Universität Basel

Research Project

Evaluation and Validation of Ultrasound for the Management of Organ Motion in Tumour Therapy.

Third-party funded project

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Cancer is a leading cause of death worldwide. It accounted for 13% of all deaths in 2007. The main types of lethal cancer are lung, stomach, liver, colon, and breast tumours. All these sites are subject to respiratory motion, which can be a complicating factor for treatment. A well known and established method for the treatment of non-resectable tumours is radiation therapy, which uses ionising radiation to destroy tumour cells. The art of radiation therapy is to deliver a lethal dose to all cancerous tissue whilst sparing as much healthy tissue as possible, in particular organs that are radiation sensitive or for which the consequences of side effects can be severe. Consequently, accurate target localisation and delivery is one of the main challenges in radiation therapy.There are a number of different factors contributing to potential inaccuracies in irradiation. Of these, respiratory motion is one of the major problems in the thorax and in the abdomen and has been shown to have a large dosimetric impact on conventional radiotherapy. Besides quasi-periodic respiratory motion, which includes variation in breathing depth and speed, the organs undergo other modes of deformation, called secondary modes. The secondary modes are caused for example by the cardiac cycle motion, digestive activity, gravity, muscle relaxation, or filling of the bladder. These two components constitute the total organ motion seen during treatment.Recent advances in three-dimensional planning and advanced treatment technologies, such as intensity modulated radiotherapy (IMRT), intensity modulated proton therapy (IMPT) and high-frequency focused Ultrasound (HIFU), have brought about new possibilities in delivering highly conformal dose distributions. The advantage of highly localised treatment makes these techniques sensitive to organ motion, which represents a limiting factor for exploiting their full potential.Countless works on handling organ motion, more specifically breathing motion, have been published in the last ten years. A comprehensive overview including practical guidelines can be found in a recent report of the American Association of Physicists in Medicine. An obvious method to avoid respiratory motion is to completely interrupt breathing while the therapy beam is on. In gated treatment the beam is only turned on during a certain period of the breathing cycle, for example during exhalation. Although the aforementioned approaches compensate to some extent breathing motion they require reproducibility of the organ position for the selected breathing phase and prolong the treatment time. More importantly, they only compensate for the perpetual breathing motion and as such are completely oblivious to all other modes of organ motion. Thus they are only accurate in a short window of a couple of minutes after patient set up.Thus, organ motion during radiotherapy continues to be a problem and much research effort is being put into understanding and addressing this issue. At last years ESTRO conference for example, 4 out of the 5 selected highlighted papers were discussing the issues surrounding organ motion. This only shows the importance of tackling this problem.It would be desirable to keep the target and the treatment beam aligned throughout the

entire breathing cycle. This technique is commonly referred to as tracking. Tracking is very demanding as it requires some prediction of the target motion. Although tracking is in principle designed to follow any target motion, it profits from a possibly regular breathing pattern because this simplifies the required short-time prediction of the motion trajectory. The high sampling rate and low lag of Ultrasound (US) makes it a very attractive non-ionising imaging modality to use for tracking of the target.

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