Design & Development of Nanobots for Cancer Cure Applications in Bio-Medical Engineering

Rajesh J.
8th Sem UG BE Student
ECE Department, DSCE
USN : 1DS13EC739

Pavithra G.
Full Time Research Scholar
VTU RRC, Belagavi, Karnataka
USN : 5VZ16PEJ56

Dr. T.C. Manjunath
Prof. & Head of the Dept.,
Dept. of E & C E,
Dayananda Sagar CE, B'lore

***Abstract*:- A brief review of the nanorobots that are currently used in the biomedical engineering to cure various types of diseases are being presented. In the context, we are carrying out a literature survey for the treatment of cancer using the nano-technology concept. The way we have picked is the union of nanotechnology and medicine. The mix of nanotechnology into medication is probably going to get some new difficulties restorative treatment. Nanorobot is a superb vision of medicine in future. The most exceptional nanomedicine includes the utilization of nanorobots as small scale specialists. Advancement in nanotechnology may allow us to build artificial red blood cells called Respirocytes capable of carrying oxygen and carbon dioxide molecules (i.e., functions of natural blood cells). Respirocytes are nanorobots, small mechanical gadgets intended to work on the atomic level. Respirocytes can give a brief substitution to characteristic platelets in the instance of a crisis. Subsequently respirocytes will truly change the treatment of coronary illness. We can imagine a day when you could infuse billions of these nanorobots that would skim around in your body. A standout amongst the most sensible and almost doable accomplishments is the cure for growth which is one of the primary centers of this work. Nanorobots could carry and deliver large amounts of anti-cancer drugs into cancerous cells without harming healthy cells, reducing the side effects related to current therapies. These nanorobots will have the capacity to repair tissues, clean veins and aviation routes, change our physiological capacities. The work presented in this paper is the UG credit seminar work of the undergraduate student that was undertaken by the UG student & just provides a brief review of the applications of the nanorobots that could be used in the medicine for the curing of the cancer treatement and is just a review paper, which serves as a basis for all the students, faculties as a base for carrying out the research in this exciting field of nanorobotics.**

General Terms:- Nanorobots, Medicine

Keywords:- Cancer, Treatment, Coronary, Artery

1. INTRODUCTION

A nanorobot can be defined as an artificially fabricated object able to freely diffuse in the human body and interact with specific cell at the molecular level. The figure shows a schematic representation of a nanorobot that can be activated by the cell itself when it is needed. Stress induced by disease or infectious attack generally leads to changes in the chemical content of the cell which in turn trigger the nanorobots.

Nanorobots can be coated with different agent depending on their application or tissue destination. The external shell is a crucial point because it has to be recognized as a part of the body (inert coating) and be able to release different ideal matrix that it is not toxic at the nanometer level. The pore size can be tuned permitting release of different size sizemolecules (tunable porosity). A rigid shell like silica is an molecules. The surface is easily functionalizable with simple chemical methods but most important is that the silica is not biodegradable permitting a long-term activity in the body.

Nanorobots will be able to analyze each cell types surface antigens to recognize if the cell is healthy, what the parent organ is, as well as almost all information about the cell, and using chemotactic sensors, certain molecules and cells could be identified and easily targeted for action. A 1 cm3 injection of nanorobots would be able to deliver selectively into cells at least 0.5 cm3 of chemical agent, and the sensors could test levels of the chemical to guard against an accidental overdose. Self-Assembly and Nanomanipulation are two main ways for the production of nanorobots.

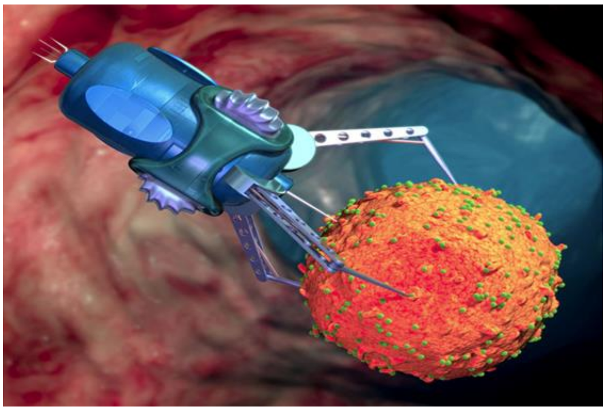

Fig 1 : Nanorobots which are used to attack the cancerous cells

2. OVERVIEW

We will describe a mobile robot (nanorobot) that can be created with existing technology, that can be used to seek out and destroy inimical tissue within the human body that cannot be accessed by other means. The construction and use of such devices would result in a number of benefits. It would provide either cures or at least a means of controlling or reducing the effects of a number of ailments
Nanotechnology has the potential to radically increase our options for prevention, diagnosis, and treatment of cancer.

