PhD Thesis Title: "Novel in-treatment dose verification methods for adaptive radiotherapy"

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Graduation Date:	31 March 2016
Available on line:	n/a

Abstract:

Radiotherapy is one of the main treatment modalities to treat cancer. Image based treatment verification has been recently introduced. However, a quantitative comparison between the planned and delivered dose is a novel development in the field of radiotherapy. In this thesis, the added value of quantitative in-treatment dose measurements techniques to facilitate adaptive radiotherapy has been investigated. Several methods have been developed for in-treatment dose verification: 1) Planar dose verification; 2) 3D dose verification; and 3) Time-resolved dose verification. The thesis therefore is divided into two parts, **part one** where novel technologies were developed to compare dose distributions in 3D and compare time-resolved dose distributions. In **part two,** the clinical applications and the advantages of dose guided radiotherapy are studied. In **chapter 2,** the calculation of dose differences was optimized for processing on a graphics processing chip resulting in sub-second calculations times. In **chapter 3,** the calculation has been optimized to analyze and compare time-resolved dose information. The current method (the gamma calculation) has been extended with an extra degree of freedom; besides dose differences and spatial differences, temporal differences are considered. This results in a method which can accurately evaluate time-resolved dose information. In part, two planar dosimetry has been investigated for 3D conformal radiotherapy. A method was developed to divide inter-fractional differences into random and systematic differences (**chapter 4**). This difference was essential to improve performance of informed decision making for adaptive radiotherapy. It is the systematic dose difference where one would like to act upon while random differences may usually be ignored. The planar dose verification research proceeded with an investigation to the advanced rotational therapy VMAT in **chapter 5**. A correlation was sought between relevant dose differences in the 3D dose distribution based upon dose volume histograms metrics and dose differences measured with integrated planar portal dosimetry, but none was found. In **chapter 6** therefore, the advantages of 3D portal dosimetry for lung cancer patients was investigated. Lung cancer was investigated because in a large number of patients relevant geometrical changes can occur during treatment. Advanced 3D portal dosimetry has many advantages for lung cancer patients and therefore adapt the treatment accordingly. In the final chapter of this thesis (**chapter 7**), a novel time-resolved in-treatment planar dose verification method has been investigated as a continuation on the negative results of **chapter 5**. The aim was to see if time-resolved portal dosimetry delivers more accurate and robust results. In this study, several cases were analyzed to investigate the advantages of this novel method in comparison with time-integrated portal dosimetry. The study showed a great potential for time-resolved portal dosimetry for VMAT treatments.

In summary, it was shown that for the different verification methods for the clinical application, the use of quantitative dose information is useful for informed decision making for adaptive radiotherapy.

References to author publications that relate specifically to the dissertation:

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