Faster tracking of lung tumors may help treatment

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Today, at the 52nd Annual Meeting of the American Association of Physicists in Medicine (AAPM) in Philadelphia, a group of researchers from Stanford University will describe the latest developments toward their goal of integrating two existing medical devices -- medical linear accelerators, or "linacs," which produce powerful X-rays for treating cancer, and magnetic resonance imagers (MRIs), which are widely used to image tumors in the human body.

The new research involves trying to significantly increase the speed of MRI imaging using a concept called "spatio-temporal sparsity," which traces its origins to video compression and streaming Web movies. By using it on medical MRI images, the Stanford team managed to triple their image acquisition speed -- fast enough to acquire 2D and 3D images of lung tumors in real time as they move with a patient's every breath.

This faster speed allowed the team to visualize tumor tissue itself in real time inside two human patients -- just fast enough and at sufficient resolution to guide treatment. And they believe that they can improve on this further.

With these new results and the hardware integration work done to date by other groups in this field, Amit Sawant, a researcher in the Department of Radiation Oncology at Stanford University who led this research, says that the first prototype hybrid Linac-MR system may be available within a year. He adds, however, that clinical trials and federal

regulatory approval of clinical protocols are expected to take a few more years.

IMAGING TUMORS IN MOTION

The success of modern radiation therapy often depends on how well doctors can determine the exact location and shape of a tumor based on a set of images. Imaging techniques have improved to the point that doctors can now define the edges of many tumors to within a fraction of an inch. During treatment, however, many tumors will move. Tumors in the lungs, for instance, can move up to an inch or more as a person breathes.

In recent years, a variety of imaging techniques have emerged for guiding radiation treatment, and two approaches have typically been used to guide radiation therapy delivery to tumors in the lung and abdomen. The first, the use of external "surrogate" markers placed on the chest wall, suffers from the assumption that a tumor inside the lung will move more or less in sync with chest contraction and expansion during breathing. The second approach makes use of internal surrogates, dense gold seeds implanted into either lung bronchi or the tumor itself, that define the tumor location based on X-ray images. But neither of these approaches gives true image-based guidance of the entire volume of the tumor, says Sawant.

A hybrid Linac-MR system, however, would allow doctors to accurately monitor moving tumors in a patient's lungs and other soft tissues such as the liver or prostate in real time at a resolution and speed that would allow effective guidance of radiation therapy while the treatment is ongoing. Last year, a group in Canada overcame many of the technical hurdles to building such a device and demonstrated the first operating prototype Linac-MR system.

Now Sawant and his Stanford colleagues Kim Butts Pauly and Paul Keall have made another important contribution to the development of this technology, which Sawant and his student Cheol Pyo Hong will present in Philadelphia this week.

THE NEED FOR SPEED

The problem they were addressing is one that may be known to anyone who has had an MRI scan -- the machines are slow. Typical imaging times for MRI range from several seconds to a few minutes per image, which is not fast enough to track tumors in motion.

"What we need is 10 times that speed if we want to be confident we are capturing the motion," says Sawant. Now they are a closer to that goal.

Rather than sampling the entire tumor and processing all that data in real time, they developed an imaging technique that calculates the difference between successive images. Human anatomy and the shape of a tumor don't change radically from image to image, says Sawant, explaining "We only need to image what HAS changed."

By selecting only for changes in successive images, they can streamline the scanning process by close to 70 percent -- essentially cutting the time needed to obtain each image to less than one-third.

"This was an initial investigation," says Sawant. "With clever reconstruction schemes, you could further increase the imaging speed probably by a factor of 10."

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