DTU Informatics
Department of Informatics and Mathematical Modeling

Auto-Segmentation of Medulla Spinalis for Radiation Therapy

Troels Bjerre, M.Sc. & Christian Hollensen, M.Sc.

Introduction

The use of radiation therapy in cancer treatment has increased in the last decade. Recovery likelihood depends on the localization of cancer volumes and healthy tissues vulnerable to radiation.

Medulla spinalis is the nerve cell bundle running in the vertebral column. Radiation damage to these cells can cause severe and permanent disabilities to motor function, sensory capabilities or reflexes.

Currently, contours of tumor volumes and vulnerable tissues are drawn manually and form the basis for the dosis plan. Reducing the manual workload by automated segmentation would be beneficial.

In this work we assess 2- and 3-dimensional active contour approaches for segmentation of medulla spinalis on head and neck cancer patients.

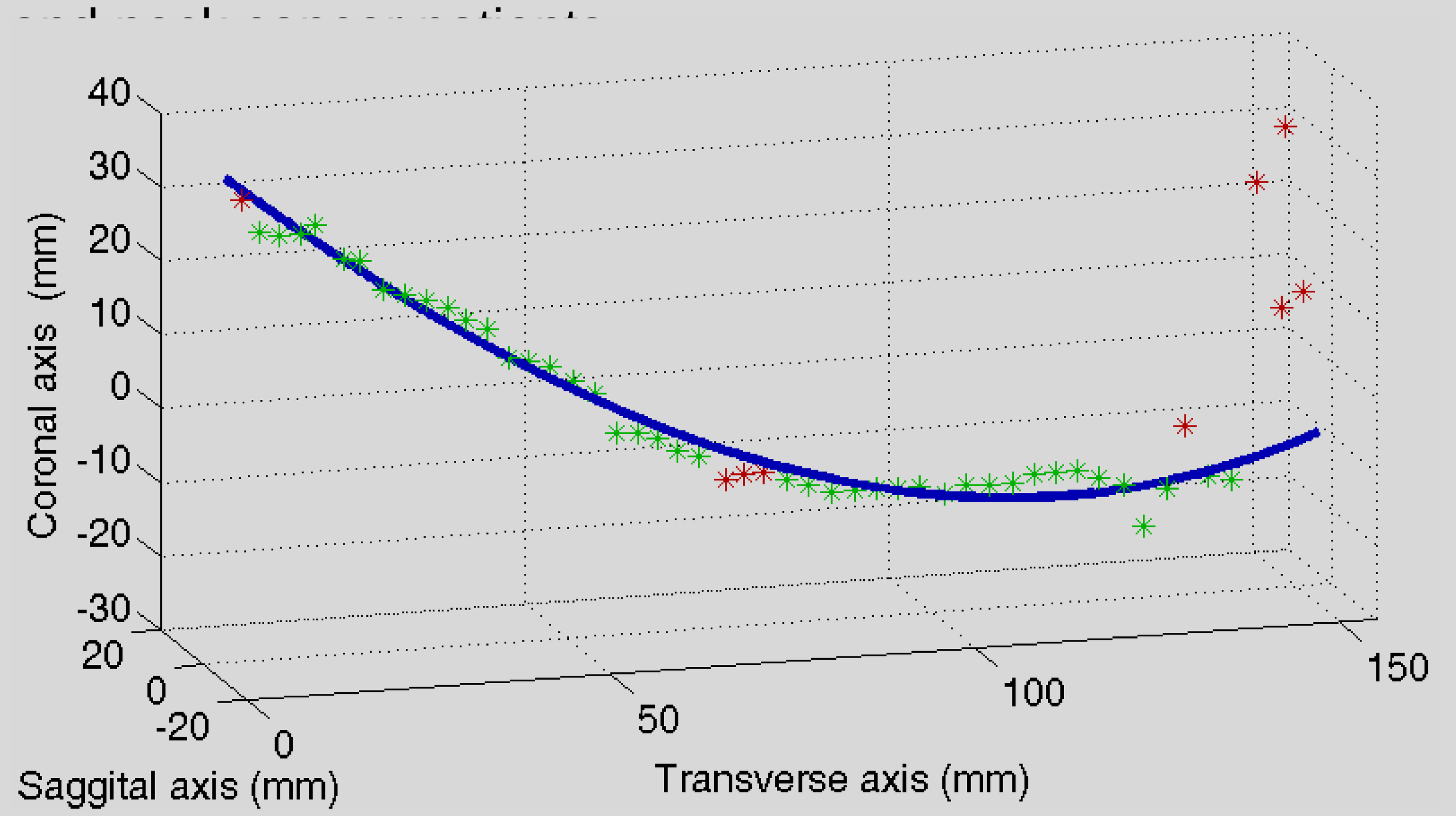

Figure 1. Illustration of vertebral center coordinate estimation. Vertebral center coordinates (*,*) as detected by the initial convolution of each CT slice with an ellipse. Inliers (*) as determined by the RANSAC algorithm. 3rd degree polynomium (-) fitted to the inliers.

Patient data

The data consisted of CT scans from 185 head and neck cancer patients, eligible for radiation therapy. In each slice of the scans, the medulla spinalis had been contoured by a radiologist as part of the standard radiation therapy planning procedure. 5 patients were used for optimizing algorithm parameters. 180 patients were used for evaluation.

Methods

The vertebral column center was located in each CT slice by convolution of a bone threshold image with an ellipsoid. The RANSAC algorithm[1] was applied for excluding outliers and the vertebral centers were estimated in all CT slices by fitting a 3rd degree polynomium to the inliers.

