

Fully automated 3D segmentation of liver tumours moves a step further towards clinical reality

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The reliable detection of liver tumours in CT scans and their precise measurement form the basis for effective diagnosis, surgery planning and therapy control in liver cancer. Since manual measurement of 3D structures is extremely time-consuming, cost-intensive and subjective, automated methods offer promise for today's challenging clinical environment. However, due to significant variability in the appearance and shape of liver tumours, reliable automated segmentation represents a nontrivial task.

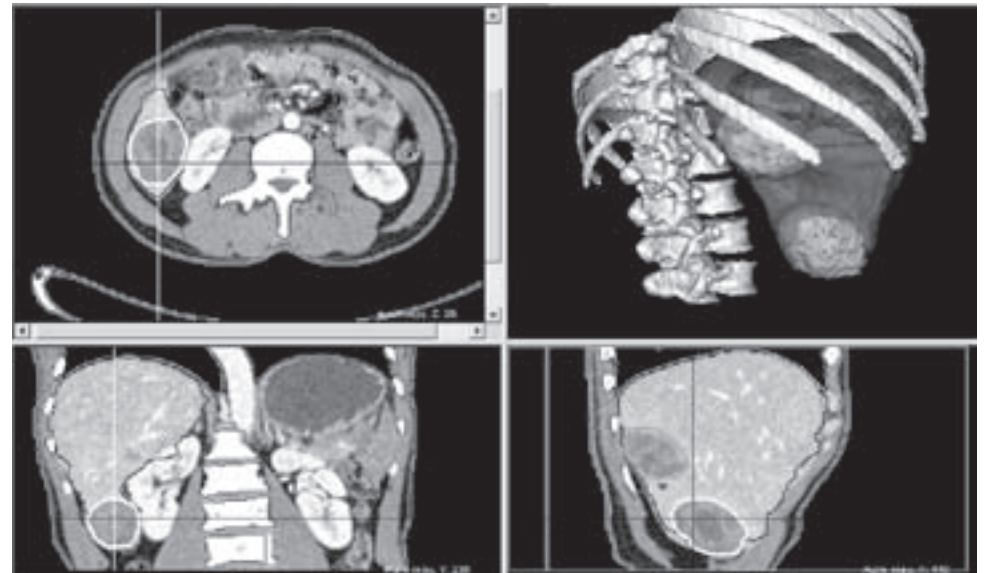
In this study, Definiens Cognition Network Technology[®] was utilised to develop an application for the fully automatic segmentation of liver tumours. The results were evaluated on a set of six CT scans containing ten tumours, using the following comparison metrics: volumetric overlap, volume difference, average surface distance, RMS and maximal surface distance.

The data set used in the analysis was provided by the organisers of the Medical Image Computing and Computer Assisted Intervention Society (MICCAI) 2008 workshop. It contained ten annotated tumours from four patients (training set) and ten tumours from six patients without annotations (test set).

The segmentation algorithm was developed in Definiens' Cognition Network Language (CNL) and contained the following two parts: In the first part, the liver is segmented: The

body is separated from the background, while within the body initial Image Objects (e.g. fat tissue, muscle layer, organs, skeleton) are refined based on their volume and intensity. From these distinguished body parts an additional layer of 3D edge information is calculated, which provides a reference for further refinement. After this pre-processing step, the left and right lungs are classified as Image Objects with maximal volume on the left and right sides of the body. Adjacent to the right lung, the gall bladder is segmented. In combination with the skeleton this provides further constraints for the liver. Finally, the liver is located below the right lung and is demarcated by the gall bladder and the skeleton (particularly the ribs). The liver is thus classified as an Image Object with maximal volume.

During the second part, the tumours are segmented: The liver is partitioned into segments with high, medium, and low intensity. Segments with high or low intensity provide the tumour candidates. The surfaces of the tumour candidates are smoothed using a 'shrink and grow' strategy and are filtered according to a volume threshold. 'Normal' liver parts (i.e. liver segments with medium intensity) that are enclosed by tumour candidates are merged with the latter. The tumour candidates are further refined through comparison to a given surface tension and volume criterion is again used to remove candidates considered too small. Further refinement is performed by growing the tumour candidates and subsequent filtering according to roundness and relative proximal borders to the liver.



Screenshot of an MPR view of segmented liver lesions.

The above algorithm was applied to both the training and test sets. The figure shows an example of the segmentation results.

Visual inspection of the segmentation results indicates that the tumour segmentation algorithm tended to identify a superset of the reference segmentations without a smooth surface. This is a consequence of our conservative approach to ensure a guaranteed enclosure for each tumour. Additional smoothing with certain restrictions may improve this method.

Furthermore, we do not yet consider the differentiation of tumours from blood vessels

to be satisfactory. Since tumours can be both brighter and darker than the surrounding liver, small parts of blood vessels proximal to tumours were misinterpreted as belonging to the tumours.

In summary, we presented an algorithm based on Definiens Cognition Network Technology[®] for the segmentation of liver tumours in 3D data using contextual information. Although the current iteration is not considered suitable for clinical use, the results indicate it represents a promising step in the development of a computer-aided diagnosis system for liver tumours.

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13:15-13:30 Clinical Experiences with ShearWave[™] Elastography
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