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Convergence nanorobot analysis for radiation therapy – Industrial innovations in nuclear engineering

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1. Introduction

Following the highly advanced robot technology pursuit, the nanoscale robot is investigated for the nuclear engineering and radiological industry [1]. Nanorobot is imagined for the commercialized challenge in the radiological applications in which the nearly complete cure by cancer cell killing is examined. The proposed omni-directional cancer treatment program (OCTP) is studied in the radiation therapy planning where all cancer cells are killed in minimizing the damage to normal cells. Clinically, it is considered as the most important things in the radiation therapy planning. Fig. 1 shows the conventional nuclear bio-medical technology with medical imaging and radiation therapy in which two kinds of major concepts have been established as the imaging and therapy. By the way, in this paper, the newly imagined convergence nuclear bio-medical technology with nanorobotics for diagnostics, therapy, and surgery in Fig. 2. Fig. 3 describes the anticipated configuration of the movement for the nanorobots. The nanorobot has two tails which would supply the moving power with the actuator. It makes the movements like the tadpoles with the similar size of bacteria and the two tails have a role for the direction changes without the circulations. Furthermore, the nanorobot has the sensing equipment where the small sized detecting system would be installed inside of the nanorobot body.

In some literatures, Zhang et al. [2] studied that the radiation isotopes are delivered to the cancer target for therapy where the monitoring and clinical applications have been done. Gruaz-Guyon et al. [3] worked that antibodies incorporated with small radio-labeled molecules are effective together to treat the cancer cells in which the clinical purposes are immunoscintigraphy and radioimmunotherapy. In addition, Mairs and Boyd [4] performed that the radioactive particles are used to seek the tumor in the patient by amalgamation of gene transfer in which the radiation therapy is used for the cancer target strategy.

2. Methods and Results

In the historic review, there were many ancient mythologies in which artificial people were shown as the mechanical handmaidens that were made by the Greek god Hephaestus [5]. After that, there have been many kinds of automatic machines. In the modernized systems, the remote controlled systems and the humanoids are frequently introduced. In the early 1870s, John Ericsson, John Louis Lay, and Victor von Scheliha made the remote controlled torpedoes [6]. In 1921, the robot was used first by the Czech writer, Karel Čapek who used the Czech ‘robota’ as a meaning of servitude [7]. In the scientific fiction movies, the humanoid robots are showing amazing adventures. Although the roles of the robots are substituting with the human works, the power and functions are overwhelming than those of the general human. Heavy weighing or flying fast is the exampled behavior of designed robots.

Some industrial applications of the robotics are published. For the substitutions, the RoboLogix is applied to save the time and increase the safety level, because it can be done before the real operations of the system [8]. In addition, the real-time computing by RoboLogix for the simulations by robotics is performed for the geometrical and kinematical designs in which the ‘what if’ scenarios used [9]. The operations of industrial robots were about 1,153,000 and could be reached to 1,575,000 by the end of 2015 from the International Federation of Robotics (IFR) study World Robotics 2012 [10].

In this study, the radiation isotope is Au-185 which has shout half-life of 4.25 minutes and 5.18 MeV. Since this half-life is quite short, it is necessary to make the therapy planning meticulously. It produces the alpha particle and shows the Bragg-peak distributions. Designed radiation isotopes are installed in the nanorobot and it is shielded by cover until it reaches to the cancer tumor. Then, the cover opens and the radiation exposes to the tumor cells. It is needed to consider making the shielding cover considering the whole nanorobot size. In the planning of the therapy, the nanorobot moves to one direction which is shown in Fig. 4. Many numbers of nanorobot are needed for the treatment. Once it reaches to the other side of the cancer cell lump, it goes to the opposite direction without circulation due to the other tail. So, the treatment plan is done in the whole volumetric stuff. The radiation beam distributions are described where the Bragg-peak is formed following the movement of the nanorobot in which the valley shape is constructed to the direction of the movement of nanorobot. The sizes of the peaks are usually several centimeters and related to the particle and energy. Fig. 5 is the distribution of energy to recoil following the simulations.

