

Review on Nano robots application and research developments

Introduction

Nano robot is a cross discipline subject about nano tech and electronic engineering. According to the definition, nano is a concept of scale of 10^{-9} . The construction of nanobots both need the technology of nano scale manipulation and design of electronic engineering.

Nanorobotics is a pretty new field that grew up during the late 1990s and early 2000s¹. The field of nano robotics includes the design, programming, computer simulating, virtual assembling, virtual testing and manufacturing. Like any robot system, nano robotics is high sophisticated and highly decorated by advanced technology. With the feature of super small scale and extraordinarily high value, nano robotics has many applications which are biological related. Two of the pioneers Eric Drexler and Robert Freitas, developed the concept of nano robotics in the late 1990s. However, considering the nano technology at that time, actual work of nano robots was not achievable. Before 1990, the focus was in the field of nanobots generation and nanobots modeling. With the wild spread of computer and internet at that time the computational and experimental nanorobot's prototype finally came out.

The impact of nano concept is intensive both in labs and on magazine and medias. The recent movie of 'GIJOES' series focus on nano weapons in the near future which attracted millions of thousands fans all over the world. Both the fear and curiosity drive people to the cinema and movie theatre. It is a common phoneme that nano related products are more attractive and better sales. It is true that some function of nano materials in the fiction are realized today, but we have to admit that fiction is all about imagination.

The term of nanorobot is popularized in the academic field because of the following feature and tags which are extremely eye-catching: manipulation, precise targeted, artificial intelligence, biosensor, information processing, data mining, big data, self-assembling, natural selection. All of the terms are treasure and golden coat outside the field. The mysterious and amazing description serves well when we first establish connection with those research papers.

Nano manipulators are important parts of nano robots. The use of SPM, STM, AFM are three common tools for the task which can be crucial for nano robots to execute orders and change the formation and structure of targets. Take the SPM for example, if the SPM is used to change the structure of atoms, it will carry out missions in the way of three dimensions, just like the 3D printing machine. The X,Y,Z positional system ensure the plan in the server will be accurately followed and behave well. As the rise of manipulators, more and more demands come out. In new area people will need four or even more dimensional manipulators to control the vibration, real time feedback will be needed to collect data and self-evolve, liquid environment function will be needed to enter the blood vessels or human body, better resolution will be needed for smaller size atoms, coupling SPM system and calibration system needs to be improved to enter the body and

¹ Mavroidis, Constantinos, and Antoine Ferreira. "Nanorobotics: Past, Present, and Future." *Nanorobotics*. Springer New York, 2013. 3-27.

do the surgery.

DNA related research is also a popular topic for nano robot researchers, the goal of bio nano robots is to use all kinds of bio elements to accomplish specific missions. These components are preprogrammed in response to the specific stimuli. So that the proteins and DNA become motors, mechanical joints or sensors. As long as all the parts are assembled properly, they are technically nano robot devices with the ability of applying forces and manipulating objects in the nano scale. They are highly efficient and reliable because of the nature of the material. Conventional robots are used to provide forces and motions to accomplish specific tasks, bio nano robots can do even more like to manipulate objects in nano scale, to fabricate other products; to perform maintenance, repair, and inspection mission.

Nanomachines are the base of nanobots. Some primitive molecular machines and nanomotors have been developed and perfectly functional. An example is a 1.5 nanometers step motor, capable of counting specific molecules in a chemical sample. One promising application of nano lies on the cancer curing field. Another potential application is the detection of toxic materials, and the measurement of their concentrations in the environment. Rice University has demonstrated a single-molecule car with Bucky balls for wheels and nanomotors mentioned before.

The theory of nanobots is initiated by Albert Hibbs who suggested 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 look around.”² As is described above, the nano robot is first aimed at curing in biology. So lots of DNA manipulating robots are developed by nano scientists.

