Section: **Segmentierung, Registrierung**

ID: 98

Abstract-Title:
AUTOMATIC SEGMENTATION OF CALVARIAL TUMORS IN COMPUTED TOMOGRAPHY IMAGES

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Abstract-Text:
Purpose:
The objective of CRANIO project for computer assisted craniotomy is precise and efficient robotic ablation of calvarial tumors accompanied with preoperative modeling and manufacturing of individual calvarial implants. Exact resection path and geometry have to be known prior to the surgery to allow preoperative implant manufacturing. Therefore, it is necessary to know precise tumor borders in order to avoid in situ residuals after the surgical procedure. Manual delineation of tumor border is a time consuming process, due to the size of calvarial tumors spreading often over tenths of slices. Automatic and semiautomatic approaches can offer better time efficiency. In this case, time efficiency does not only address execution speed of an algorithm itself but also amount of time a surgeon has to interact with the system. Automatic approaches offer more robustness and reproducibility compared with unpredictable intra and inter-operator variability inherent to manual segmentation.

Materials:
Ten patient CT datasets with diagnosed and postoperatively confirmed calvarial tumors are used in the study. Datasets have been manually segmented by various clinicians (between 2 and 5 for each dataset) at the Clinic for Neurosurgery, Ruhr-University Bochum, using commercially available imaging software (OsiriX Medical Imaging Software). For some cases, manual segmentations of the same expert, taken at different times, were available. Methods:
The segmentation method used is a fully automated knowledge-based level set algorithm. Before segmentation, a training of a priori knowledge has been performed. Each model has been trained with nine patients excluding the datasets to be segmented (leave-one-out method). Generation of the a priori model is done prior to the segmentation process, not influencing the computing time of the algorithm itself. The a priori intensity model has been trained with Expectation-Maximization algorithm as a Gaussian mixture model with three classes: cortical bone, trabecular bone, and soft tissue, Fig. 1. The model is used twofold: as an initialization of level set algorithm and as an additional term in the level set propagation. The level set surface evolution is realized through two forces guiding the movement: gradients (image specific term) and the a priori belief map (knowledge specific term).
Accuracy assessment of algorithm proposed is done by comparison with a latent gold

standard extracted from manual segmentations performed by experts, using the STAPLE algorithm. Spatial overlap index (Dice coefficient) was used as accuracy metric. Additionally, goodness analysis is performed in the ROC space (sensitivity and specificity).
Results:
Due to the uncalibrated nature (prevalence and level of test dependence) of accuracy metrics used in the medical image segmentation evaluation, it is necessary to analyze values obtained in relation to intra- and inter-expert variability. Mean spatial overlap between the experts was approximately 78%, the best overlap achieved between two experts 92%, and the worst 74%. Spatial overlap between the automatic algorithm and the latent ground truth for each patient was between 71% and 87%. Robustness of an algorithm could be analyzed in the ROC space as the variance of the algorithmic response with varying inherent parameters. An example of the response for one patient is given in Fig. 3. Algorithm executing lasts up to five minutes on a standard desktop computer. Example results are shown in Fig. 4. Discussion and Conclusion:
Results have demonstrated that the spatial overlap of the best segmentations (algorithm and inherent parameters) was in the range of inter-expert variability. Hence, the gold standard used for the validation is imperfect and it is difficult to draw a conclusion about the true accuracy of the algorithm. However, the results indicate that the algorithm could be a satisfactory substitution for the time consuming manual segmentation.

Bild 1/JPG

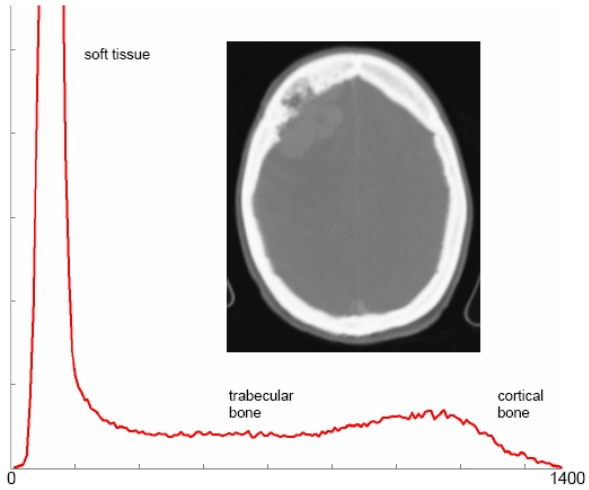
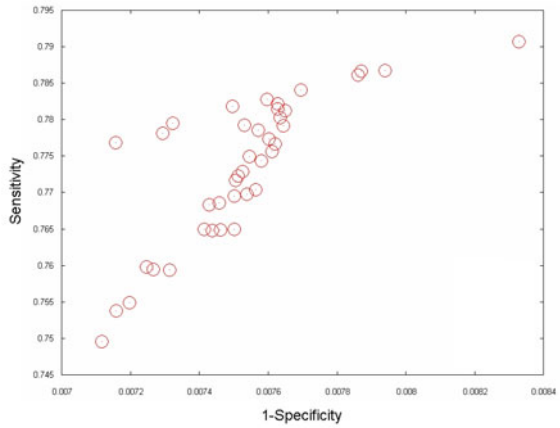


Bild 2/JPG



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