DESIGN AND EXPERIMENTAL INVESTIGATION OF NANOBOTS FOR CANCER THERAPY

S. Chandravadhana

Department of Mechatronics Engineering, Agni College of Technology, Chennai.

ABSTRACT

Oncologists all over the globe, relentlessly research on methodologies for detection of cancer and precise localization of cancer therapeutics with minimal adverse effects on healthy tissues. Since the previous decade, the fast growing research in nanotechnology has shown promising possibilities for achieving this dream of every oncologist.Nanorobots (or nanobots) are typical devices ranging in size from 0.1 to 10 µm and constructed of nanoscale or molecular components. Robots will augment the surgeon's motor performance, diagnostic capability and sensations with haptics and augmented reality. The article here aims in briefly describing the architecture of the nanorobots and their role in oncotherapy. Although, research into nanorobots is still in its preliminary stages, the promise of such technology is endless.

INTRODUCTION

Nanotechnology is popularly known as the science of the small or scientifically described as the technology to develop materials and structures of the size range from 1 to 10 nm. Oncologists all over the globe, relentlessly research on methodologies for detection of cancer and precise localization of cancer therapeutics with minimal adverse effects on healthy tissues. Since the previous decade, the fast growing research in nanotechnology has shown promising possibilities for achieving this dream of every oncologist.[1] Burgeoning interest in the medical applications of nanotechnology has led to the emergence of a new field called nanomedicine.[2],[3],[4] Most broadly, nanomedicine is the process of diagnosing, treating and preventing disease and traumatic injury, of relieving pain and of preserving and improving human health, using the molecular tools and molecular knowledge of the human body.[2],[5]Nanorobotics is the technology of creating machines or robots at or close to the microscopic scale of nanometers (10^{-9}).[3] More specifically nanorobotics, refers to the still largely theoretical nanotechnology engineering discipline of designing and building nanorobots. Nanorobots (or nanobots) are typical devices ranging in size from 0.1 to 10 µm and constructed of nanoscale or molecular components. As no biological nanorobots have so far been created they remain a hypothetical concept at this time.

Another definition sometimes used is a robot, which allows precision interactions with nanoscale objects, or can manipulate with nanoscale resolution. Following this definition even a large apparatus such as an Atomic force microscope (AFM) can be considered a nanorobotics instrument when configured to perform nanomanipulation. Furthermore, macroscale robots or microrobots, which can move with nanoscale precision can also be considered nanorobots.[6] Molecular nanotechnology (MNT) or nanorobotics [2],[7],[8] takes as its purview the engineering of complex nanomechanical systems for medical applications. Just as biotechnology extends the range and efficacy of treatment options available from nanomaterials, the advent of MNT will 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 on individual human cells. The ability to design, construct and deploy large numbers of microscopic medical nanorobots will make this possible.[9]

Nanorobots are expected to provide advances in medicine through the miniaturization from microelectronics to nanoelectronics.[10] The aim of this article is to present the future use of nanorobots to combat cancer. Cancer can be successfully treated with current stages of medical technologies and therapy tools. a task in order to find intensity of E-cadherin signals.[13]

HISTORICAL PERSPECTIVE

In his remarkably prescient 1959 talk "There's Plenty of Room at the Bottom," the late Nobel physicist Richard P. Feynman proposed employing machine tools to make smaller machine tools, these to be used in turn to make still smaller machine tools and so on all the way down to the atomic level.[15] Feynman was clearly aware of the potential medical applications of the new technology he was proposing. He said, "A friend of mine (Albert R. Hibbs) suggests a very interesting possibility for relatively small machines. He says that, although it is a very wild idea, it would be interesting in surgery if you could swallow the surgeon. You put the mechanical surgeon inside the blood vessel and it goes into the heart and looks around (Of course the information has to be fed out). It finds out which valve is the faulty one and takes a little knife and slices it out. Other small machines might be permanently incorporated in the body to assist some inadequately functioning organ." Later in his historic lecture in 1959, Feynman considered the possibility, in connection with biological cells, "that we can manufacture an object that maneuvers at that level!" The vision behind Feynman's remarks became a serious area of inquiry two decades later, when Eric Drexler, published a technical paper [15] suggesting that it might be possible to construct, from biological parts, nanodevices that could inspect the cells of a living human being and carry on repairs within them.

