engineers can monitor the manufacturing of habitats via telepresence utilizing cameras and sensors created on the surface of the Mars by nanorobots all generate the comfortable confines of earth. Venus could be traveled through with Nanorobots too.

B. ELECTRONICS

In today's world, colossal scale integration gets done on the electronic chips. Each chip contains millions of electronic circuits. For a proper functioning, each circuitry must get designed with high precision. As nanorobots can operate at the nanoscale invention of such chips can be done without any difficulty.

C. MEDICAL

Possible applications for Nanorobotics in medicine include early diagnosis and targeted drug delivery for cancer, arteriosclerosis, blood clots, kidney stones, wounds biomedical instrumentation, surgery, pharmacokinetics monitoring of diabetes and health care [4].

During such plans, future therapeutic nanotechnology is demanded to operate nanorobots inserted into the patient to deliver work at a cellular level. Such nanorobots designed for use in medicine should be non-replicating, as replication would needlessly increase device complication, reduce reliability, and interfere with the medical mission.

1) TREATING ARTERIOSCLEROSIS

Arteriosclerosis relates to a disease where plaque forms along the walls of arteries. Nanorobots could conceivably handle the condition by separating away the plaque, which would then invade the bloodstream.

2) SPLITTING UP BLOOD CLOTS

Blood clots can cause complexities ranging from muscle death to a stroke. Nanorobots could move to a lump and split it up. This use is one of the most dangerous operations for nanorobots – the robot must be able to eliminate the blockage without losing small pieces in the bloodstream, which could then move elsewhere in the body and cause more issues [20]. The nanorobot must also be cheap enough so that it does not block the flow of blood itself.

3) PREVENTING CANCER

Doctors hope to use nanorobots to cure cancer patients [3]. The nanorobots could fight tumors using lasers directly, or microwaves (ultrasonic signals), or they could be part of a chemotherapy treatment, delivering drugs directly to the cancer site. Doctors believe that by giving small but precise doses of medication to the patient, side effects can get minimized without a loss in the medicine's effectiveness [9].

4) HELPING THE BODY CLOT

One particular kind of nanorobots is the blastocyte or artificial platelet. The blastocyte carries a small-scale mesh net that dismisses into a sticky membrane upon contact with blood plasma. According to Robert Freitas, the man who designed the blastocyte, lumping could be up to thousand times faster than the body's natural clot process. Doctors could use colonocytes to treat hemophiliacs or patients with severe open injuries.

5) PARASITE ELIMINATION

Nanorobots could conduct micro-war on bacteria and small-scale parasitic organisms inside a patient. It might take several nanorobots working associatively to remove all the parasites.

6) GOUT

Gout is an illness where the kidneys lose the capability to eliminate waste from the splitting of fats from the bloodstream. This waste sometimes solidifies at positions near joints like the knees and ankles. Humans can tolerate from gout experience and extreme pain at these joints. A nanorobot could split the crystalline structures at the joints, giving relief from the symptoms, though it would not be capable of reversing the illness indefinitely.

7) CLEANING INJURIES

Nanorobots could help eliminate debris from injuries, decreasing the likelihood of virus. They would be possibly useful in cases of puncture wounds, where it might be difficult to treat using more conventional methods [8].

8) REMOVAL OF KIDNEY STONES

Kidney stones can be extremely painful: the enormous the rock, the more troubling it is to pass. Doctors split up large kidney stones using ultrasonic frequencies, but it is not always purposeful. A nanorobot could split up kidney stones using a small-scale laser.

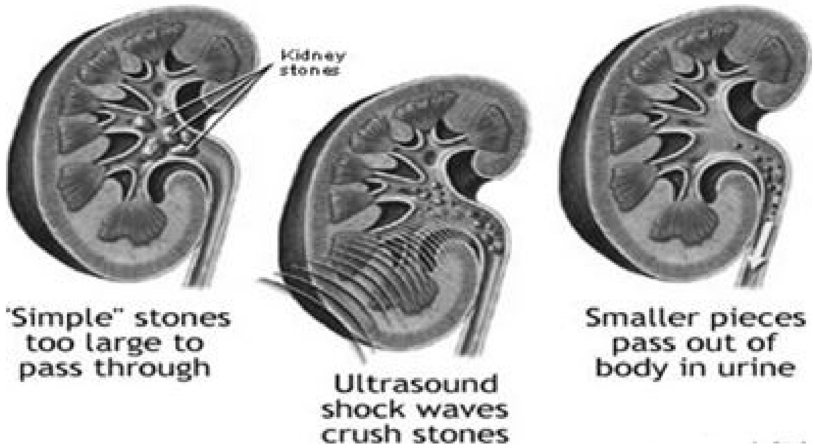

Fig 4. Nanorobot use in kidneys

V. CHALLENGES IN NANOROBOTICS TECHNOLOGY

A. TECHNOLOGICAL LIMITS

While there has been much rise in the field of Nanorobotics this technology is still in research and development (R&D) phase; only limited first designs have got tested. We cannot completely depend on these devices. It is hard to predict the behavior of nanorobots [22].

B. SECURITY THREATS

With the help of Nanorobotics more advanced weaponry could be built. Atomic weaponry can now be more available and made to be more robust and damageable. These can also become more accessible with the support of this technology.

C. PRODUCTION COST

Currently, nanotechnology is very costly and developing it can cost us much money. Nanotechnology is also tough to produce, and that is why their products are expensive in cost as well [21]. Moreover, that is why nanorobots too are costly to build.

CONCLUSION AND FUTURE SCOPE

Nanomedicine will remove nearly all the widespread diseases of the 21st century, almost all narcotic agony, and pain, and allow the extension of human abilities most especially our mental capacities.

Consider that a nanostructure data storage tool measuring ~8,000 micron3, a cubic volume about the size of a single person's liver cell and minute than a typical neuron, could contain an amount of information equal to the complete information in the government. If inserted someplace in the human brain, combining with the proper interface techniques, such a device could provide extremely high-speed entree to this data information.

A single nanomachine processor, also having the size of just one little human cell unit, could calculate at the rate of 10 teraflops (1013 floating-point ops per sec), approximately equivalent (by multiple estimations) the computational output of the entire human brain. Such a nanomachine may manufacture only about 0.001 W of furnace waste heat, in comparison to the ~25 W of furnace waste heat for the biological brain where the nanomachine may get fixed.

However, perhaps the most significant long-term benefit to human society as a whole could be the dawning of a new era of peace. We could hope that people who are well-fed, well-clothed, well-housed, smart, well-educated, healthy and happy will have little inspiration to make well. Humans who have a reasonable future of living many "normal" lifetimes will learn patience and stability from their experience, and will be extremely careful and unlikely to risk those "multiple lives" for any of the most compelling of reasons.

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