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Lageerkennung des Tumors mithilfe eines intensitätsbasierten 4D Registrierungsverfahrens

Determination of the Tumor Position by an Intensity-Based 4D Registration Procedure

Kajetan Berlinger[1], Dr. Michael Roth[1], Manfred Dötter[2], Dr. Otto Sauer[3], Lucia Vences[3], Jens Fisseler[4], Prof. Dr. Achim Schweikard[4]

[1]Informatik IX, Technische Universität München
[2]Universität Würzburg, Klinik für Strahlentherapie
[3]Universität Lübeck Institut für Robotik und Kognitive Systeme

PURPOSE

We designed a system that can track tumors moving due to respiratory motion. This allows a more specific and effective irradiation of the tumor. Healthy tissue is spared and higher doses can be used to treat the tumor.

MATERIAL & METHODS

First two CT-Scans are taken during maximal inhalation and exhalation. Then several synthetic intermediate CT-Scans are computed by using different morphing methods like thin-plate splines. This yields a 3D motion picture.
Before treatment „live" x-ray images are taken periodically and compared to the computed 4D model of the lung. In these x-rays the tumor is not visible, but in the CT scans the target region is determined. Our registration method is intensity-based and uses pattern search optimization.
After registration of the live image with the 4D model we know the best matching stack in the series and therefore also the tumor position and the respiratory state. Thus we acquire correlation from respiratory state to tumor position.

At the moment, registration time for a new live image is about 10 seconds for each stack. This yields only intermittent information about the target location. At the time the comparison of all stacks with the current live shot is completed, the target may already have moved.

To solve this problem we use a sensor to report information on the current state of respiration in real time. This sensor is an infrared tracking system, with emitters attached to significant positions on the patient.s chest and abdomen. The information of the sensor is correlated to the target location computed by the comparison between the live shot and the stacks of the whole respiratory cycle. Therefore, the live shot has a time stamp, and we can determine which reading of the real time sensor corresponded to this point in time. Repeating this time stamp synchronization, a complete correlation model can be obtained, which correlates target motion to the readings of the real time sensor (internal to the external motion), without internal fiducials, which we used in earlier systems.

RESULTS

First attempts were made with the very critical part of the system, the 4D registration step, needed to determine the respiratory state. We computed 9 intermediate scans out of two initial CT-Scans, one taken during inhalation and one during exhalation. Then in one arbitrary stack (real or synthetic) we generated two mutually orthogonal DRRs, which we matched afterwards to the generated 4D model. The best match certainly was the stack originating the created DRRs, but the neighboring stacks led to the next best results, as we hoped for. The greater the difference between the respiratory states, the worse is the result of the used metric (mutual information, correlation coefficient).

CONCLUSIONS

We have shown that it is possible to determine the respiratory state by matching a generated DRR to the generated 4D model of the liver using our intensity registration method. This shows that our approach fullfills the basic requirement for a later succesfull registration, performed with real x-rays.