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Special Reports

Approach to Development of Heavy-Ion Radiotherapy Systems for Cancer Treatment

Toward Dissemination of Patient-Friendly Heavy-Ion Radiotherapy for Cancer Treatment
OKAMURA Kiyoshi

Toshiba's Advanced Technologies Contributing to Heavy-Ion Radiotherapy for Cancer Treatment
IIKURA Takahiko
Toshiba has been focusing efforts on cancer treatment in the healthcare field, which is likely to continue to expand in the future. Our objective is to offer healthcare processes from early detection by means of regular cancer examinations, through to precise diagnosis, treatment ensuring the quality of life (QOL) appropriate to individual patients, and aftercare. In particular, we are promoting the development of heavy-ion radiotherapy systems incorporating our range of technologies for particle accelerators, irradiation devices, superconducting magnets, and information processing and networks. By offering healthcare processes with advanced heavy-ion radiotherapy systems as a core, our approach is expected to contribute to high-quality cancer treatment.

Application of Toshiba's Advanced Technologies to Heavy-Ion Radiotherapy Facilities
ONO Michitaka / HIRATA Yutaka / YAZAWA Takashi
With the increase in cancer patients due to the growth of the elderly population and improvements in diagnostic technologies in recent years, attention is being increasingly focused on heavy-ion radiotherapy and the number of treatment facilities is also increasing.
Toshiba is promoting the development of heavy-ion radiotherapy equipment based on its proprietary technologies cultivated through its experience in the development of accelerator technologies. We have been participating in the development of heavy-ion radiotherapy facilities for the National Institute of Radiological Sciences (NIRS), and have developed three core technologies for next-generation heavy-ion radiotherapy systems: a three-dimensional (3D) scanning irradiation system, a patient handling system using a robot arm-type treatment table, and a treatment information system. In addition to these, we are developing other new technologies including a rotating gantry technology. We have also received orders for equipment for a heavy-ion radiotherapy facility at the Kanagawa Cancer Center called i-ROCK (Ion-beam Radiation Oncology Center in Kanagawa), and have been developing equipment for that facility.

Toshiba's Accelerator Technology and Approach toward Higher Performance and Downsizing for Heavy-Ion Radiotherapy
SATO Kohsuke / SATO Kiyokazu / TASAKI Kenji
Toshiba has developed various systems and components for particle beam accelerators, and delivered a number of accelerator systems including for SPring-8, which is the world's largest-class synchrotron radiation facility, as well as for the Central Japan Synchrotron Radiation Facility (provisional name). Combining our proprietary technologies cultivated through our experience in the development of particle beam accelerators, we are promoting the development of an accelerator for heavy-ion radiotherapy. Toward the higher performance and downsizing of its accelerator, we are also focusing on the research and development of both an ion source applying laser beam technologies, and a superconducting deflecting magnet for accelerators.

Toward Realizing High-Efficiency and High-Accuracy Irradiation System for Heavy-Ion Radiotherapy and Reducing Burden on Patients
ISEKI Yasushi / HANAWA Katsushi / KURUSU Tsutomu
Toshiba has developed a high-speed scanning irradiation system as a next-generation irradiation system for heavy-ion radiotherapy equipment, equipped with both multistage energy control of the accelerator and beam-position feedback control in order to perform more highly precise irradiation. This system makes it possible to deliver radiation conforming to the three-dimensional shape of the target area affected by cancer, and shortens the treatment time by eliminating the need to manufacture and install treatment implements.
We are also developing a rotating gantry that can irradiate from many directions by rotating in a 360° circle. By realizing miniaturization of the gantry using a superconducting electromagnet in the beamline, we expect heavy-ion radiotherapy equipment incorporating this system to be introduced in private-sector hospitals in the near future.

Advanced Medical Systems Realizing Smooth Operation of Heavy-Ion Radiotherapy
KASAI Shigeru / MIURA Yukio
In order to treat more cancer patients using heavy-ion radiotherapy systems, Toshiba has developed the following advanced medical systems: (1) a patient handling system consisting of a selectively compliant articulated robot arm (SCARA) type treatment table, a top plate, and a cart, which makes it possible to increase the number of treatments per treatment room by accurately and rapidly determining the beam-irradiation position; and (2) a treatment information system that collects the treatment information in conjunction with the medical information systems used at each step from reception to irradiation, facilitating sharing of the information among the staff involved in the treatment and ensuring smooth operation of the heavy-ion radiotherapy system.

Medical Equipment and Design Approach Contributing to Evolution of Heavy-Ion Radiotherapy
KUWAHARA Takayuki / OTOHA Shigeru
As part of the efforts being made to realize high-quality cancer treatment, the Toshiba Group is striving to offer healthcare processes with the advanced heavy-ion radiotherapy system as the core. In addition to key technologies including ion accelerators and irradiation devices developed by Toshiba, Toshiba Medical Systems Corporation has developed an image-guided radiotherapy (IGRT) technology for rapid and highly accurate determination of the beam irradiation position using computer tomography (CT) images taken by an Aquilion$_{TM}$ X-ray CT scanner installed in the same treatment room. Moreover, in the area of design, Toshiba has employed a comprehensive approach that considers both optimal operations for the medical personnel and psychological care for the patient in each medical workflow, regarding the various items of equipment as a whole treatment system. In order to realize smooth communication between medical personnel and patients, Toshiba has also applied a design that provides efficiency and comfort appropriate to the treatment status to the displays of the treatment information system.

