Squamous cell carcinoma (HNSCC) through the use of diagnostic position MRI (MRI-D) images deformably registered to the planning CT. This study assessed whether optimising image registration of MRI-D to planning CT (pCT) is an adequate surrogate for delineation on a gold standard (GS) treatment position MRI (MRI-RT) rigidly registered to the pCT.

**Material and Methods:** Fourteen patients with HNSCC underwent a pCT and T1-weighted MRI in both a diagnostic and treatment position. The GTV was delineated on all images by a single radiation oncologist and intra-observer variability was assessed over 5 patients having been contoured on 3 occasions. GS structures were defined as contours from MRI-RT transposed to pCT using rigid registration. The GS was compared to contours produced by 4 methods: MRI-D transposed to pCT with deformable image registration (DIR) over the whole image (DIR-Whole); MRI-D transposed to pCT with rigid registration or DIR optimised on a 3cm ROI around the GTV (Rigid-ROI and DIR-ROI respectively); and on pCT alone. Registrations were performed with Mirada RTx v1.4 (Mirada Medical, Oxford UK) and 6 contour comparison metrics were calculated with ImSimQA v3.1 (OSL, Shrewsbury UK).

**Results:** MRI delineation reduced intra-observer variability compared to pCT. DIR-Whole resulted in GTVs significantly closer to the GS as determined by multiple positional metrics in comparison with CT-only delineation (normalised results are shown in Figure 1). The mean Dice Similarity Coefficient was 0.6 and 0.72 for pCT and DIR-Whole respectively with p=0.019. Use of MRI-D with Rigid-ROI or DIR-ROI provided no advantage over CT-only delineation.

**Conclusion:** In the absence of dedicated MRI-RT, image registration software can aid the integration of MRI-D into the treatment pathway. MRI-D is most accurately integrated into the radiotherapy planning pathway when contours are transposed to pCT with DIR over the whole patient.

**EP-1893**

Automatic contouring of soft organs for image-guided prostate radiotherapy

K. Cai\(1\), C.B. Schönlieb\(1\), J. Lee\(2\), J. Scaife\(3\), H. Karl\(4\), M. Sutcliffe\(5\), M. Parker\(3\), N. Burnet\(2\)

\(1\)University of Cambridge, Department of Applied Mathematics and Theoretical Physics, Cambridge, United Kingdom
\(2\)University of Cambridge, Department of Oncology, Cambridge, United Kingdom
\(3\)University of Cambridge, Department of Physics, Cambridge, United Kingdom
\(4\)University of Cambridge, Department of Engineering, Cambridge, United Kingdom

**Purpose or Objective:** Image-guided radiotherapy (IGRT) is a primary modality in treatment for cancer types such as prostate or neck cancer. Its pipeline involves the analysis of planning- and treatment-day CT scans (kV CT and MV CT in our case). In particular, to explore the relationship between the delivered dosage and its side effects on nearby normal tissues, an automatic contouring method for the precise delineation of target and adjacent critical organs during the treatment is essential and is also the main aim of our work.

**Material and Methods:** Our proposed 3D automatic contouring method constitutes a robust iterative approach on a 3D active contour segmentation model, customised for the IGRT application. The model contains two main driving principles: two data fidelity terms and one regularization term which keep the distance of the auto-contoured organ as close as possible to its true location and sufficiently close to the initialization given by the registered planning scan; and another regularization term which imposes smoothness of the contour around the segmented soft organ. The desired contour in the treatment scan is then computed iteratively, solving a convex minimization problem with an efficient solver called ADMM in each iteration. The initialization at the first iteration is obtained by transferring the manual contour in the planning scan to the treatment scans using a spline-based image registration method. Then, the global minimizer found after the first iteration is used to update the initialization for the next iteration to find the new global minimizer, which ensures the stability and robustness of the approach. We stop the iteration when the preset maximum iteration number (=10 in our case) is reached.

**Results:** We test our method by contouring the rectum of four patients with prostate cancer. Results are given in Fig. 1 and Table 1. Fig. 1 visually validates that our method indeed achieves accurate results and improves upon a registration of the planning contour alone. Table 1 gives the quantitative results for the registered planning contour and our proposed method. Each iteration of our method costs less than 10 seconds.

**Fig. 1:** Contouring results of Patient 1 in slices. Green: manual contour obtained by registration of the planning scan. Red: manual contour computed by our method.

<table>
<thead>
<tr>
<th>Registration method (initialization)</th>
<th>mean(acc)</th>
<th>std(acc)</th>
<th>mean(sex)</th>
<th>std(sex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1 (37 scans)</td>
<td>69.9%</td>
<td>4.2%</td>
<td>53.9%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Patient 2 (36 scans)</td>
<td>69.4%</td>
<td>4.0%</td>
<td>53.1%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Patient 3 (37 scans)</td>
<td>68.3%</td>
<td>6.1%</td>
<td>52.2%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Patient 4 (37 scans)</td>
<td>61.2%</td>
<td>3.4%</td>
<td>44.1%</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Our automatic contouring method</th>
<th>mean(acc)</th>
<th>std(acc)</th>
<th>mean(sex)</th>
<th>std(sex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1 (37 scans)</td>
<td>91.8%</td>
<td>3.2%</td>
<td>76.2%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Patient 2 (36 scans)</td>
<td>89.8%</td>
<td>3.4%</td>
<td>71.2%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Patient 3 (37 scans)</td>
<td>83.3%</td>
<td>4.0%</td>
<td>71.6%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Patient 4 (37 scans)</td>
<td>85.9%</td>
<td>3.5%</td>
<td>73.6%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

| Table 1: Mean and standard deviation (std) of the accuracy (acc) and sensitivity (sen) of the spline-based registration method on the treatment scans of four patients. |
Conclusion: Our proposed 3D automatic contouring method achieves an accuracy of >0.8 and sensitivity of >0.7, which is comparable to the performance of manual contours clinically. We are currently working on a fully automated setup (parameters selection) of the method which is learned from a set of 3700 manually contoured treatment scans.