This was followed a decade later by Drexler's seminal technical book [8] laying the foundations for molecular machine systems and molecular manufacturing and subsequently by Freita's technical books on medical nanorobotics.[9] Nanorobots are theoretical microscopic devices measured on the scale of nanometers (1 nm equals 1 millionth of 1 mm). 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 that have until now been the stuff of science fiction. Nanomedicine's nanorobots are so tiny that they can easily traverse the human body. Scientists report the exterior of a nanorobot will likely be constructed of carbon atoms in a diamondoid structure because of its inert properties and strength. Super-smooth surfaces will lessen 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. Nanomachines are largely in the research and-development phase,[16]

ARCHITECTURE OF NANOROBOT

The architecture is based on two criteria, which are means of nanorobot navigation and methods to attach to the cancerous cells. The way a nanorobot moves in a liquid environment is the main consideration during the design. It is important that the device is able to have a smooth trajectory path while navigating in the blood environment and at the same time does not cause any damage to other cells. The tentacles need to have a very high responsive rate in order to move its tentacles forward just in time to capture the cancerous cell once it is detected. On the other hand, a microcomputer consisting of a miniature processor might be needed to provide a "brain" to the nanorobot.[18] The body of the nanorobot will be constructed from carbon nanotube due to its intrinsic property where they tend to absorb near infrared light waves, which pass harmlessly through human cells. Ultrasonic sensors are attached around the body of the nanorobot for collision avoidance purposes. This is to prevent nanorobot from knocking onto each other as well as other cells in the blood vessels. Folate materials on the body of the nanorobot act as an agent that will cause the attraction of the nanorobot to the cancerous cells, which is also known as the folate-receptor cells. For modeling purposes, the folate material is modeled as an object attached to the nanorobot, rather than a coating so that the viewer can have a better visualization of the treatment process.

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The flagella provide the movement the nanorobot in the blood environment. It is powered by flagella motors, which is a set of rotary motor that is able to generate an impressive torque, driving a long, thin, helical filament that extends several cell bodies into the external medium. These are necessary to help the cell decide which way to go, depending on the change of concentration of nutrients in the surroundings.[18]. The rotary motion imparted to the flagella needs to be modulated to ensure the cell is moving in the proper direction as well as all flagella of the given nanorobot are providing a concerted effort toward it. When the motors rotate the flagella in a counterclockwise direction as viewed along the flagella filament from outside, the helical flagella create a wave away from the cell body. Adjacent flagella subsequently intertwine in a propulsive corkscrew manner and propel the nanorobot. When the motor rotates clockwise, the flagella fly apart, causing the bacteria to tumble, or change its direction.

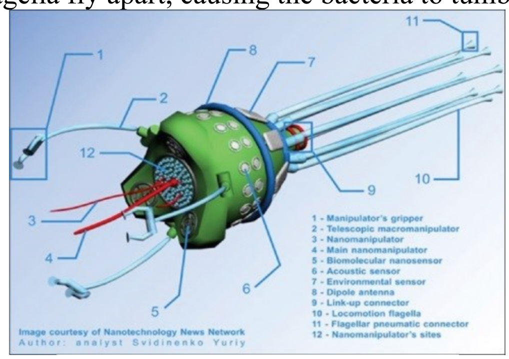

Fig. 1. Nano Robot Architecture

CHEMICAL SIGNALS

Chemical signals and interaction with the bloodstream is a key aspect to address the application of nanorobots for cancer therapy. The nanorobot sensing for the simulated architecture in detecting gradient changes on E-cadherin signals is examined. To improve the response and bio-sensing capabilities, the nanorobots maintain positions near the vessel wall instead of floating throughout the volume flow in the vessel an important choice in chemical signaling is the measurement time and detection threshold at which the signal is considered to be received. Due to background concentration, some detection occurs even without the target signal. After the first nanorobot has detected a tumor for medical treatment, it can be programmed to attach on it. Then, beyond attracting a predefined number of other nanorobots to help for incisive chemotherapeutic action with precise drug delivery above the tumor, the architecture permits it to use wireless communication to send accurate position for the doctors informing that a tumor was found.[23]