Nanotechnology may also be useful for developing ways to eradicate cancer cells without harming healthy, neighboring cells Nanotechnology uses therapeutic agents that target specific cells and deliver their toxin in a controlled, time-released manner.
As a syringe is today used to inject medication into the patient's bloodstream, tomorrow, nanorobots could transport and deliver chemical agents directly to a target cell. Nanokiller (i.e., nanorobot) could find and repair damaged organs, detect and destroy a tumor mass. They would be able to communicate their positions, operational statuses, and the success or failure of the treatment as it progresses. They would tell you how many cancer cells they have encountered and inactivated. Respirocytes identify tumors and then allow the nanokiller to kill cancerous cells with a tiny but precise amount of a chemotherapy drug. It would not only find cancers in their earliest stages before they can do damage or spread, but also deliver a small amount of a drug targeted directly at tumors, which would cause little or no side effects. Nanomedicine could result in non-invasive devices that can enter the body to determine glucose levels, distinguish between normal and cancerous tissue, and destroy the tumor in the initial stage itself. This nanorobot has vibrating cilia like structures with inbuilt nanosensors to detect the cancerous tissue. This nanorobot shells are specially coated with gold that allow them to attach to malignant cells and they can deliver the drug internally.

Fig 2 : Removal of cancer by surgery using the conventional method

3. CONVENTIONAL METHODS OF CANCER THERAPY TREATMENTS

Most people with cancer receive surgery, chemotherapy, radiation therapy, or other conventional therapies at some point during treatment, and many will have a combination of these treatments. Injection of drugs affects both cancerous and non cancerous cells in conventional method. So, the main types of cancer treatment include : Surgery, Radiation Therapy, Chemotherapy, Immunotherapy, Targeted Therapy, Hormone Therapy.

4. THE MAJOR DRAWBACKS OF THE CONVENTIONAL METHODS USED IN THE CANCER THERAPY

Injection of drugs affects both cancerous and non cancerous cells in conventional method. There are various side effects with the conventional methods as it effects both the cancerous and non cancerous cells. Surgery and radiation therapy remove, kill, or damage cancer cells in a certain area which also effects healthy cells. The time to heal is longer with the conventional methods that includes methods like surgery, radiation therapy. Some of the side effects that that occur when conventional method is followed are
Fatigue -This is a persistent feeling of physical, emotional, or mental exhaustion. Cancer-related fatigue differs from feeling tired due to lack of rest. Receiving multiple treatment types may increase your fatigue. For example, having chemotherapy and radiation therapy.
Pain : Chemotherapy sometimes causes these types of pain: Headaches, Muscle pain, Stomach pain, Pain from nerve damage etc..,
Mouth and throat sores : This causes painful sores, a condition called mucositis.
Diarrhea : This means having loose or watery bowel movements.
Nausea and vomiting, Appetite loss, Hair loss etc..
Constipation : This means having infrequent or difficult bowel movements.
Blood disorders : Bone marrow is the spongy tissue inside your bones. It makes new blood cells. But chemotherapy affects this process. Therefore, you may experience side effects from having too few blood cells.
Nervous system effects : Some drugs cause nerve damage.

5. THE MODERN TECHNOLOGY USED TO CURE CANCER THERAPY

Nanotechnology uses therapeutic agents that target specific cells and deliver their toxin in a controlled, time-released manner. As a syringe is today used to inject medication into the patient's bloodstream, tomorrow, nanorobots could transport and deliver chemical agents directly to a target cell. Nanokiller (i.e., nanorobot) could find and repair damaged organs, detect and destroy a tumor mass. They would be able to communicate their positions, operational statuses, and the success or failure of the treatment as it progresses. They would tell you how many cancer cells they have encountered and inactivated. Respirocytes identify tumors and then allow the nanokiller to kill cancerous cells with a tiny but precise amount of a chemotherapy drug. It would not only find cancers in their earliest stages before they can do damage or spread, but also deliver a small amount of a drug targeted directly at tumors, which would cause little or no side effects. Nanomedicine could result in non-invasive devices that can enter the body to determine glucose levels, distinguish between normal and cancerous tissue, and destroy the tumor in the initial stage itself. This nanorobot has vibrating cilia like structures with inbuilt nanosensors to detect the cancerous tissue. This nanorobot shells are specially coated with gold that allow them to attach to malignant cells and they can deliver the drug internally.

