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A New Cancer Radiotherapy System Using Multi Robotic Manipulators

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1. Introduction

Owing to an increase in the incidence of tumors, the need and demand for treatment is increasing. Eliminating a tumor through anatomical surgery is impossible in some cases. In addition, physically weakened elderly patients should minimize the surgery stress. Therefore, surgery regardless of the anatomical surgery of the body, and irradiates the tumor cells from external radiation without compromise, which is a recent trend. The CyberKnife system[1-4] is state-of-the-art cancer treatment equipment that combines an image tracking technique, artificial intelligence software, robot technology, accelerator technology, and treatment simulation technology.

The current CyberKnife System has significant shortcomings. The biggest problem is that it takes a longer time to treat a tumor. A long treatment time gives stress to patients. Furthermore it makes the patients uncomfortable with radiation and thus it is difficult to measure the exact radiation dose rate to the tumor in the processing. Linear accelerators for radiation treatment are dependent on imports, and demand high maintenance cost. This also makes the treatment cost higher and prevents the popularization of radiation. To solve the disadvantages of the existing CyberKnife, a radiation treatment robot system applied to several articulated robots, as shown in Fig. 1, is suggested. Essential element techniques for new radiotherapy robot system are investigated and some problems of similar existing systems are analyzed.

This paper presents a general configuration of a new radiation robot treatment system including with a quantitative goal of the requirement techniques.

2. Cancer Radiotherapy Robot System

Fig.1. General graphic layout for new cancer radiotherapy robot system

A new radiotherapy robot system consists of tumor tracking technology using a marker attached to the outside of the body, a radiation measurement system to measure the radiation dose accurately, a decrease in radiotherapy time using multi manipulators, and a localization of compact linear acceleration.

2.1 Image processing techniques to track the position of the tumor

Because radiation therapy is treated by aiming accurately at a lesion, it is necessary to have image processing technology to track the exact location of the tumor.

The image obtained using a high-resolution two-dimensional camera is converted into three-dimensional spatial information. It is then used as spatial information in real time as compared with tomographic image information. Fig. 2 shows a tracking conceptual diagram of an affected area using several markers. The target value of the tracking technology and image acquisition for application to the system is in ± 1mm.

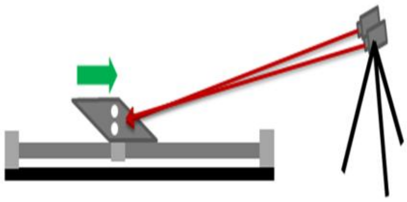

Fig.2. Conceptual Tracking diagram using markers

2.2 Radiation dose precision measurement technology

The cumulative radiation dose for a lesion is obtained using a semiconductor-type sensor in real-time, which is then reflected upon in the treatment program. The objective measurement range of the radiation dose precision measurement technology is 5-10Mev. Fig. 3 shows a sensor module for measuring the radiation dose rate.

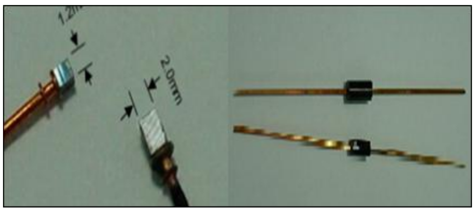

Fig.3. Tiny sensors for measuring the radiation exposure dose rate

2.3 An X-band linear electron accelerator

The proposed linear electron accelerator has a targeted weight of 200 kg below that of an existing industrial accelerator for use in the treatment system. It has an energy range of 6 - 10Mev. Fig 4 shows a conceptual diagram of a small X-band linear electron accelerator with a light weight.

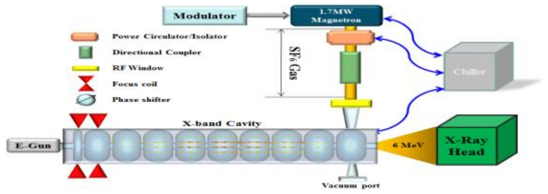

Fig.4. A conceptual diagram of an X-band linear electron accelerator

2.4 Kinematic analysis of robotic arms

The CyberKnife system with one robot arm has a disadvantage in that the processing time is long. It is possible to shorten the operating time by investigating the radiation source at the same time using a light-weight linear electron accelerator with multi robotic arm. To develop this Radiotherapy Robot System, research on an optimum real-time beam trajectory design using multiple robot arms is required.

It is thus necessary to plan an optimal beam irradiation path of a robot arm through the synthesis of the acquired image information in real time, and to reflect the conditions of the treatment planning program for a coordinated control of multiple robot arms. In addition, a control to track the tumor lesion and synchronization control technology of the robot arm of the plurality is required.

Since the robotic system utilizes multiple robot arms, studies on how to deploy the robot arms must also be performed. Fig. 5 (a) shows how to fix all four robot arms onto the floor. Fig. 5 (b) shows how to place two robotic arms on both the ceiling and floor.

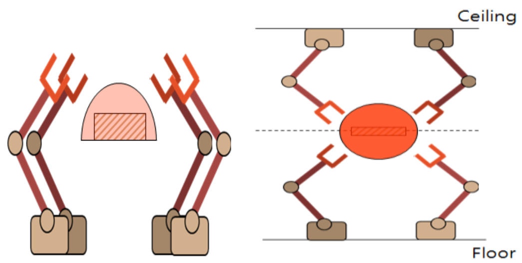

Fig.5. Structure selection of robot arms

2.5 Smart bed system

If the image of the X-ray detection of the tumor position at the time of ordering to receive treatment in a cancer treatment system and the CT images of the previous cancer treatment do not match, it takes a long time to set up the system initially. Because a smart bed system is composed of a joint robot with multi-degrees of freedom, the posture correction and position of the patient may be achieved in a short time. The proposed smart bed system has been designed with the structure of six degrees of freedom to include three degrees of freedom for the position and three degrees of freedom for the posture.

Fig.6. Smart robotic bed system

3. Conclusions

This paper described a new radiotherapy robot system to track the tumor using multiple articulated robots in real time. The existing CyberKnife system using a single robot arm has disadvantages of a long radiotherapy time, high medical fee, and inaccurate measurement of the radiotherapy dose. So a new radiotherapy robot system for tumors has been proposed to solve the above problems of conventional CyberKnife systems. Necessary technologies to configure new the radiotherapy robot system have been identified. Quantitative targets of each technology have been established. Multiple robot arms are adopted to decrease the radiotherapy time. The results of this research are provided as a requisite technology for a domestic radiotherapy system and are expected to be the foundation of new technology. The results of this research are provided as a requisite technology for a domestic radiotherapy system and are expected to be a foundation for radiation therapy robotic technology.

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