Recent study

There are several approaches to make nanorobotics³, one of them is biochip. It is tiny lab platform that can perform thousands of hundreds biochemical reactions simultaneously. Biochips help researchers to quickly swap large numbers of biological analytes for all kinds of purposes, from disease diagnosis to detection of biohazard agents. Recently a programmable Nano bio chip (NBC) sensor emerged which makes clinical analysis more accurate and deep. Clinical analysis is a important way for us to understand the mysterious system of life. The NBC can synergize components and medicines from nanotech, clinical chemistry and other functional objects in order to achieve a certain goal. There are four noticeable feature of NBC: quality analytical behavior, a programmable design, the breadth of function and the inexpensive nature of analysis ensemble. Aiming at the four features of NBC, the construction of that is highly compatible with rapid detection, nano scale fabrication and low cost material.

Also there is significant advantage with the nano scale electronic signals. The extraordinary length of Stokes shift and significant level of intensity of quantum dots (QDs) combined with their

² Feynman, Richard P. "There's plenty of room at the bottom." *Engineering and Science* 23.5 (1960): 22-36.

³ Jokerst, Jesse V., et al. "Programmable nano-bio-chip sensors: analytical meets clinical." *Analytical chemistry* 82.5 (2010): 1571-1579.

narrow emission profiles and simultaneous excitation enables these inorganic fluorophores better than other measures. So the NBC has the feature of intensive signals which provide the chip stable currency signals which is vital to any chip

Another advantage is in bio field, with the programmable technology and artificial intelligence the bio chip can be perfect. Every individual has totally different components and biomarkers which makes it impossible for us to identify or monitor the signals with one standard sample. However the NBC enabled the fluctuations analysis which allow chips to customize a criteria for every individual. So the base line of the signals will be established by chip automatically so that the any tiny change will be detected accurately and handled immediately.

Especially the Saliva-Based nano biochip is proved to be fully functional and exceptionally well-demonstrated in the study by Pierre N Floriano⁴. In his study the use of nano biochip is crucial to his results which reveals the fact that the salivary CRP and MYO level is critical for researchers to identify and diagnose the chest pain related diseases.

Another bio relation nano application is Tubular micro nano chip by Samuel Sanchez which I quote: 'We demonstrated that tubular micro robots can be employed for self-propulsion at small scales with high power output, versatility in applications towards bio-relevant issues. Catalytic bubble-propelled micro robots continuously developed and nowadays, the wireless control, transport of particles, capture of cells, and motion in microfluidic chips with biological samples has become a reality.'⁵

Also in the DNA field Harish Chandran has some up to date idea as I quote: 'The ultimate goal of nanorobotics is the creation of autonomous nano systems that are capable of carrying out complex tasks. Additionally, we would like these systems to be programmable in the sense that one should not resort to complete redesign of the system to achieve simple changes in target behavior. The programmability of DNA makes it an ideal construction material at the nano scale. DNA self-assembly offers a massively parallel method for low cost manufacturing of complex nano systems.'⁶

There are also useful application in health care, as Nandkishor Kshirsagar mentioned 'Nanorobot are programmed nano devices or controlling machine that is used for protecting or treating human body against pathogen. "Nanorobot can diagnose, monitor and treat disease". The size of Nano robots is normally range from 0.5 to 3 microns in diameter. These devices include miniature power-driven mechanical parts that are required to retract, dispense drug or do a needful action at the required site in the body to cure diseases. The most recent application of these Nano robots in drug delivery are in brain targeting, glucose monitoring in diabetes patients, bone reconstruction, cancer treatment, in removal of blood clot, nerve regeneration, and protein and peptide drug delivery system.'⁷

One of the application for the NBC system lies on the detecting of HIV positive patients whose T lymphocytes is abnormal. According to the bio-immune system, the level of CD3+ and

⁴ Floriano, Pierre N., et al. "Use of saliva-based nano-biochip tests for acute myocardial infarction at the point of care: a feasibility study." *Clinical chemistry*55.8 (2009): 1530-1538.

⁵ Sánchez, Samuel, et al. "Tubular Micro-nanorobots: Smart Design for Bio-related Applications." *Small-Scale Robotics. From Nano-to-Millimeter-Sized Robotic Systems and Applications*. Springer Berlin Heidelberg, 2014. 16-27.