There are three main considerations need to focused on designing a nanorobot to move through the body -- navigation, power and how the nanorobot will move through blood vessels. For directing the nanorobots to the cancerous cells we can make use of ultrasonic signals which are emitted by the nanorobot. These ultrasonic waves are detected by ultrasonic sensors. Nanorobots can also be fitted wit a small miniature camera assuming the nanorobot isn't tethered or designed to float passively through the bloodstream, it will need a means of propulsion to get around the body. Because it may have to travel against the flow of blood, the propulsion system has to be relatively strong for its size. Another important consideration is the safety of the patient, the system must be able to move the nanorobot around without causing damage to the host.

For locomotion we can mimic Paramecium, It moves through their environment using tiny tail-like limbs called cilia. By vibrating the cilia, the paramecium can swim in any direction. Similar to cilia are flagella, which are longer tail structures. Organisms whip flagella around in different ways to move around. The nanorobot would move around like a jet airplane. Miniaturized jet pumps could even use blood plasma to push the nano robot forward, though, unlike the electromagnetic pump, there would need to be moving parts

For powering a nanorobot we could use the patient's body heat to create power, but there would need to be a gradient of temperatures to manage it. Power generation would be a result of the Seebeck effect. The Seebeck effect occurs when two conductors made of different metals are joined at two points that are kept at two different temperatures. The metal conductors become a thermocouple, meaning that they generate voltage when the junctures are at different temperatures. Since it's difficult to rely on temperature gradients within the body, it's unlikely we'll see many nanorobots use body heat for power. These are some of the most practical ideas which have been implemented in real life.

Fig 3 : Nanorobots moving inside the blood stream in the veins / capillaries to destroy the cancerous cells

6. ADVANTAGES OF THE MODERN TECHNOLOGY EMPLOYED

With the help of nanorobots, we can further understand the complexity of human body and brain. The development will further help in performing painless and noninvasive surgeries. Even the most complicated surgeries will be done with ease. Due to their microscopic features they could surf through the brain cells and generate all the related information required for further studies. Scientist specially will be benefited from this nanotechnology application.

The best part is the nanobot are so small that it is not visible with naked eyes, so they can be injected in a human body very easily. Days in future will be like this when a single shot will cure diseases. More than million people in this world are affected by this dreaded disease. Currently there is no permanent vaccine or medicine is available to cure the disease. The currently available drugs can increase the patient’s life to a few years only, so the invention of this nanorobot will make the patients to get rid of the disease. As the nanorobot do not generate any harmful activities there is no side effect. It operates at specific site only. The initial cost of development is only high but the manufacturing by batch processing reduces the cost.

7. LITERATURE SURVEY

A large number of scientists, researchers, students had worked on the curing of the cancer treatment using the nano robots. Here follows a brief review of the same. In the 1980’s by Nobel Prize laureate Richard Smalley. Smalley has extended his vision to carbon nanotubes, discovered by Sumio Iijima, which he envisions as the next superinter connection for ultra small electronics. The term nanotechnology has evolved to mean the manipulation of the elements to create unique and hopefully useful Structures.

December 29, 1959: Richard Feynman gives thefamous “There’s Plenty of Room at the Bottom” talk. First use of the concepts of nanotechnology. Describes an individual atoms and molecules can be manipulated.

1974: Professor Norio Taniguchi defines nanotechnology as “the processing of, separation, consolidation, and deformation of materials by atom / molecule.”

1980’s: Dr. Eric Drexler publishes several scientific articles promoting nanoscale phenomena and devices.

1986: The book Engines of Creation: The Coming Era of Nanotechnology by Dr. Eric Drexler is published. He envisioned nanorobots as self-replicating. A first book on nanotechnology. [5]

1981: Gerd Binnig and Heinrich Rohrer of IBM Zürich. Invented of the Scanning Tunneling Microscope (STM)By Used for imaging surfaces at the atomic level and identifying some properties (i.e. energy).