For the mechanics of the movement, it is consideredThe velocity can be obtained as follows [1, 11];

$$V_n = -Vsin\emptyset + \frac{\partial k}{\partial t}cos\emptyset \tag{2.1}$$

$$V_t = Vcos\emptyset + \frac{\partial k}{\partial t}sin\emptyset \tag{2.2}$$

where $\emptyset = \frac{\partial k}{\partial x}$, *k* is the vertical axis, *V* is the velocity of tadpole, V_n is the velocity of tadpole in *n* direction, and V_t is the velocity of tadpole in *t* direction with the Fig. 6. Then,

$$V_n^2 + V_t^2 = \left\{V^2(sin\emptyset)^2 - 2V \cdot sin\emptyset \cdot cos\emptyset \cdot \frac{\partial k}{\partial t} + \left(\frac{\partial k}{\partial t}\right)^2 (cos\emptyset)^2\right\} + \left\{V^2(cos\emptyset)^2 + 2V \cdot sin\emptyset \cdot cos\emptyset \cdot \frac{\partial k}{\partial t} + \left(\frac{\partial k}{\partial t}\right)^2 (sin\emptyset)^2\right\} \tag{2.3}$$

$$V_n^2 + V_t^2 = \left\{V^2 + \left(\frac{\partial k}{\partial t}\right)^2\right\} \tag{2.4}$$

$$V^2 = V_n^2 + V_t^2 - \left(\frac{\partial k}{\partial t}\right)^2 \tag{2.5}$$

$$V = \pm\sqrt{V_n^2 + V_t^2 - \left(\frac{\partial k}{\partial t}\right)^2} \tag{2.6}$$

Then,

$$time = \frac{distance}{\pm\sqrt{V_n^2 + V_t^2 - \left(\frac{\partial k}{\partial t}\right)^2}} \tag{2.7}$$

If the distance is 2 cm,

$$time(sec) = \frac{2cm}{\pm\sqrt{V_n^2 + V_t^2 - \left(\frac{\partial k}{\partial t}\right)^2}} \tag{2.8}$$

This equation means that the time is shorter in the case of fast velocity and smaller tail's angle. Hence, the tail should be made as a straighter shape as much as possible. The remote control should be possible between the nanorobot and the operator who can control the motion of the nanorobot where the signal receiving system should be installed in around patients. The Brownian motion for tiny object like the bacteria was explained in the literature [12].

3. Results

In the mechanical behavior, the collision interaction event happens around 35 nm which is performed by The Stopping and Range of Ions in Matter (SRIM) [13]. It is possible to consider that the curable length is about 5 nm as it is seen in the simulations where the peak is higher than other reasons. Hence, one movement of nanorobot radiates about 10 nm [1]. In the case of the calculation of moving numbers of 2 cm diameter cancer regions,

2cm / 10 nm = 2 × 10^7 nm / 10 nm = 2 × 10^6

Therefore, 2 million times treatments are necessary to treat for the whole area in the two dimensional view. For the case of the robot returns one time, the number is 2 × 10^6 / 2. In the 10 times' return case, 2 × 10^6 / 10 = 2 × 10^5 are needed to perform the therapy.

4. Conclusions

The important step of the commercialization is the make the prototype nanorobot where lots of applications could be introduced for the industry. For the much more advanced operations of the nanorobot, it is needed to imagine the strategy for the operation in the non-regular shaped organs like the lung which shows the different feature following breaths. The biological stuffs are usually in the irregular shape and could be changed by the external force or the infected viruses. The biological substance could be made by the amorphous material which is used frequently in the industry. The antibody reaction is a particular matter which could be happen in the human body. So, the adaptations of the nanorobot could be increased for the practical purposed.

Fig. 7 is the newly imagined convergence nuclear technology with nanorobotics for nuclear engineering fields in which many kinds of applications are imagined. Following the new applications of the nanorobot, it is possible to challenge for the difficult matters in the conventional nuclear industry. Fig. 8 shows the historic mistakes in commercialized nuclear power plants (NPPs) considering the nuclear reactor analysis and safety system induced by the accident. Firstly, the non-matched flux shapes made by the multiplications of Bessel function and cosine function by the cylindrical core shape, which is different from the spherical or rectangular core shape, couldn't describe the exact flux shape. Secondly, the safety system installed to start in the accident is the piping-based injection equipments. However, the safety injection systems have failed in three major sever accidents as Three Mile Island (TMI), Chernobyl, and Fukushima cases due to the significant piping failures. Fig. 9 is the delivering of fuel molecules for constructing the ideal fuel shuffling which can solve the non-matched flux shapes. Fig. 10 shows the blocking by the nanorobots in the ruptured area of the piping of safety injection system. So, the nanorobot could make the ideal innovative achievements in safety as well as economy for the nuclear industry.

