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Quantitative evaluation of tumor subregion automatic segmentation in glioblastoma for monitoring of growth patterns

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Purpose/Objective:

Glioblastoma (GB) is the most aggressive malignant primary brain tumour, with variable therapeutic response. This project focuses on the quantitative evaluation of an automatic segmentation tool for three tumour sub-regions in pre-operative patients, with the ultimate aim of providing detailed mapping of tumour growth and developing algorithms for predicting tumour recurrence sites, leading to the implementation of AI-guided dose painting.

Material/Methods:

We used a UNet-based architecture [1] to develop a segmentation model for 3 tumor zones: necrosis, edema, enhancing tumor. The model was trained and evaluated using T1, T1 contrast-enhanced, and FLAIR MR images from a multicenter cohort, which included data from three French centers as well as the BRATS multicenter dataset, with N=1194 patients for training and N= 297 (47 from our multi-institutional cohort, 250 from BRATS) biopsy patients for testing. Ground truth contours were generated by one radiation oncologist (a total of 6 radiation oncologists were involved, harmonization meetings were held to ensure consistency of practice) and validated by a senior radiation oncologist for the French multi-center dataset, and by one to four radiologists and validated by a senior neuroradiologist for the BRATS dataset [2]. We evaluated the similarity between the automatic and manual contours on the test dataset using the Dice Similarity Coefficient (DSC) and Hausdorff95 distance (HD95).

Results:

The automatic segmentation achieved average DSCs for both datasets of 0.77, 0.79, 0.85, with HD95 values of 5.4 mm, 7.3 mm, 3.7 mm for necrosis, edema, enhancing tumor respectively. Detailed metrics are shown in Table 1.

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Zone	French multi-center dataset (DSC)	BraTS (DSC)	French multi-center dataset HD95 (mm)	BraTS HD95 (mm)
Necrosis	0.75	0.79	5.4	5.4
Edema	0.74	0.84	8.8	5.7
Enhancing Tumor	0.83	0.88	3.4	3.9

Table 1: DSC and HD95 results for the autosegmentation algorithm ran on French multi-center dataset and BRATS test datasets across different tumor zones.

Conclusion:

The results demonstrate that the automatic contouring approach has a robust performance, especially in enhancing tumor regions, and supports potential integration into clinical workflows, facilitating consistent practices at the target volume delineation stage. These findings open new possibilities for disease follow-up and should offer insights into tumor progression. Further studies will focus on five-zone segmentation and post-operative cases, targeting surgical cavity and post-operative modifications to enhance precision in disease monitoring and treatment adaptation.

Keywords: glioblastoma, auto-segmentation, tumor subregions