1985: Discovery of fullerenes (molecules composed entirely of carbon). They have many applications in materials science, electronics, and nanotechnology.

1991: discovering Carbon nano tubes (cylindrical fullerenes) as direct result of the fullerenes. – Exhibit high tensile strength, unique electrical properties, and efficient thermal conductivity. Their electrical properties make them ideal circuit components (i.e. transistors and ultra-capacitors). Recently, researched chemical and biomedical engineering have used carbon nano tubes as a vessel for delivering drugs into the body. [5]

1991: Invented of atomic force microscope (AFM)– it has imaging, measuring and manipulating matter at the nanoscale. It performs its functions by feeling the surface with mechanical probe. – Since interaction with materials on the nanoscale, it is considered a nanorobot.

2000: United States national nanotechnology Initiative is founded to coordinate federal research and development in nanotechnology

2000: The company nano factory collaboration is founded. Developing a research agenda for building a nano factory capable of building nanorobots for medical purposes.

Currently, DNA machines (nucleic acid robots) are being developed. Performs mechanical-like movements, such as switching, in response to certain stimuli (inputs).

Molecular size robots and machines paved the way for nanotechnology by creating smaller and smaller machines and robots. The applications of the nano robotics are more as: microrootics, emerging drug delivery application, health care, bio-medical application, cancer therapy, Brain Aneurysm, communication system, and new future nanotechnologies. Etc.

The major development of nanomedicine molecular nanotechnology (MNT) or nanorobotics. Just as biotechnology extends the range and efficacy of treatment available from application of nanomaterials, the advent of molecule of nanotechnology will be again expand enormously the effectiveness, precision and speed of future medical treatments while at the same time significantly reducing their risk, cost, and invasiveness. MNT will allow doctors to perform direct in vivo surgery of human cells.. Nanomedicine's that can easily traverse the human body because nanorobots are so tiny. Scientists report that nanorobot constructed of carbon atoms in a diamonded structure because of its inertproperties and strength. Glucose or natural body sugars and oxygen might be a source for propulsion, and it will have other biochemical or a molecular part depends on task. A large Potential applications for nanorobotics in medicine include early diagnosis and targeted drug delivery with treat mental medicine for cancer biomedical instrumentation, surgery, pharmacokinetics, monitoring of diabetes, and health care. In future medical technology is expected to nanorobots injected into the patient to perform treatment on a cellular level.

8. MAIN OBJECTIVE OF NANO-ROBOTICS IN MEDICAL FIELDS

To help monitor the patients body continuously and be able detect cancer and other diseases at early stages.

To destroy cancerous cells without affecting the healthy cells.

To reduce the time of recovery for people fighting against cancer and other diseases.

To carry and deliver large amounts of anti-cancer drugs into cancerous cells without harming healthy cells, and thus reducing the side effects related to current therapies.

To repair tissues, clean blood vessels and airways, transform our physiological capabilities, and even potentially counteract the aging process.

The above mentioned objective of our work can be achieved using the following steps one by one as follows …

First finding out the method of entry into the body for the nanorobot

Finding means of propulsion for the nanorobot

Finding means of maintaining a fixed position while operating

Finding how to control of the device

Finding the appropriate power source to nanorobot

Finding means of locating substances to be eliminated by the nanorobot

Finding means of doing the elimination the substance from the body

Finally continuously monitoring the body and giving feedback.

9. DESIGN OF NANOROBOTS FOR MEDICAL APPLICATIONS

Locomotion : There are a number of means available for active propulsion of our device.

Propeller : The very first Feynman prize in Nanotechnology was awarded to William McLellan for building an electric motor that fit within a cube 1/64th of an inch on a side. This is probably smaller than we would need for our preliminary microrobot. One or several of these motors could be used to power propellers that would push (or pull) the microrobot through the bloodstream. We would want to use a shrouded blade design so as to avoid damage to the surrounding tissues (and to the propellers) during the inevitable collisions

Cilia/flagellae : In this scenario, we are using some sort of vibrating cilia (similar to those of a paramecium) to propel the device. A variation of this method would be to use a fin-shaped appendage. While this may have its attractions at the molecular level of operation, an electric motor/propeller combination would be more practical at the scale we are talking about.