⁶ Chandran, Harish, Nikhil Gopalkrishnan, and John Reif. "DNA Nanorobotics." *Nanorobotics*. Springer New York, 2013. 355-382.

⁷ Kshirsagar, Nandkishor, et al. "REVIEW ON APPLICATION OF NANOROBOTS IN HEALTH CARE." (2014).

CD4+ cell is required to reach normal standard so that immune system can function well. So the NBC takes the responsibility of testing and monitoring the signals with background comparison.

In the future, NBC system will be applied to the all the medicine which makes use of the self-assemble nano chemicals to treat and contain the symptoms as well as relief the pain.

In the meantime positional nano assembly is also a research branch of nanorobotics which is first founded by Robert Freitas to focus on the nano factory collaboration in order to build diamonded medical nanobots. Recent work is mainly in the field of top-down precision assembly, such as making use of compliant, passive MEMS micro grippers to manipulate nano scale chemicals. There is also a advancement of 3D micromechanical structural system like the μ^3 wafer based nanorobot created by Aditya N Das.⁸ The 3D table top assembly system is composed of 19 DOF stages arranged into 3 robotics manipulators. The three μ^3 manipulators sharing 3 centimeters are responsible for three axis of XYZ and 7 degree of freedom which allow the system to manufacture all kinds of nano material. The position and calibration system lie on the nano sensor on the first two manipulators which send out signals to the labview and can be monitored and modified by users. Also there is an innovative Iterative improvements of assembly yield system which uses the sensors to analyze the yields real time and send feedback immediately back to the offline controlling system to filter the intolerable yields and make adjustment and direct next manufacturing step. The idea of the system match Dwain's natural selection theory and optimize the system itself. Although there are some flaws in the final product, the paper still give an advanced view of 3D nano manufacturing system.

There is an actual sample of using nanorobotics to assembly a nano scaled medicine and demonstration of the function of nano assembly virtual environment by Adriano Cavalcanti⁹. The emerge of the virtual environment perfectly solve the problem of high cost failure problem. The software environment simulates the real background of the solution and all kinds of variables inherited which gives researchers a better prospective of the upcoming products.

Nano medicine is described in detail by T.Venkat Narayana Rao, as I quote: 'Bio-nanotechnology has become a hopeful area of research that is bringing radical advancements and changes in the current century of technological mutiny. It is a one part of Nano technology. It has shown its clear participation in all fields, there is an integral part of the nano in human science and medicine. Nano medicine is the process of diagnosing cancers, treating, preventing disease, relieving pain, and of preserving and improving human health using molecular tools and molecular knowledge of the human body. Most of the symptoms such as fever and itching have specific biochemical reasons that can also be controlled, reduced, and eliminated using the appropriate injected nano robots. This paper mainly concentrates on reviewing role and implementation of nano robots in medical field and how it can replace present medical scenarios with cost reduction along with vision to permanent solutions to many human ailments towards surgery less treatments'¹⁰

⁸ Das, Aditya N., et al. " μ^3 : Multiscale, deterministic micro-nano assembly system for construction of on-wafer microrobots." *Robotics and Automation, 2007 IEEE International Conference on*. IEEE, 2007.

⁹ Cavalcanti, Adriano, and Robert A. Freitas Jr. "Nanorobotics control design: A collective behavior approach for medicine." *NanoBioscience, IEEE Transactions on* 4.2 (2005): 133-140.

¹⁰ Rao, Venkat Narayana. "Nanorobots in Medicine-A New Dimension in Bio Nanotechnology." *Transactions on Networks and Communications* 2.2 (2014): 46-57.

Future

After so many years of research and development, we have to ask ourselves 'where is nano robots going to lead us'. It is a common when some new element invaded to our life and we have no idea what it is going to be. Nano robot is just the same type. There is currently no actual commercialize or factory manufacturing nano robots. We can even confirm that the wild spread of nano robots is many years away from now. However, one thing for sure the work we have done today is crucial to the future path. Currently speaking the high cost of nano motor, the extravagantly expensive nano sensors and manipulators make the production of nano robot very difficult. The funding is only affordable to superpowers and state financing. In this case, one important and must-do mission is to lower the cost. The lower barrier there is, the faster growth there will be in nano robot field.

