A novel methodology to differentiate shrinkage vs erosion in CBCT images of lung tumours

George Needham[1]*, Rhydian Windsor[1]*, Marianne C Aznar[2], Eliana M. Vasquez Osorio[2], William Beasley[2], Marcel van Herk[2], Alan McWilliam[2]

[1]The University of Manchester, School of physics and Astronomy, [2]The University of Manchester, Division of Cancer Sciences , Manchester, UK

INTRODUCTION:

- Lung cancer tumours treated with radiotherapy may display elastic (true shrinkage) or non-elastic (eroding) changes, see figure 1.
- Adapting treatment fields to non-elastic shrinkage can lead to a potential treatment failure due to underdosage of residual microscopic disease.
- Our hypothesis is that, at the lung/tumour boundary, erosion will lead to a gradual decrease in Hounsfield units (HU) while true shrinkage will result in faster HU changes on cone-beam computed tomography (CBCT) images, as low-density lung tissue is returning to replace tumour tissue.
- In this project, we develop a methodology to determine density changes in the region of interest (ROI) surrounding the tumour.

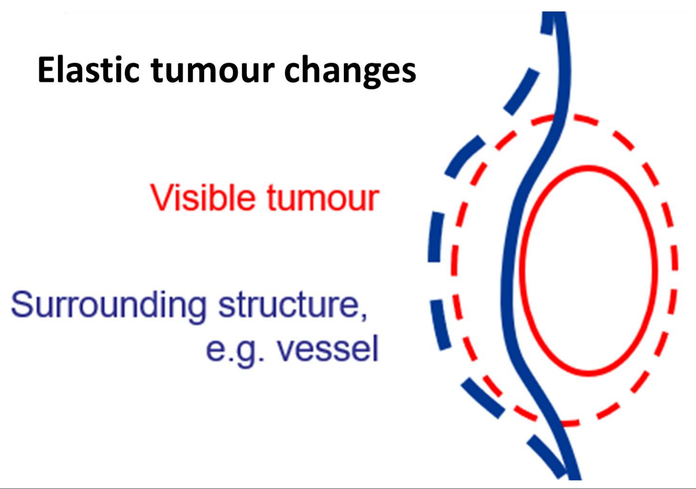


Figure 1: Schematic of elastic and non-elastic tumour changes. The dashed red line represents the initial tumour growth, the solid the tumour growth at a timepoint during treatment. The blue line represents normal anatomy position with respect to the tumour position at the same timepoints. For elastic changes, normal tissue that was moved with the tumour growth returns to position. For non-elastic tumour changes, despite a visible reduction in the tumour, nearby anatomy does not return to its previous position. Microscopic disease may be left behind.

MATERIALS AND METHODS:

- The dataset consisted of CBCTs from 8 non-small cell lung cancer (NSCLC) patients treated with 55Gy in 20 fractions
- The tumour was segmented, using the clinician-generated GTV and excluding all voxels < 500 HU, allowing the edge of the tumour to be found.
- Next, an annular ROI (2mm inside and 2mm outside the segmented contour) was created and rigidly propagated across all CBCTs .
- Histograms of HU within these ROIs were fitted with a bimodal Gaussian distribution. It is assumed that the lower HU peak corresponds to healthy lung tissue and the higher HU peak corresponds to cancerous tissue.
- The rate of change in the relative heights of the peaks was used to determine the mode of regression of the tumour.