Electromagnetic pump : This is a device with no moving parts that takes conductive fluid in at the front end and propels it out the back, in a manner similar to a ramjet, although with no minimum speed. It uses magnetic fields to do this. It would require high field strengths, which would be practical with high capacity conductors. At the scale we are talking about, room (or body) temperature ceramic superconductors are practical, making this a possibility.

Jet Pump : In this scenario, we use a pump (with moving parts) to propel blood plasma in one direction, imparting thrust in the opposite direction. This can either be done with mechanical pumps, or by means of steam propulsion, using jets of vaporized water/blood plasma.

Membrane propulsion : A rapidly vibrating membrane can be used to provide thrust, as follows: Imagine a concave membrane sealing off a vacuum chamber, immersed in a fluid under pressure, that is suddenly tightened. This would have the effect of pushing some of the fluid away from the membrane, producing thrust in the direction toward the membrane. The membrane would then be relaxed, causing the pressure of the fluid to push it concave again. This pressure would impart no momentum to the device, since it is balanced by the pressure on the other side of the device. At the macro scale, this thrust is not significant, but at the micro scale it is a practical means of propulsion.

Crawl along surface : Rather than have the device float in the blood, or in various fluids, the device could move along the walls of the circulatory system by means of appendages with specially designed tips, allowing for a firm grip without excessive damage to the tissue. It must be able to do this despite surges in the flow of blood caused by the beating of the heart, and do it without tearing through a blood vessel or constantly being torn free and swept away.

Navigation : This information will be used to navigate close enough to the operations site that short range sensors will be useful.

Ultrasonic : This technique can be used in either the active or the passive mode. In the active mode, an ultrasonic signal is beamed into the body, and either reflected back, received on the other side of the body, or a combination of both. The received signal is processed to obtain information about the material through which it has passed. This method is, of course, greatly similar to those used in conventional ultrasound techniques, although they can be enhanced greatly over the current state of the art.

In the passive mode, an ultrasonic signal of a very specific pattern is generated by the microrobot. By means of signal processing techniques, this signal can be tracked with great accuracy through the body, giving the precise location of the microrobot at any time. The signal can either be continuous or pulsed to save power, with the pulse rate increasing or being switched to continuous if necessary for more detailed position information.

In the passive mode, the ultrasonic signal would be generated by means of a signal applied to a piezoelectric membrane, a technology that has been well developed for at least a decade. This will allow us to generate ultrasonic signals of relatively high amplitude and great complexity.

NMR/MRI : This technique involves the application of a powerful magnetic field to the body, and subsequent analysis of the way in which atoms within the body react to the field. It usually requires a prolonged period to obtain useful results, often several hours, and thus is not suited to real-time applications. While the performance can be increased greatly, the resolution is inherently low due to the difficulty of switching large magnetic fields quickly, and thus, while it may be suited in some cases to the original diagnosis, it is of only very limited use to us at present.

Radioactive dye : This technique is basically one of illumination. A radioactive fluid is introduced into the circulatory system and its progress throughout the body is tracked by means of a fluoroscope or some other radiation-sensitive imaging system. The major advantage of this technique is that it follows the exact same path that our microrobot would take to reach the operations site. By sufficiently increaing the resolution of the imaging system, and obtaining enough data to generate a three dimensional map of the route, it would provide valuable guidance information for the microrobot.

The active form of this technique would be to have a small amount of radioactive substance as part of the microrobot. This would allow its position to be tracked throughout the body at all times. Additionally, since the technique would not require the microrobot to use any power, or require a mechanism of any sort, it would greatly simplify the design of the microrobot. While there are risks from radiation, the amount of radioactive substance used would not be even a fraction of the amount used in radioactive dye diagnosis. Additionally, as advances in electronic sensors continue, the amount of radiation needed for tracking would steadily be reduced. In fact, infrared sensing techniques are so advanced that we can fully shield the radioactive substance and merely track its heat directly.

