AbstractID: 7873 Title: Patient motion: Adaptive RT

Organ motion blurs dose distributions. The blurring can be described in a statistical way by use of a motion probability (density) function (PDF). The motion-blurred dose distribution is obtained by a convolution of the “sharp” (static case) dose distribution with the motion PDF. This holds true for both inter- and intra-fraction motions. If intra-fraction motion is present during an IMRT treatment, the dose distribution will also be affected by an “interplay” effect, in addition to the blurring. It has been shown that the interplay effect averages out during the course of a fractionated treatment, and that it is usually negligible after a typical number of fractions. The convolution model relies on the linear superimposition principle, which holds true for dose values but not for the biological effect. This issue has recently been addressed and will be discussed.
Several investigations have now looked at the feasibility of un-doing the motion blur through the use if intensity-modulation. In principle it should indeed be possible to de-convolve the motion PDF from the intensity maps, to compensate for motion effects. This approach has been called 4D optimization or 4D inverse planning. Motion de-convolution cannot, however, compensate motion effects exactly and it cannot be applied in a naïve straight-forward way, because that would lead to undeliverable intensity maps with sharp spikes and negative values. The method of choice is rather to include the motion PDF in the IMRT optimization process. It has been shown that this can indeed yield a surprisingly high degree of motion compensation and it can even compete with other motion compensation methods such as gated delivery. However, this is only true if the motion characteristics (the PDF) are known with great precision. If the actually realized motion PDF deviates substantially from the planned PDF, the method becomes less useful and can, in principle, make things worse.
More recently, uncertainties in the knowledge of the motion characteristics have been taken into account by use of robust optimization techniques. With these one can now compensate for motion effects in an approximate way for a large class of motion characteristics. In terms of the sparing of normal structures, the results are in between the use of conventional margins and the idealistic case of perfect motion compensation. The resulting intensity maps exhibit “horns”, which can shave off a few mm from the margins.

Educational objectives:

1. Understand the concepts of motion blur and PDF
2. Understand the idea of de-blurring a dose distribution through “4D” motion optimization
3. Be able to discuss the relative potential and limitations of 4D motion optimization in comparison with margins and gating