Soft Tissues in the Patient Digitization for the Monte Carlo Radiotherapy Treatment Planning

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The aim of IMAGINE project[1], started in autumn, 2002, is to develop a high-speed and accurate dose distribution calculation system for the photon radiotherapy, with employing Monte Carlo technique and parallel computing technique. Though this system is considered to be able to calculate accurate dose distribution latently, the accuracy may be degraded by the traditional qualities of modeling method. One of the modeling methods to be assessed is the patient digitization, the conversion from the patient CT image to the digitized geometry consisting of a large number of rectilinear volume elements so-called voxels. In most of the present treatment planning systems, all the voxels are regarded to liquid water equivalent, though these voxels actually have various elemental compositions. Therefore we need to survey the more detailed conversion method and estimate the accuracy degradation caused by the traditional conversion method. As an introducing study, we performed the calculations of the target doses for the anthropomorphic voxel phantoms, with changing the substitution materials for the soft tissue.

Two CT-based computer phantoms were used[2]. The phantom bodies were categorized into six groups, bone, lung, skin, muscle and other organs, adipose tissues and the target. All the voxels in skeleton were handled as the mixture of hard-bone and bone-marrow, with its ratio determined by the interpolation from CT-value. The voxels in other groups have uniform densities. We assigned the compositions/densities based on ICRU46[3], to these groups in a manner keeping the voxel's linear attenuation coefficient unchanged. We have calculated 7 methods of soft tissue substitution. The most detailed methods was converting all the soft tissue to four materials (ICRU lung, ICRU skin, ICRU adipose tissue and ICRU skeletal muscle), while the most simple one was to the liquid water. We have not changed the skeletal voxels and the target voxels. The calculations were performed by UCRTP[4], a EGS4[5] user code, on the Beowulf-type computer consisting of nine Pentium4 PCs. The X-ray source was 360-degree rotating, planar cone beam 100cm apart from isocenter. Three X-ray energy spectra, 120kV (tube), 6MV and 24MV (linac) were taken into calculations of the 9 targets.

For the 120 kV tube X-ray, 1.2% deviations were shown in the target dose D_{mean}, the average dose over the target volume, between the most detailed model and "bone-and-water" model in some targets. The deviations were 0.5% at most for two linac X-ray. Though these deviations itself were quite small, we still did not have any evidence about the uniformity of the delivered dose in the target volume so that the further study is still continuing.

Reference:

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