Requirements for the accuracy of electron density data planning for MRI based cervix treatment planning

Radiotherapy treatment planning using MRI alone would have a number of benefits compared to CT based treatment planning; MRI images have superior soft tissue contrast, do not utilise ionising radiation, and have the potential to provide physiological as well as anatomical information [1]. A primary obstacle to the use of MRI for treatment planning is the lack of Electron Density (ED) information provided by an MRI scan. Methods exist to correlate ED information with MRI scans; however all include some error. The impact of this error on treatment planning is not well understood. In this work we have quantified the impact on treatment planning of using incorrect ED data on five cervical cancer patients. To the best of our knowledge this is the first study to examine MRI based treatment planning for cervical cancer, as well as being the first to assess the impact of incorrect ED data on plan design.

We simulated a number of existing methods to map ED data to an MRI scan by manipulating the original CT data of each patient. It should be noted that our aim was not to comment on the merits of one method versus another, but rather to attempt to understand what effect different errors in ED may have on finalised treatment plans. In particular, the 5 data sets created from the original CT scan were based on the following methods of mapping ED to MRI:

- **Homogenous bulk density correction [2]:** ED set to the value of water (1.0g/cm$^3$) everywhere
- **Bulk density correction with bones contoured [2]:** Bones given a separate value of 1.21g/cm$^3$
- **Rigid registration of CT to MR:** All ED data translated 3mm laterally and anteriorly to simulate registration error
- **Gaussian mixture regression based pseudo CT [3]:** Errors of +/-150 HU added to each pixel (mean error -112.5 HU)

Results obtained for 3DCRT suggest that impact on plan design is minimal. Provided care is taken in mapping ED to MRI, dose calculation error can also be kept within an acceptable range (figure 2). Future work will test whether these conclusions can be extended to IMRT.

![Figure 1](a) Original CT Image. (b) Image with a bulk density correction applied. (c) The dose difference map of the same plan on the two images. Differences are shown in percent of local dose.

![Figure 2](The average PTV error in equivalent uniform dose. The error bars represent the total range of results obtained.)

**References**