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Tumor Invasion Margin on the Riemannian Space of Brain Fibers

Glioma is one of the most challenging types of brain tumors to treat or control locally. One of the main problems is to determine which areas of the apparently normal brain contain glioma cells. Gliomas are known to infiltrate several centimetres beyond the clinically apparent lesion that is visualized on standard CT or MRI scans. To ensure that radiation treatment encompasses the whole tumor, including the cancerous cells not revealed by MRI, doctors treat the volume of brain that extends 2 cm out from the margin of the visible tumor. This approach does not consider varying tumor-growth dynamics in different brain tissues, thus it may result in killing some healthy cells while leaving cancerous cells alive in the other areas. These cells may cause recurrence of the tumor later in time, which limits the effectiveness of the therapy.

Knowing that glioma cells preferentially spread along nerve fibers, we propose the use of a geodesic distance on the Riemannian manifold of brain diffusion tensors to replace the Euclidean distance used in the clinical practice and to correctly identify the tumor invasion margin. This mathematical model results in a first-order PDE that can be numerically solved in a stable and consistent way with.

To compute the geodesic distance, we use actual Diffusion Weighted Imaging (DWI) data from 11 patients with glioma and compare our predicted growth with follow-up MRI scans. Results show improvement in predicting the invasion margin when using the geodesic distance as opposed to the 2 cm conventional Euclidean distance.