A Novel Method for Dose-Of-The-Day Calculation for HN

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INTRODUCTION

A common issue in head and neck (HN) radiotherapy (RT) arises from a rapidly changing anatomy over a conventional treatment course. Several factors contribute to anatomical changes, including weight loss, parotid gland shrinkage, and effective treatment of the tumor. Significant anatomical changes may result in large differences between planned and delivered dose, which may result in poorer outcomes, either in tumor control or late effects.

Adaptive RT seeks to address this by adjusting the treatment plan during the treatment course to better suit the new anatomy. To achieve this, a physician must decide if and when to order a resimulation. Cone-beam computed tomography scans (CBCTs) may be taken in the normal course of treatment and used to assess the degree of anatomical change. However, they cannot be used to determine the effect on treatment dose directly, since they have a reduced field of view (FOV) and inaccurate Hounsfield units (HU).

Many procedures deform dose to the CBCT or calculate dose on a deformed CT (dCT) truncated to the CBCT FOV. However, dose deformation and calculation on incomplete anatomy may result in inaccurate estimates

AIM

To provide a strategy for calculating dose on a full size CT deformed to the anatomy of the CBCT to improve adaptive therapy methods.

METHOD

Fifteen HN patients with three CBCTs and one planning CT (pCT) each were used for this study. The steps for each patient were as follows, with the software used for each step indicated with brackets.

1. **Resampling and padding CBCT** to match the voxel and image array size of the pCT [MATLAB]
2. **Creation of cylindrical mask matching** the FOV of the CBCT [MATLAB]
3. **Rigid and deformable registration** of the pCT to the resampled CBCT [`elastix`[1]]
4. **Conversion of dCT from MHD** format used by elastix to the **DICOM** format [MATLAB]
5. **Import** to treatment planning system (TPS)
6. **Recalculation of original treatment plan on dCT**

The similarity metric was mutual information, and a bending energy penalty term was added to constrain the deformation. Deformations were assessed via the determinant of the Jacobian and visual inspection. Contour deformation was not performed.

RESULTS

Preliminary results are presented here.

The DIR methods were successful for all patients, resulting in images with similar anatomic coverage and HU values to the pCT while reflecting the anatomical changes for that fraction.

Dose could be calculated on the dCT, and the resulting dose distribution demonstrated differences between the planned dose and the delivered dose, most visibly in the **increase in hot spots and Dmax**. Although contour deformation has not yet been performed and therefore dose-volume histogram (DVH) parameters are not available at this time, qualitative changes on the dose distribution could be visually inspected using isodose lines and maximum dose values.

The process took **less than 1 hour** per CBCT.

In Figure 1, a patient with significant weight loss over the course of treatment is shown. This is fairly common in HN cases and can result in a significant difference between the planned and delivered dose. In this specific case, the maximum dose increased, and hot spots covered a larger part of the target.

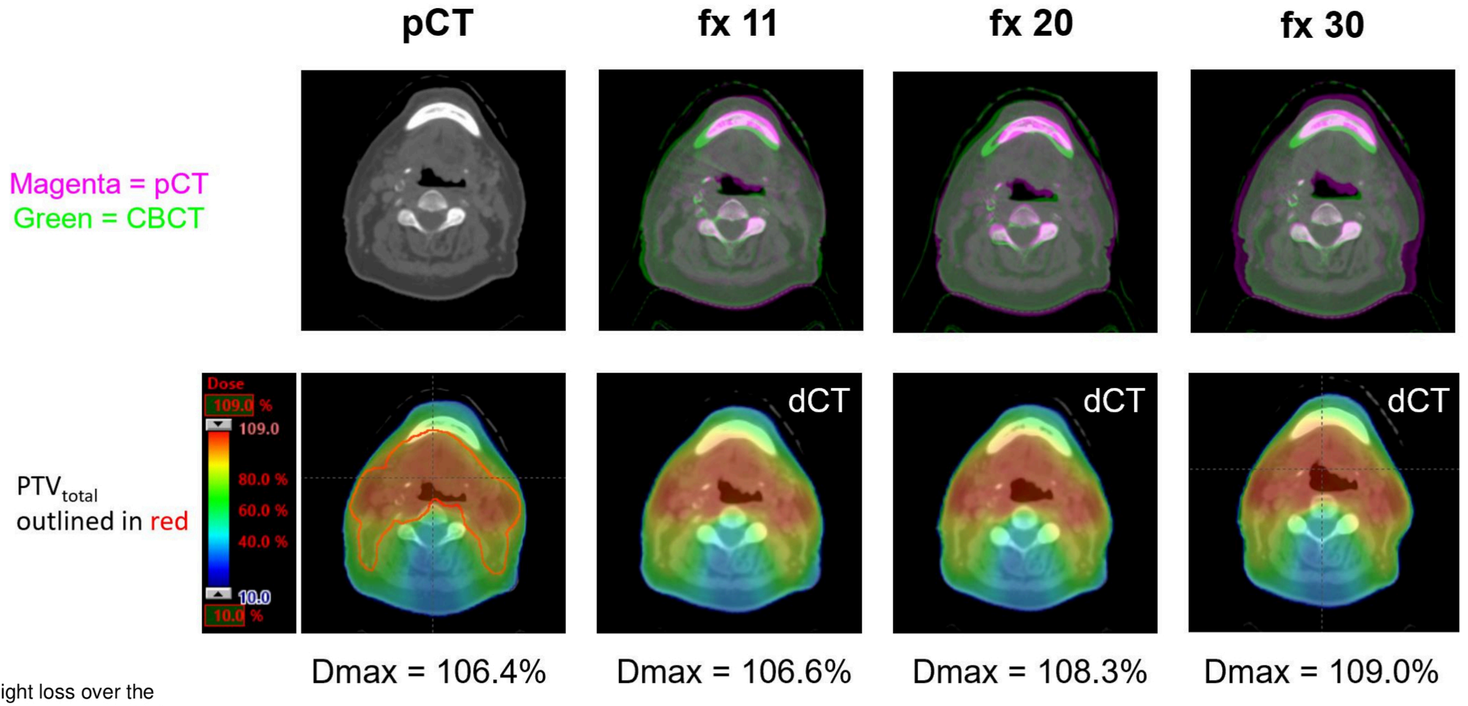

Figure 1 Images taken from one patient in the study. CBCTs for each patient were selected as close to the 10th, 20th, and 30th fraction as possible. Fusions are the CBCT-pCT registration performed at each fraction. All images are taken at the same slice referenced to the pCT.

CONCLUSIONS

A simple method for recalculating dose mid-treatment is presented. The DIR procedure used no commercial medical software and resulted in images with approximately the same FOV as the pCT as well as correct HU values. Even in the case of very large anatomical changes due to weight loss and tumor shrinkage, the algorithm produced deformed images with acceptable matching to the CBCT.

Future work will focus on contour propagation such that DVHs can be compared directly to give a quantitative measure of dose differences.

REFERENCES

1 **S. Klein et al.** elastix: A Toolbox for Intensity-Based Medical Image Registration, IEEE Trans. Med. Imaging 29(1), 196–205 (2010).

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