Hierarchical Multi-task Transformer for tumor segmentation and response assessment in patients with malignant gliomas via structural and amide proton transfer-weighted MRI

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INTRODUCTION:

Amide protein transfer weighted (APTw) MRI[1-3] has been validated to accurately detect recurrent malignant gliomas across different studies. However, APTw image interpretation is time consuming and requires professional knowledge. Our goal was to develop a reliable, automated imaging diagnostic tool to assess malignant glioma response to therapies are urgently needed.

METHODS:

We proposed Hierarchical Multi-task Transformer framework to address both tumor segmentation and response assessment in patients with malignant gliomas. 3 key components of proposed framework are as follows: (1) Pixel branch to provide anchor queries to the lesion branch for initial pixel-wise segmentation. (2) Lesion branch composed of the transformer decoder in Mask2Former with improved segmentation loss to enhance recall of small enhancing tumor (ET) regions. (3) Patient branch to make dedicated scan-level predictions with a lesion-patient consistency loss. Pixel and lesion branches are designed to output the progression-aware segmentation map that further divide ET and non-enhancing tumor region (NER) into stable, improved or increasing regions. A total of 126 MRI scans (T1w, T2w, FLAIR, APTw, and contrast enhanced T1w) from 83 patients post-treated malignant gliomas were reassessed. Each scan was annotated as “response" to treatment or “progressive disease" according to the RANO criteria and pixel-wise annotated following the protocol in BraTs Challenge with ET, NER and the peritumoral edematous tissue. 5-fold cross-validation with random patient-level 80%/20% splits of imaging dataset was performed to evaluate the performance of tumor recurrence classification and volumetric and distance metrics of tumor sub-region segmentation.

RESULTS:

For the response assessment, the proposed model without APTw images as input achieved an AUC of 0.84 (sensitivity, 0.91; specificity, 0.84). By adding the APTw images to the input, the classification result improved to AUC 0.87 (sensitivity, 0.86; specificity, 0.92). For brain tumor segmentation, by adding APTw images to the input, the Dice coefficient increased the most for the enhancing tumor core region from 0.64 to 0.76, suggesting that APTw imaging can help to distinguish tumor boundary.

DISCUSSION:

The proposed unified deep-learning framework utilizing multi-parametric MRIs with both structural and APTw images showed promising results in distinguishing between tumor progression and response post-treatment and brain tumor segmentation.

CONCLUSION:

The proposed method could be a highly efficient solution for clinical experts to make precise diagnoses for patients with post-treatment malignant gliomas and further prognosis analysis.

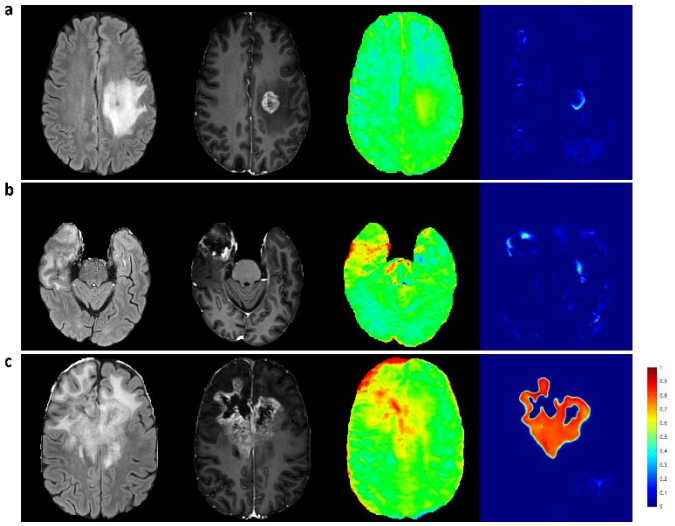

Figure 1 Columns from left to right: FLAIR, T1w-Gd, APTw images and Grad-CAM derived from our trained deep learning network. (a) (b) (c) correspond to patient annotated as “Response”, “Stable” and “Recurrent” case respectively. Grad-CAM images indicates that the enhancing tumor regions has significant attention (red regions) for tumor recurrent case than response case.

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