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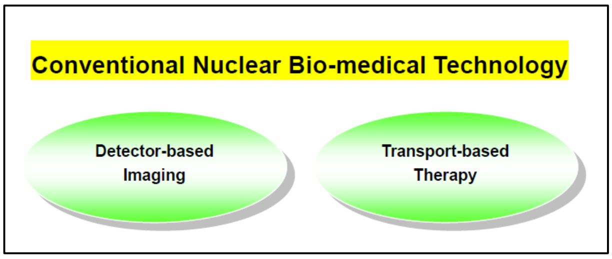

Fig. 1. Conventional nuclear bio-medical technology with medical imaging and radiation therapy.

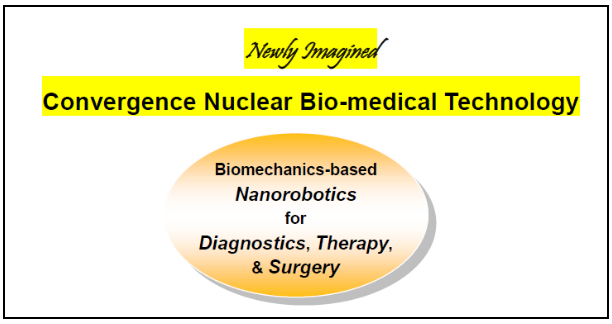

Fig. 2. Newly imagined convergence nuclear bio-medical technology with nanorobotics for diagnostics, therapy, and surgery.

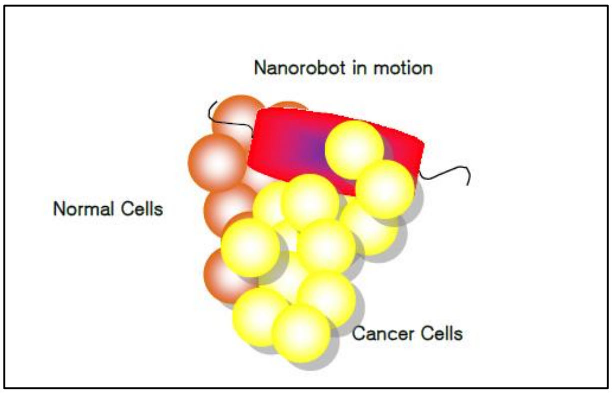

Fig. 3. Configuration of nanorobot and human cells of normal and cancer state as the molecular shapes.

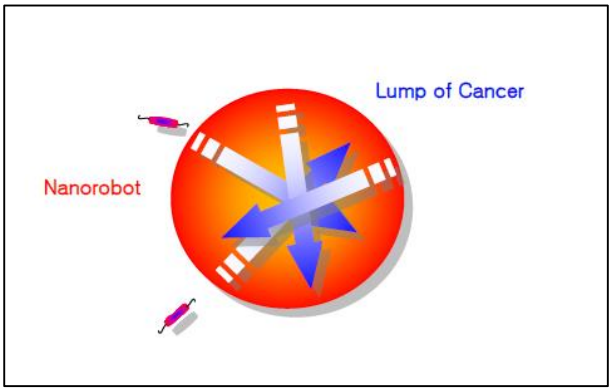

Fig. 4. Schematics of radiation therapy by nanorobot in the cancer molecular tumor cell.

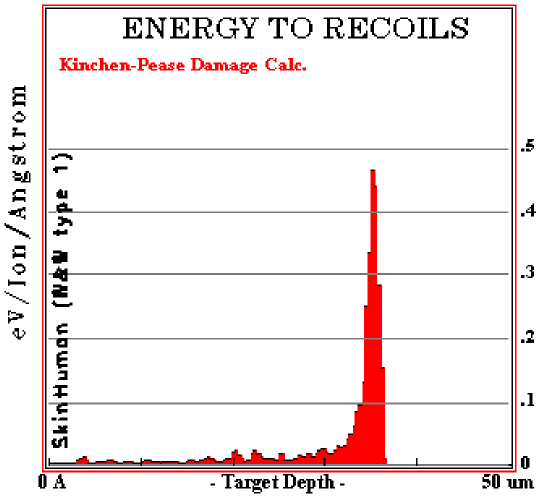

Fig. 5. Distribution of energy to recoil.

