Predictive Modeling of Brain Tumor Evolution and Anatomical Invasion: A Novel 3D Time Series Forecasting Approach for Enhanced Treatment Planning

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Each year, nearly 2 million individuals in the United States alone receive a cancer diagnosis. Traditional methods for tracking tumor growth are inaccurate and invasive as MRI scans and biopsies are expensive, can lead to implications, and fall short in predicting tumor growth. As of now, tumor growth modeling primarily relies on partial differential equation (PDE) approaches, which are not only slow but also prone to inaccuracies and power intensive. Therefore, The core goal for this project was to create and optimize a time series forecasting machine learning software that can compile 3d tumor models from 2d MRI tumor segmentations from patient dicom imaging, forecast the growth of the 3d tumor models, and predict the 3d tumor anatomical invasion sites of tumors. After experimenting with multiple iterations of the software, the LSTM neural network iteration outperformed the ARIMA and regression based iterations as it outputted the most accurate predictions, achieving an average volume overlap index(volume of the intersection between predicted and actual tumor) of 84.2%, an average Hausdorff distance(largest distance between predicted and actual tumor model) of 5.84mm, an average volume % difference of 16.76%, and predicted anatomical invasion regions with an average accuracy of 90%. This software could be used to assist medical professionals in treatment planning, radiation therapy, and surgery design, and allow doctors to make educated decisions about patients in the future, helping to personalize cancer care and save lives in the process.