The medulla spinalis was segmented using both a 2-dimensional gradient vector flow (GVF) snake[2] and a 3-dimensional level set method (LSM)[3]. The energy function of the LSM was both gradient and intensity dependent.

For each CT scan, the auto-segmentation was compared to that made by the radiologist, by calculating the Dice coefficient between the volumes spanned by the contours.

Results

Using the RANSAC algorithm, center points were found inside the medulla spinalis in each CT slice for all patients. Applying the GVF snake and LSM on the CT scans of the 180 test subjects yielded mean Dice coefficients of 0.69±0.10 and 0.67 ± 0.07 respectively. A paired t-test gave t=0.06. Both methods perform the segmentation in a few seconds. Figure 2 shows a segmentation example.

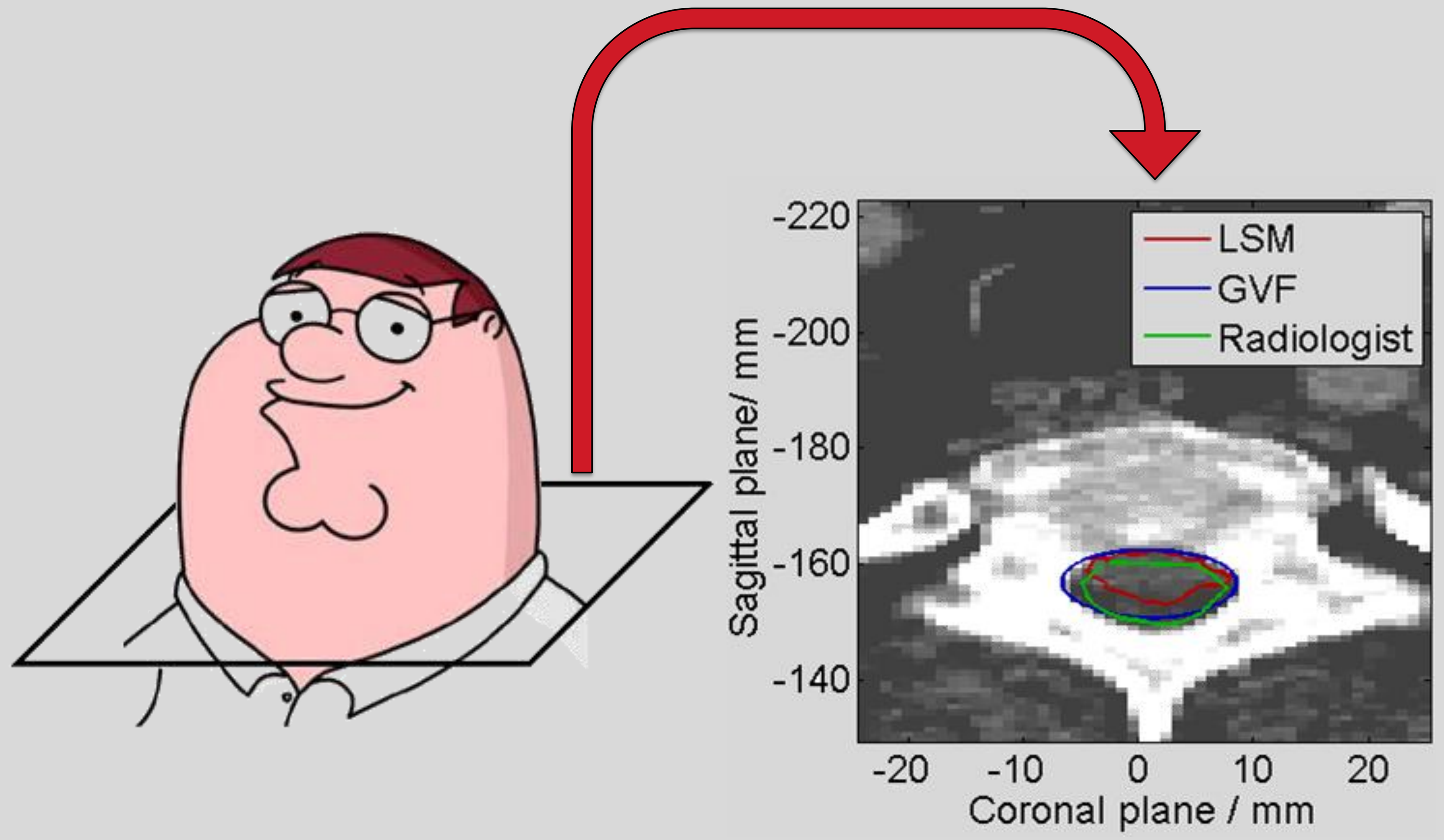

Figure 2. This figure illustrates the orientation of a CT slice in which the medulla spinalis is segmented. In this example the radiologist contouring is displayed along auto-segmentation results produced by the gradient vector field (GVF) snake and the level set method (LSM).

Conclusion

Both methods yielded equally good segmentation results based on the calculated Dice coefficients. However, the GVF snake generally produces larger segmentation volumes than the radiologist, while the LSM produces smaller volumes.

References

[1]: Fischler, M. & Bolles, R., Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography. *Communications of the ACM,* 1981, *24*, 381-395.

[2]: Xu, C. & Prince, J.L., Snakes, shapes, and gradient vector flow., *IEEE Trans Image Process,* 1998, *7*, 359-369.

[3]: Osher, S. & Sethian, J.A., Fronts propagating with curvature-dependent speed. *Journal of Computational Physics*, 1988, *79*, 12-49.