EP-1894
Evaluation of a novel method for automatic segmentation of rectum on daily MVCT prostate images
M. Romanchikova1, D.I. Johnston2, K. Harrison1, M.P.F. Sutcliffe3, J.E. Scaife1, S.J. Thomas4, N.G. Burnet5
1Cambridge University Hospitals, Medical Physics and Clinical Engineering, Cambridge, United Kingdom
2University of Cambridge, School of Clinical Medicine, Cambridge, United Kingdom
3University of Cambridge, Cavendish Laboratories, Cambridge, United Kingdom
4University of Cambridge, Mechanical Engineering, Cambridge, United Kingdom
5University of Cambridge, Oncology, Cambridge, United Kingdom
6Cambridge University Hospitals NHS Foundation Trust, Medical Physics and Clinical Engineering, Cambridge, United Kingdom

Purpose or Objective: Rectal toxicity is a major complication from radiotherapy (RT) for prostate cancer. The VoxTox project aims to link rectum dose to the observed toxicity for 500 prostate cancer patients who received intensity modulated RT on TomoTherapy with daily image guidance (IG).

Rectum dose is calculated using IG megavoltage CT (MVCT) scans. MVCT images have lower soft tissue contrast and signal-to-noise ratio than conventional CT. To date, there are no auto-segmentation methods for rectum delineation on MVCT. With 200,000 rectum contours required, an experienced oncologist would need over 2 years to complete the outlining.

To automate this task, we developed an in-house auto-contouring software to outline the rectum. Our software can complete the outlining in several days.

The aim of this work is to evaluate the quality of auto-generated contours and to provide a basis for further refinement of the algorithm. The method can be extended to evaluate other auto-segmentation tools.

Material and Methods: Rectum contours were produced using a Matlab code based on 2D Chan-Vese segmentation method. The contours were overlaid on the corresponding MVCT images centred at 87 Hounsfield Units (HU) and width of 220 HU.

7110 slices from 689 daily IG MVCT scans of 20 patients were inspected by a trained doctor.

A contour quality index was defined where 1 was ‘very poor’ and 5 was ‘very good’ (clinically acceptable).

Contouring errors were categorized as
1) too large;
2) too small;
3) cut air pocket (contour cut through gas pocket in rectal lumen);
4) missed air pocket (contour excluded gas pockets);
5) shift (contour is shifted with respect to actual organ location);
6) shape (sharp corners present in contour).

Results:
Contour quality:
70% of contours were scored as “very good” (Figure 1a), and 12% were “good”. 13% of contours were of “average” quality, and 4% were “poor” or “very poor”.

Figure 1: Auto-contoured (red line) and reference (yellow line) rectum. a) Clinically acceptable error-free contour. b) c) d) Error examples. Error distribution:
The most frequent error was under-contouring (“too small”, 21% of all reviewed images), followed by “cut air pocket” (14%). We observed an even error distribution across scans and patients (Table 1).

Table 1: Prevalence of errors across images and scans. Left: entire data set; centre: scans where ≥1 image has the error; right: patient data sets where ≥1 image has the error.

<table>
<thead>
<tr>
<th>Error category</th>
<th>Prevalence across all images (n=7110)</th>
<th>Prevalence across scans (n = 699)</th>
<th>Prevalence across patients (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too large</td>
<td>5%</td>
<td>25%</td>
<td>95%</td>
</tr>
<tr>
<td>Too small</td>
<td>21%</td>
<td>69%</td>
<td>100%</td>
</tr>
<tr>
<td>Cut air pocket</td>
<td>14%</td>
<td>49%</td>
<td>100%</td>
</tr>
<tr>
<td>Missed air pocket</td>
<td>2%</td>
<td>11%</td>
<td>70%</td>
</tr>
<tr>
<td>Shifted</td>
<td>3%</td>
<td>18%</td>
<td>80%</td>
</tr>
<tr>
<td>Odd shape</td>
<td>3%</td>
<td>22%</td>
<td>95%</td>
</tr>
<tr>
<td>Error-free</td>
<td>70%</td>
<td>14%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Conclusion: Our auto-contouring method produces clinically usable contours for the majority of cases and offers a considerable time- and resource-saving potential. We identified six error categories, four of which can be automatically detected during the auto-outlining and will drive the re-contouring process. The presented method can be used to evaluate the performance of other auto-segmentation tools for cavitory organs.

EP-1895
Towards adaptive radiotherapy: a new registration-segmentation framework for focal prostate cancer
Y. Feng1, K. Cheng1, D. Montgomery1, D. Welsh1, J. Lawrence2, L. Forrest1, S. McLaughlin1, D. Argyle1, W. Nailon1
1Edinburgh Cancer Centre, Department of Oncology Physics, Edinburgh, United Kingdom
2University of Edinburgh, Royal Dick School of Veterinary Studies, Edinburgh, United Kingdom
3University of Wisconsin-Madison, School of Veterinary Medicine, Madison, USA
4Heriot Watt, School of Engineering and Physical Sciences, Edinburgh, United Kingdom

Purpose or Objective: Commercial treatment planning systems can combine pre-treatment magnetic resonance (MR) images with radiotherapy planning computed tomography (CT) images using rigid or non-rigid registration. However, these systems lack the ability to combine registration with automatic image analysis/segmentation methods that may be helpful in prostate cancer boost therapy when mapping of a