High-sensitivity Robot Arms

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High-sensitivity Robot Arms

Robots are commonplace with car manufacturers. The buzzing servants, made from steel and aluminum, weld metal, pack door sheeting, and lift entire carriage skeletons through the factory hall. But now these tireless assistants are faced with new and unusual tasks: Starting next year, they will position patients with previously unknown sensitivity, flexibility, and highest comfort for patient and personnel.

By Tim Schröder

Robots are part of the new Heidelberg Ion Beam Therapy Center, where highest precision is the order of the day. To optimally spare adjacent tissue, the particle beam of carbon ions or protons has to impinge on the tumor with millimeter precision.

Whenever the patient has to be positioned with great accuracy, the robot will take over: for treatment planning, for position verification, and during treatment. The robot lifts the patient tabletop from below and automatically guides it into the correct position. The flexibility of the load arm, with its six degrees of freedom, is highly advantageous. This means that the arm does more than move up and down, forward and backward, or from left to right like a common stretcher. In addition, rotational movements are possible just as with robots in the factory. As a result, it is possible to gently position the patient in front of the beam outlet so that the particle beam reaches the target tissue at the planned entrance angle with the highest accuracy.

The Components Division of Siemens Medical Solutions in Kemnath, Germany, contracted KUKA Roboter and is developing the new highly accurate positioning and verification machine. KUKA Roboter GmbH (Ltd.) was the company of choice because it successfully

established itself years ago in the automobile industry. Headquartered in Augsburg, Germany, the company produces five basic robot models. One of these was tailormade according to the specifications of Siemens Medical Solutions for application in particle therapy. The center in Heidelberg is using a model that weights 1,200 kilograms and lifts patient loads up to 200 kilograms.

Unique Precision

The engineers from Siemens and KUKA Roboter were faced with the challenge of teaching their heavy machinery the necessary precision. "To meet these requirements, we had to adjust a whole series of components," explains Ralph Berke, Head of Medical Robotics at KUKA Roboter. But he will not tell which – because today the precision of these new robots is still sui generis. The steel arm positions patients even better than within a 0.5 millimeter radius of absolute position accuracy. And that is not all: the robot can subsequently correct the position in one tenth of a millimeter increments.

Berke adds that "Industrial robots are usually trimmed for repeatability. It is their task to hit the same points, day in and day out, on thousands upon thousands of car bodies. But none of them will reach the accuracy of the Siemens model implemented in Heidelberg." The performance is amazing. A machine weighing more than a ton moves toward a point with an accuracy of one tenth millimeter. Anyone who has ever tried to maneuver a car into a tight parking spot can imagine what this means. Siemens and KUKA Roboter are currently setting the gold standard with these robots, Berke emphasizes.

Usually, industrial robots and people are separated by safety fences – primarily to ensure that careless workers are not accidentally captured by the machines. Conditions in the new therapy center are, however, completely different. Here, human and machine meet eye to eye. This requires carefully planned safety systems. The positioning robot is equipped with new safety software – the Safe Robot System. The robot uses this system to monitor given room limits by itself

FROM THE LAB directly into the Heidelberg Ion Beam Therapy center: Thanks to the robot, patients can be positioned much more precisely for therapy. Top and center photos: test at Siemens; bottom photo: installation of the system at the customer site

»The system is much more flexible and precise than conventional patient-positioning tables – and comparatively cost-effective.«

Thomas Haberer, PhD,
Scientific-Technical Director,
HIT GmbH, Heidelberg, Germany

and will, for example, trigger emergency stop commands on its own. This makes the entire system faster – fractions of a second that can make all the difference.

Man and Machine

For four years now, KUKA Roboter has been demonstrating that humans and robots can work very well together – their robot-controlled roller coasters are the attraction at amusement parks. The robot carousel twirls visitors through the air at the fair. A safety system ensures the safety of the riders. The robot at the hospital will, of course, react with much greater sensitivity.

At the beginning of the treatment, the robot lowers the patient tabletop to provide the patient with easy access to the table and enable the treatment personnel to immobilize him or her comfortably. Exact positioning and immobilization of the patient are necessary to obtain maximum precision during treatment as well. Should the immobilization of the patient require more time, a shuttle system can be used. The patient tabletop is then located on a gurney. The patient is immobilized in a separate room and then moved into the treatment room. The robot arm docks on the tabletop and moves the patient to the required position, without any physical effort of the health personnel.

To align the patient exactly in front of the beam outlet unit at the previously calculated position, the treatment room at the Heidelberg facility is equipped with a second robot which is anchored in the ceiling. This second robot carries an X-ray system. Elaborate anti-collision systems in the robot control prevent the collision of the cooperating machines. Immediately prior to the treatment, the target tissue is imaged and compared with the images from the treatment plan.

Enormous Flexibility

In case of deviation, the computer calculates a shift vector. After confirmation by the oncologist, the robot aligns the patient accordingly and sets the most optimal radiation position. Due to its six degrees of freedom, the robot can maneuver patients in a highly flexible manner. This is not possible with the tables currently used in conventional radiation therapy. The robot also demonstrates its flexibility at the site of implementation: in addition to fixed-beam treatment rooms, it can be used in treatment rooms where the beam exit is part of a rotating gantry, or to move the patient in the planning CT in exactly the same orientation as he or she will be treated afterwards.

Considering its flexibility and enormous precision, the positioning robot is part of the essential equipment and unique selling proposition of the Heidelberg system, according to Thomas Haberer, PhD, Scientific-Technical Director of HIT (Heidelberg Ion Therapy) GmbH. "The system is much more flexible and precise than conventional patient-positioning tables – and comparatively cost-effective."

In addition to seizing and moving a patient table, the robot can also handle heavy quality assurance devices and verification tools. These are objects that enable measuring and fine-tuning of the particle beam. Among them is, for example, a 200-kilogram heavy measurement basin. The robot is equipped with an adapter which can be coupled to a wide variety of accessories. It lifts the measurement basin with ease and moves it into the proper position. "Without positioning systems, the measurement basin would have to be lifted onto the table with a great deal of effort and then shifted into the right position," says Haberer.

Siemens Medical Solutions and KUKA Roboter detailed the requirements to be met by a robot working at a particle therapy system – with special attention to safety and patient friendliness. The fusion of Siemens medical knowledge and KUKA Roboter's technology leads to this highly useful innovation for the field of particle therapy; an innovation enabling precise and time-efficient treatments.

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