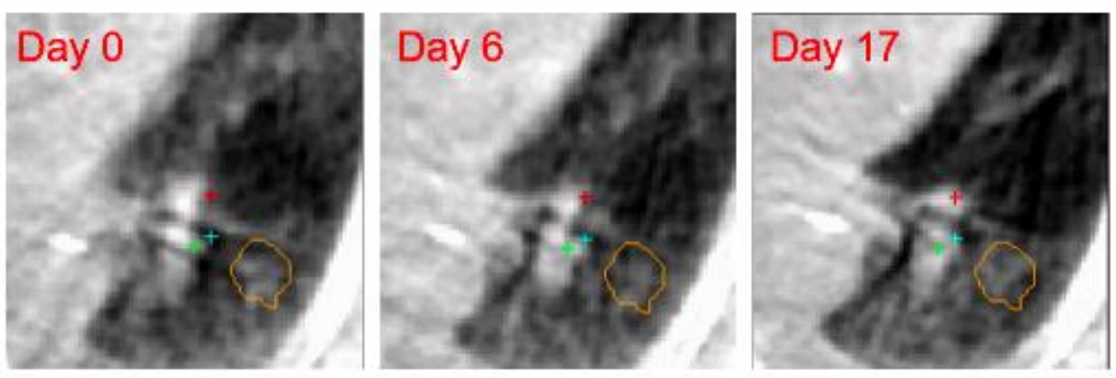
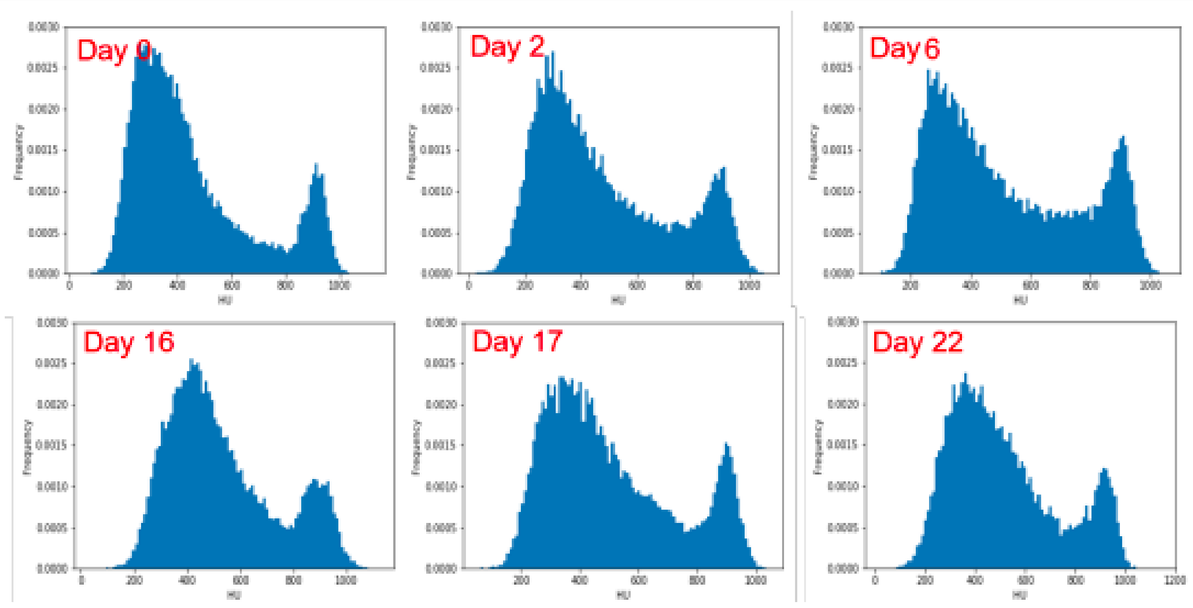


Figure 2: An example of one representative patient showing the CBCT from three fractions during treatment and corresponding histograms from the annular ROI. This patient was visually classified as having an eroding tumour and the slow change on the histograms, with the lung peak broadening as the tumour erodes, agrees with this classification.



RESULTS:

- Figure 2 shows the output from this methodology for one representative patient.
- Visual evaluation of the motion of anatomical landmarks (e.g bronchioles) classified 5 tumours as, predominately, displaying non-elastic changes (eroding) while 3 displayed elastic changes (shrinking).
- Shrinking tumours displayed a larger and more consistent change in relative peak heights throughout the treatment course, with changes appearing rapidly.
- Eroding tumours showed a more gradual change in relative peak heights.
- Additionally, eroding tumours showed a lower correlation coefficient than shrinking tumours, i.e. greater variability in relative heights.

CONCLUSIONS:

- This project demonstrates a novel, but simple methodology to explore elastic and non-elastic tumour changes.
- We believe that change of statistics of the HU in the tumour rim has the potential to differentiate between eroding and shrinking tumours.
- The small patient numbers prevented robust statistical analysis of these differences and we will now apply this method in a much larger patient cohort.

@RT_Physics