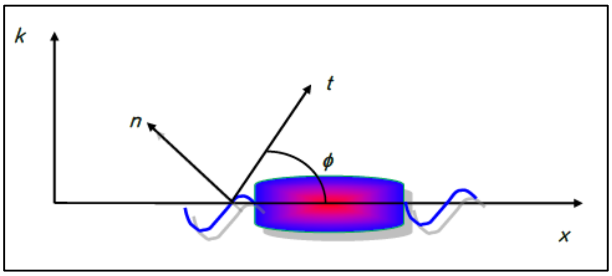

Fig. 6. Axes for coordinates by tadpole motion.

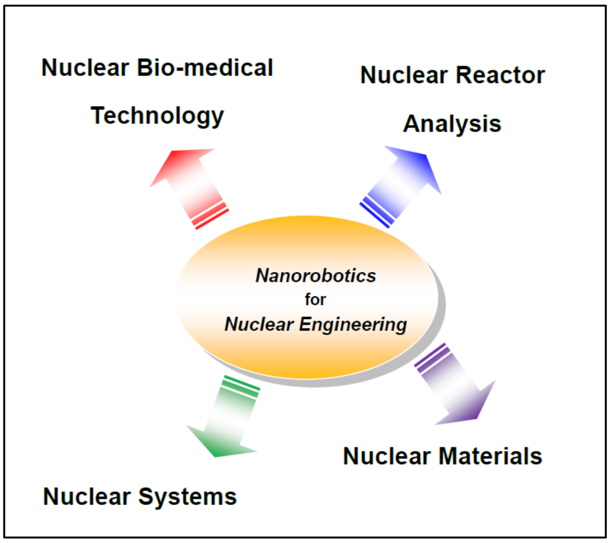

Fig. 7. Newly imagined convergence nuclear technology with nanorobotics for nuclear engineering fields.

Fig. 8. Historic mistakes in commercialized nuclear power plants (NPPs).

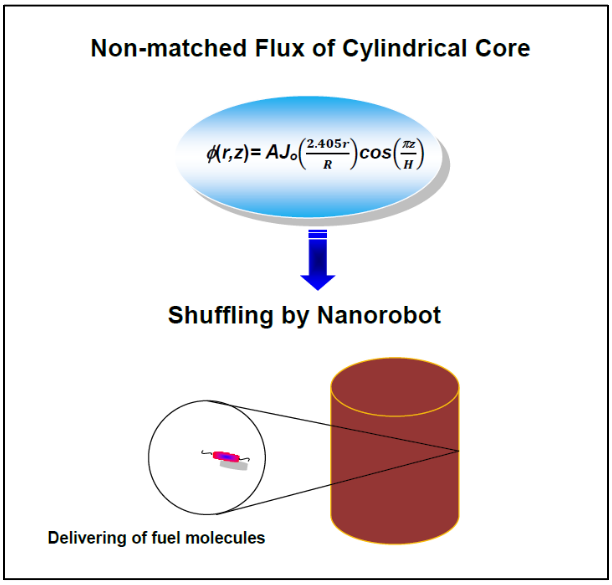

Fig. 9. Delivering of fuel molecules for constructing the ideal fuel shuffling.

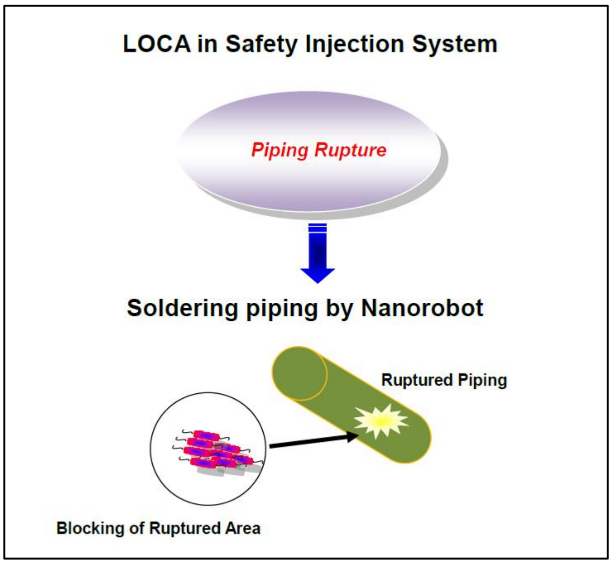

Fig. 10. Blocking of ruptured area for constructing the safety injection system.