X-ray : X-rays as a technique have their good points and bad points. On the plus side, they are powerful enough to be able to pass through tissue, and show density changes in that tissue. This makes them very useful for locating cracks and breaks in hard, dense tissue such as bones and teeth. On the other hand, they go through soft tissue so much more easily that an X-ray scan designed to show breaks in bone goes right through soft tissue without showing much detail. On the other hand, a scan designed for soft tissue can't get through if there is any bone blocking the path of the x-rays. Another problem with x-rays is that it is very difficult to generate a narrow beam, and even if one could be generated, using it to scan an area in fine detail would necessitate prolonged exposure. Consequently, x-rays are useful only for gross diagnosis, for which several of the techniques listed above are far better suited.

Radio/Microwave/Heat : Again, these techniques (really all the same technique) can be used in both passive and active modes. The passive mode for the techniques depends on the various tissues in the body generating signals that can be detected and interpreted by external sensors. While the body does generate some very low frequency radio waves, the wavelength is so large that they are essentially useless for any sort of diagnostic purposes of the type we are interested in.

POWER : One major requirement for our microrobot is, of course, power. We have to be able to get sufficient power to the microrobot to allow it to perform all of its required operations. There are two possible paths we can take for this. The first is to obtain the power from a source within the body, either by having a self-contained power supply, or by getting power from the bloodstream. The second possibility is to have power supplied from a source external to the body.

Source within the body : There are a number of possible mechanisms for this scenario. The basic idea is that the microrobot would carry its power supply within itself. It would need enough power to move to the site of the operation, perform its functions, which might be very power intensive, and then exit the body. There are three basic scenarios for on-board power supplies.

Body heat : This method would use body heat to power the microrobot, in effect using the entire body as a power supply. The basic problem with this is that a power supply requires an energy gradient in order to function. In this case, we would need to areas of different temperature, so that we could set up a power flow between them. Since our microrobot would have to be mobile, and operate at full capacity in many different environments, this requirement would be difficult to fulfill.

Power from the bloodstream : There are three possibilities for this scenario. In the first case, the microrobot would have electrodes mounted on its outer casing that would combine with the electrolytes in the blood to form a battery. This would result in a low voltage, but it would last until the electrodes were used up. The disadvantage of this method is that in the case of a clot or arteriosclerosis, there might not be enough blood flow to sustain the required power levels. Also, if the electrodes were ever embedded in anything that blocked their access to the blood, power would drop to zero and stay there. This means that a backup would be required.

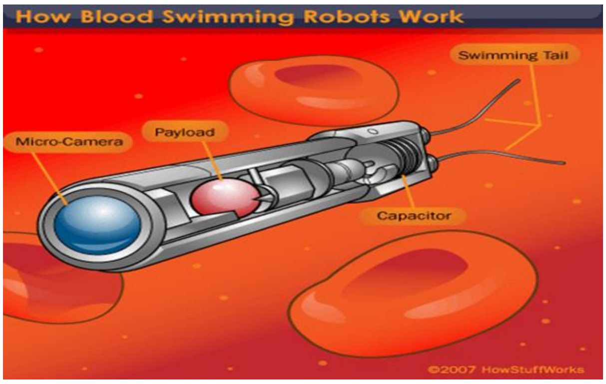

Fig. 4 : Nano machines in the blood vessel

The second way to get power from the bloodstream is by means of a fuel cell, or simply by burning blood chemicals. This is similar to a battery except that rather than obtain power from current flow between electrodes, we would obtain power by causing chemical reactions to take place at a controlled rate and obtaining power from this. This is much the same way that the body gets its own power by consuming fuel chemicals from the bloodstream. This has the same problem as the electrode method; it will stop working if access to the blood is blocked, or if the chemicals are not replenished.

10. POSSIBLE OUTCOME OF OUR SEMINAR WORK UNDERTAKEN

In the approach presented above nanorobots perform similar tasks on detecting and acting upon medical targets demanding surgical intervention. Each nanorobot is programmed to move through the workspace being tele operated from the surgeons. The fluid flow pushes the concentration of the diffusing signal downstream. Consequently a nanorobot passing more than a few microns from the source won‘t detect the signal while it is still relatively near the source. As an example, the first nanorobot passing close a lymph node may on average detect the higher signal concentration within about 0.16s. Thus, keeping their motion near the vessel wall, the signal detection happens after these have moved at most 10mm past the source. Those passing within a few microns often detect the signal, which spreads a bit further upstream and away from the single tumor due to the slow fluid motion near the venule‘s wall and the cells motion.