Power supply

The use of CMOS for active telemetry and power supply is the most effective and secure way to ensure energy as long as necessary to keep the nanorobot in operation. The same technique is also appropriate for other purposes like digital bit encoded data transfer from inside a human body.[24] Thus, nanocircuits with resonant electric properties can operate as a chip providing electromagnetic energy supplying 1.7 mA at 3.3 V for power, allowing the operation of many tasks with few or no significant losses during transmission.[25] Radio frequency (RF)-based telemetry procedures have demonstrated good results in patient monitoring and power transmission with the use of inductive coupling using well-established techniques already widely used in commercial applications of radio frequency identification (RFID).

Data transmission

The application of devices and sensors implanted inside the human body to transmit data about the health of patients can provide great advantages in continuous medical monitoring.[10] Most recently, the use of RFID for in vivo data collecting and transmission was successfully tested for electroencephalograms (EEG).[25]

For communication in liquid workspaces, depending on the application, acoustic, light, RF and chemical signals may be considered as possible choices for communication and data transmission.[27] Chemical signaling is quite useful for nearby communication among nanorobots for some teamwork coordination.[10] Using integrated sensors for data transfer is the better answer to read and write data in implanted devices. Teams of nanorobots may be equipped with single chip RFID CMOS based sensors.[28] CMOS with sub-micron SoC design could be used for extremely low power consumption with nanorobots communicating collectively for longer distances through acoustic sensors. For the nanorobot active sonar communication frequencies may reach up to 20 μW 8 Hz at resonance rates with 3 V supply.[29]

SYSTEM IMPLEMENTATION

The nanorobot architecture includes integrated nanoelectronics.[10] The nanorobot architecture involves the use of mobile phones for, e.g., the early diagnosis of E-cadherin levels for smart chemotherapy drug delivery and new cancer tumor detection for cancer treatments.[21] The nanorobot uses a RFID CMOS transponder system for in vivo positioning [2],[26] using well-established communication protocols, which allow track information about the nanorobot position.[21] This information may help doctors on detecting tiny malignant tissues even in initial stages of development. The nanorobot exterior shape consists of a diamondoid material [30] to which may be attached an artificial glycocalyx surface that minimizes fibrinogen (and other blood proteins) adsorption and bioactivity, ensuring sufficient biocompatibility to avoid immune system attack.[2] Different molecule types are distinguished by a series of chemotactic biosensors whose binding sites have a different affinity for each kind of molecule.[2] These sensors can also detect obstacles which might require new trajectory planning.[31] A variety of sensors are possible.[32]

NANOROBOT SIMULATION

As a result from the advances on nanoelectronics, nanorobots may be considered a promising new technology to help with new treatments for medicine.

The nanorobots are inside the vessel, they can be either observed in 3D real time with or without the visualization of red blood cell. Glucose carried through the blood stream is important to maintain the human metabolism working healthfully. The simulated nanorobot prototype model has embedded Complementary Metal Oxide semi- conductor [CMOS] bioelectronics. The nanorobot computation is performed through embedded nanosensor; for pervasive computing, performance requires low energy consumption. The nanorobot is not attacked by the white blood cells due to biocompatibility. In the medical nanorobot architecture,the significant measured data can be then transferred automatically to the mobile phone.[33]

CONCLUSION

Nanorobots applied to medicine hold a wealth of promise from eradicating disease to reversing the aging process. They will provide personalized treatments with improved efficacy and reduced side effects that are not available today and also by providing combined action – drugs marketed with diagnostics, imaging agents acting as drugs, surgery with instant diagnostic feedback The advent of MNT will again expand enormously the effectiveness, comfort and speed of future medical treatments while at the same time significantly reducing their risk, cost and invasiveness. This science might sound like a fiction now, but nanorobotics has strong potential to revolutionize health-care, to treat disease in future. It opens up new ways for vast, abundant research work in oncotherapy. We are at the dawn of a new era in which many disciplines will merge, including robotics, mechanical, chemical and biomedical engineering, chemistry, biology, physics and mathematics, so that a fully functional system will be developed.

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