Toshiba's Approach toward Technological Innovations in Equipment for Future Cancer Therapy
OZAKI Akira / YOSHIYUKI Takeshi
With the expanding use of heavy-ion radiotherapy as a result of continuing technological innovations, the number of applicable cancer patients is expected to further increase in the future. Future facilities will be equipped with a compact accelerator and rotating gantry using high-temperature superconducting magnets, and will feature high-speed and high-precision irradiation technology applying advanced tracking technologies. Furthermore, the early detection of cancer and the dissemination of advanced treatment will be accelerated through the progress of medical information coordination using advanced diagnosis technologies and cloud systems.
Toshiba is continuously realizing innovations in treatment equipment and is making efforts to provide integrated system solutions, including for community collaboration and whole hospital systems, in cooperation with Toshiba Medical Systems Corporation, medical information system companies, and facility constructors. By promoting advancement of the health care processes from cancer detection, diagnosis, and therapy to aftercare, our aim is to contribute to the early realization of a society providing a more comfortable medical environment for the largest possible number of people.

Feature Articles

FPGA Using Nonvolatile Memories for Reduction of Circuit Area and Power Consumption
YASUDA Shinichi / IKEGAMI Kazutaka / FUJITA Shinobu
The field programmable gate array (FPGA) is an integrated circuit (IC) that can be configured to realize arbitrary logic circuits by downloading circuit data after chip manufacturing. Accompanying the increase in the manufacturing cost of custom large-scale integrations (LSIs) with advanced logic processes, attention has been recently focused on FPGAs with lower development costs because the circuit can be easily reconfigured. However, reduction of the circuit area and power consumption is a major challenge facing conventional FPGAs.
As FPGAs are based on memory technologies, Toshiba has developed an FPGA technology applying a nonvolatile memory technology to reduce the configuration memory area by fabricating nonvolatile memories between the interconnect layers. Furthermore, we have confirmed that the adoption of nonvolatile memories makes it possible to shut off the power supply to unused circuits, leading to lower power consumption.

CardioLine Automatic Slice-Alignment Method for Cardiac Magnetic Resonance Imaging
NITTA Shuhei / TAKEGUCHI Tomoyuki / KUHARA Shigehide
Demand has been increasing for cardiac magnetic resonance imaging (MRI) examinations that can evaluate various cardiovascular diseases such as ischemic heart disease, cardiomyopathy, coronary aneurysm, intracardiac thrombus, and so on, and are effective for prognostic prediction. However, the preparatory step of slice alignment for cardiac MRI examinations, which can be complicated and time consuming, is a serious issue.
As a solution to this issue, Toshiba has developed an automatic slice-alignment method called CardioLine, the world's first automatic slice-alignment application, which was released by Toshiba Medical Systems Corporation in March 2012. CardioLine makes it possible to reduce the slice alignment time from the 10 minutes required for conventional manual setting to less than a minute.

Integration Technologies for REGZA 32S5/40S5/40G5 Series LCD TVs
SHIMOMICHI Tsuyoshi / MATSUO Shinji / MORITO Yoshihiro
With decreasing product prices in the TV market as a result of global economic stagnation, demand has been growing in recent years for differentiation by cabinet design and reduction of the environmental impact of liquid crystal display (LCD) TVs. In response to these market needs, Toshiba has developed integration technologies to integrate the housing structure and the LCD module for the realization of lightweight, narrow-bezel, and low-cost products, and released the REGZA 32S5/40S5/40G5 series LCD TVs incorporating these technologies.

On-line Integrated Stability Control System of Chubu Electric Power Co., Inc.
KUSANO Hideo / TAGUCHI Hiroyuki / NISHIIRI Hideaki / SAITO Nobutoshi
Commercial operation of the on-line integrated stability control (ISC) system of Chubu Electric Power Co., Inc. started in May 2012. As the power transmission line extends over a long distance of approximately 300 km linking the 500 kV trunk network to the newly built Joetsu Thermal Power Station, the ISC system has been introduced to maintain the stability of the overall power system in the Nagano area, including the voltage and frequency, in order to ensure the quality of the electricity supply. Toshiba has developed a central processing unit (A series) and external equipment including intersection for ISC system.

Automated Interactive Voice Response System Using Speech Synthesis and Recognition Technology
SAKAI Shizuma / YASUDA Hirokazu
Call centers are experiencing an increasing need for automated interactive voice response (IVR) systems as an alternative to operators, in order to reduce both operating costs and the burden on operators. In general, an IVR system provides customers with certain options using voice guidance, allowing them to select their requirements by pushing touch-tone buttons on their telephone handset. However, as it is difficult to understand the requirements of each customer in detail due to the diversification of operations in call centers, operators provide assistance to customers in many cases.
With these trends as a background, Toshiba has developed an automated IVR system for call centers that makes it possible to recognize a customer's voice and respond to it automatically, applying its proprietary speech synthesis and recognition technology.

High-Efficiency Motor with Ferrite Magnets for Washers
NITTA Isamu / SAITO Toru / SHIGA Tsuyoshi
To meet the growing demand for energy conservation in home appliances, various measures to reduce electricity consumption have been introduced into washer-dryers. Although powerful neodymium magnets are used in the motors of energy-saving models, the continued use of such magnets, which contain a small amount of the rare-earth element dysprosium, has become a critical issue.
In order to rectify this situation, Toshiba has developed a new motor using conventional ferrite magnets whose magnetic force is enhanced by adjusting the direction of internal magnetization. New automatic washer models equipped with this motor achieve a reduction in power consumption of 6% compared with our conventional models.

Frontiers of Research & Development

High-Torque-Density Motor Effective for Further Miniaturization