Thus, the present 3D simulation provides guidelines for nanorobot communication and activation control, as well as for sensor manufacturing design. Distinct performances were observed throughout a set of analyses obtained from the NCD software, where the nanorobots use also electromagnetic ultrasound transducers as the communication technique to interact dynamically with the 3D environment, and to achieve a more successful collective coordination. Figure. 4 shows the virtual environment in our study, comprised a small venule which contains nanorobots, the red blood cells (RBCs) and a single tumor cell, which is the target area on the vessel wall. Here, the target area is overleaped by the RBCs. In the simulation, the nanorobots search for possible small cancer tumor into the workspace crowded by RBCs, transmitting back information for the surgeons.

APPLIATIONS OF OUR SEMINAR WORK UNDERTAKEN

There are a large number of applications of the work that we have undertaken as a review / survey paper for the UG credit seminar topic. The applications are listed one by one as below with an in depth explanation.

Nanorobots in Cancer Detection and Treatment : The current stages of medical technologies and therapy tools are used for the successful treatment of cancer. The important aspect to achieve a successful treatment is based on the improvement of efficient drug delivery to decrease the side-effects from the chemotherapy.Nanorobots with embedded chemical biosensors are used for detecting the tumor cells in early stages of cancer development inside a patient's body.

Nanorobotics in Surgery : Surgical nanorobots are introduced into the human body through vascular systems and other cavities. Surgical nanorobots act as semi-autonomous on-site surgeon inside the human body and are programmed or directed by a human surgeon. This programmed surgical nanorobot performs various functions like searching for pathogens, and then diagnosis and correction of lesions by nano-manipulation synchronized by an on-board computer while conserving and contacting with the supervisory surgeon through coded ultrasound signals.

Diagnosis and Testing : Medical nanorobots are used for the purpose of diagnosis, testing and monitoring of microorganisms, tissues and cells in the blood stream. These nanorobots are capable of noting down the record, and report some vital signs such as temperature, pressure and immune system's parameters of different parts of the human body continuously.

Nanorobotics in Gene Therapy : Nanorobots are also applicable in treating genetic diseases, by relating the molecular structures of DNA and proteins in the cell. The modifications and irregularities in the DNA and protein sequences are then corrected (edited). The chromosomal replacement therapy is very efficient compared to the cell repair. An assembled repair vessel is inbuilt in the human body to perform the maintenance of genetics by floating inside the nucleus of a cell.

Nanodentistry : Nanodentistry is one of the topmost applications as nanorobots help in different processes involved in dentistry. These nanorobots are helpful in desensitizing tooth, oral anesthesia, straightening of irregular set of teeth and improvement of the teeth durability, major tooth repairs and improvement of appearance of teeth, etc.

11. CONCLUSIONS

In this paper, we have presented a brief review of the nano-robots that were being used in the biomedical engineering or curing of the deadliest disease in the world, i.e.., the cancer. Nature has created nanostructures for billenia. Biological systems are an existing proof of molecular nanotechnology. Rather than keep our eyes fixed on the far future, let us start now by creating some actual working devices that will allow us to cure some of the most deadly ailments known, as well as advance our capabilities directly, rather than as the side effects of other technologies. There will be a day when eliminating cancer cells are mere an out-patient medical procedure and is just a review paper, which serves as a basis for all the students, faculties as a base for carrying out the research in this exciting field of nanorobotics.

12. REFERENCES

[1] A. Cavalcanti, R. A. Freitas Jr., ―Nanorobotics Control Design: A Collective Behavior Approach for Medicine, *IEEE Transactions on Nano BioScience*, Vol. 4, no. 2, pp. 133-140, June 2005.

[2] R. Hariharan, J. Manohar.,-"Nanorobotics As Medicament (Perfect Solution For Cancer)", *IEEE Emerging Trends in Robotics and Communication Technologies* (INTERACT), ISBN: 978-1-4244-9006-6,January 2011.

[3] A. Cavalcanti, L. Rosen, L.C. Kretly, M. Rosenfeld, S. Einav, "Nanorobotics challenges in biomedical applications, design and control," *IEEE ICECS International Conference on Electronics, Circuits and Systems*, Tel-Aviv, Israel, pp. 447-450, December 2004

[4] http://www.nanorobotdesign.com

[5] http://www.nanomedicine.com

[6] http://www.www.foresight.org