Also medial application of a promising land for nano robots, it is also approved by current work. We have already using nano scale molecule to detect and diagnose potential diseases. So it is not hard to image some day we can cure any of our acute diseases by just a single injection of nano robot in our blood vessel. The small scale effect of nano robot is crucial to medial industry, somehow affect the future course of the career. If we can realize the nano doctors and nano physicians, there will be far less doctors on this planet and no more law suits and conflicts between doctors and patients. Nano robots can carry out our orders precisely and accurately, without mistake or malfunction which can provide human a longer life and better defense. There is even more, with the advancement of DNA tech, nano robots are able to change our genetic feature. Just like the X-man film, people will possess some kind of super power. Basically, there will be a mutation of genetic spot, and our body need a period of time to deal with the change. Sometime it will be considered hazards and eliminated, but we want our body accept the change so that we can meet out original purpose. Someday human can have fish tails to swim faster in the water or even covered with thick skins like crocodiles to endure heavy crush. Human can design ourselves freely and all the elite parts will be assembled to human body. But if human technology really achieved that period, the potential threat will be ourselves. Mankind is always afraid of the power we can not control, and this ability to add super power to human is one of them. People will panic and ravage the natural resources if not handled properly.

Another potential field is in space. According to the law of newton, small objects like nano robots need less power to enter the space than space shuttles. The essence of nano robots in space is the artificial intelligence. The deploy cost of nano robot can be neglected compared with the huge space shuttle. We can use the self-assembling system to assemble them in the space which is more cost effective. The difficulties will lie on the navigation system. A nano robot is hard for human eyes to detect on the desk, which is even more difficult to detect in the space. We all understand that there is a radio communication effective range. If the nano robot choice the wrong way or did not stop before get blind, the whole plan will be just dump nano rubbish into the space. And the resources on the planet is limited, so the behavior off let out precious resources will be no different than subside. Thus, mainly the power of nano robot will go to the navigation system and communication system. The nano robot will move to the target planet as planned. After landed the special sensors will do their job. They can stick on the specific object as preprogrammed and send the information including the GPS coordinates and components back the communication nano

robot which functions as a brain. It will reallocated the size of information and send back to earth so that we can have a new generation low cost space explorer. As the rule of tech advancement :the lower barrier there is, the faster it evolves. At that time, space exploration will be just like a video game which we can sit comfortably at home and watch the monitor.

Nano tech is also applicable in computer area. Think about the future personal computer will use the hardware of nano robots. There can be no redundant parts of computer, the only thing we need to work is just sit in the office building. If the clients call us, we just need to send a signal to the nano robot and it will pick up the call and visualize the person you are speaking to in front of you with nano particulars. If you need to write a report and send to your supervisor, the only thing your need to do is just think in your mind. The nano robot can pass the blood-brain barrier and catch the chemicals released when you are thinking. Nano robot in the computer field is more than a revolution. It will totally change our idea of computer, the robot and computing process will be embedded in our physical body and functions great. It is more than bio-nano-chip, it is the way of send and process data with multi-functional nano robot. Some nano robots are responsible for processing data, some are sensor in your brain and some are out put nano robots to provide you audible or visualized information which is easy for human to understand. When some nano ronts are no longer functional, the can be retrieved by receiver nano robot and new generation nano robot will be planted just be drink a cup of coffee.

Conclusion and discussion

The nanorobot has the feature from both nano science and robotics which enable people to combine the two and even more subjects together. With the fast development of science and technology we have reason to believe that the medial condition will be total different from today. One plantation of nanorobot in your body will diagnose all the diseases and treat them properly. With the help of virtual software environment and programmable chip, someday the control of nanorobot will be as easy as write a app on android system.

Reference

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