RecuNet: A Novel, Low-Cost, & Automated Pipeline for the Spatiotemporal Prediction of Brain Tumor Recurrence

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Gliomas affect 90,000 people annually in the United States and have 5-year survival rates as low as 7%, largely due to 5-year recurrence rates of 52-62%. Current imaging techniques rely on contrast enhancement (CE) to visualize the glioma, which has several limitations: (1) tumor infiltration often extends far beyond CE margins; (2) After surgery, non-contrast enhancing tumor grows undetected & appears as “recurrence” in follow-up scans. Blood Oxygen Level-Dependent (BOLD) fMRI measures blood flow, which can be disrupted by the tumor microenvironment. Therefore, BOLD, combined with current imaging, could detect real-time tumor progression prior to radiologic “recurrence”, defined by CE. This project, RecuNet, aims to (1) establish a link between BOLD, non-contrast enhancing tumor regions, and recurrence, and use deep learning to (2) detect the non-contrast enhancing tumor and (3) spatiotemporally predict tumor recurrence. Both algorithms take standard (T1 + FLAIR) scans and BOLD fMRI as inputs. The detection algorithm uses a 3D-UNet Architecture with optimized loss functions and Attention Gated Networks (AGNs). The Prediction Model is a CNN that uses temporal-spatial convolutional layers and AGNs to extract features in peritumoral regions. Preliminary detection results show an IoU of 94.1%, accurately detecting non-contrast enhancing tumor portions. The prediction algorithm has a 94.52% location accuracy and a mean average error of 5.3 days from recorded recurrence time, significantly outperforming current methods. RecuNet nearly eliminates recurrence risk by imaging the previously invisible tumor areas and accurately predicting areas with a high risk of developing tumor growth, saving money, resources, and lives.

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