

One of major impediments to ensure the accuracy of radiation delivery and to achieve treatment optimization is the inherent variability of patient and organ geometry over the course of radiation dose delivery. To overcome this obstacle, advanced imaging technologies to facilitate patient/organ geometry detection during treatment delivery are being rapidly developed. These technologies include MV portal imaging for detecting daily patient setup error, and on board ultrasound and CT imaging for detecting internal soft tissue motion. In addition, embedded radiomarker displacement monitored via on-line kV radiographic imaging, as well as body surface motion monitored using a CCD camera, have been investigated as surrogates for measuring inter or intra-treatment organ motion respectively.

In tandem advanced imaging technology, computer algorithms and software tools for measuring patient/organ geometric variation relative to the radiation beam have been developed. These algorithms can be divided into two groups: Group I for determining the rigid body motion of patient bony structure or inserted radiomarkers, and Group II mainly for determining the non-rigid body motion of patient soft tissues. Temporal variation of patient/organ geometry during radiation treatment has been classified, based on its statistic behavior, as a systematic variation and a random variation. The effects of these two variations on treatment planning are quite different, and the systematic variation is dominant factor. One should carefully examine the effects in relation to the treatment goal and clinical resources before selecting a method to correct and compensate for them.

The major goal of measuring patient/organ geometric variation can be twofold. The first is for treatment quality assurance, where patient/organ geometric variation identified from image feedback is corrected to ensure that the treatment can be delivered as pre-planned. Various methods of off-line and on-line patient/organ position correction have been proposed and some of them have been clinically implemented. Additional study of output residuals is critical and required to validate these correction methods. The second purpose of using image feedback is more proactive, whereby the feedback images are systematically applied in designing an optimal dose distribution so that treatment planning and decisions can be fully adapted to patient/organ geometric variation. Few strategies have been proposed, so far, and only for limited treatment sites. The major challenges in implementing an adaptive control strategy include image-based organ registration, organ subvolume position estimation, and beam intensity optimization. In addition, practical issue has heavily influenced the new developments on this subject.