**MIT School of Computing**

**Department of Computer Science and Engineering**

**Project Synopsis**

**Group ID: 7**

**Project Title: Mapping Brain Tumor Progrssion**

**Group Members:**

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| --- | --- | --- | --- | --- |
| **Enrollment Number** | **Roll No.** | **Name of student** | **Email Id** | **Contact Number** |
| MITU21BTCS0169 | 2213080 | Chaitry Pancholi | chaitrypancholi@gmail.com | 7028324740 |
| MITU21BTCS0036 | 2213133 | Aditya Kulkarni | kuladi03@gmail.com | 7447396321 |
| MITU21BTCS0710 | 2213191 | Vedashree Bhalerao | vedashreebhalerao46@gmail.com | 8149294632 |

**Problem Statement:**

"Create a machine learning solution to classify brain scans, detecting the presence of tumors and their approximate locations, using a textual dataset."

**Abstract:**

This project focuses on optimizing brain scan analysis exclusively using textual metadata. Leveraging a dataset containing crucial diagnostic features, including area, perimeter, convex area, solidity, equivalent diameter, major axis, minor axis, eccentricity, and class labels, our system employs advanced machine learning techniques to classify brain scans. By developing a robust model and utilizing data-driven insights, this project contributes to the refinement of brain tumor diagnosis and paves the way for more accurate and efficient medical image analysis in the healthcare domain.

**Literature Survey :**

In the field of neurosurgery, where precision is paramount, continuous monitoring and tracking of brain tumor resection during surgery have become essential. One promising development in this domain is presented in the paper titled "Continuous Mapping of Brain Tumor Resection Progression During Surgery" by Juvekar et al. (2022). The authors propose a real-time navigated tracking system that aims to map the progress of resection during surgery. This system has the potential to be a game-changer in improving the extent of tumor resection, thus extending the survival rates for glioma patients.

The core innovation of this system lies in its ability to provide a real-time map of the resection cavity using data from surgical instruments, including a navigation pointer, ultrasonic aspirator, suction, and bipolar forceps. These instruments are optically tracked and integrated into 3D Slicer via OpenIGTLink, enabling the generation of 3D maps of the resection cavity. Notably, the study reports impressive results, with the "difference map" between the resection map and the preoperative tumor contour correctly identifying the location of residual tumor in the majority of cases.

This approach also addresses some of the challenges posed by brain shift and resection cavity collapse during surgery. Even when false-positive overlaps occurred due to these factors, the resection map's general shape helped surgeons mentally compensate for brain shift and identify potential residual tumor regions. Furthermore, this system can be integrated with existing commercial neuronavigation tools, seamlessly fitting into the surgical workflow.

In addition to the real-time tracking system, the paper titled "Automatic MRI-Driven Model Calibration for Advanced Brain Tumor Progression Analysis" by Scheufele et al. (2020) contributes to the field by offering a fully automatic calibration methodology for mathematical tumor growth models. This methodology utilizes multiparametric Magnetic Resonance Imaging (mpMRI) scans to extract patient-specific biomarkers, including tumor cell proliferation rate, migration rate, and the tumor's original initiation site(s). By integrating a single-species reaction-diffusion partial differential equation (PDE) model for tumor progression with mpMRI scans, this approach robustly estimates these critical parameters.

One of the notable challenges addressed by this research is the calibration of tumor growth models from a single multiparametric scan, particularly relevant for preoperative Glioblastoma (GBM) scans. The proposed methodology uses a sparse reconstruction algorithm for tumor initial location (TIL), mitigating nonlinearity, ill-posedness, and ill conditioning. Results from applying this method to clinical data of 206 GBM patients are promising, with extracted biomarkers offering insights into tumor origin and patient overall survival. Moreover, preliminary results suggest that augmenting imaging features with biophysical parameters improves the accuracy of predicting patient overall survival.

Together, these papers represent significant strides in the field of brain tumor surgery and analysis. The real-time tracking system presented by Juvekar et al. addresses the need for precise monitoring during surgery, potentially minimizing unintentional residual tumors. Scheufele et al.'s automatic calibration methodology, on the other hand, offers a data-driven approach to understanding tumor growth and its impact on patient outcomes. Both papers contribute to the broader goal of improving brain tumor treatment and patient care.

**Proposed System :**

**Conclusion**

In conclusion, our project addresses the pressing need for precise and non-invasive brain tumor progression analysis. Leveraging advanced data-driven techniques, our software automatically calibrates mathematical tumor growth models using multiparametric Magnetic Resonance Imaging (mpMRI) scans. This innovative approach enables the extraction of patient-specific biomarkers with high accuracy, such as tumor cell proliferation rate, migration rate, and the tumor's original initiation site(s).

Our system seamlessly integrates into clinical workflows, empowering neurosurgeons and medical professionals with valuable insights into tumor behavior and patient outcomes. By automating this process, we not only enhance efficiency but also reduce the workload on healthcare providers, allowing them to focus on patient care and treatment decisions. In summary, our software represents a significant advancement in non-invasive brain tumor analysis, with the potential to improve patient survival predictions and contribute to more effective treatment strategies, ultimately saving lives in the battle against brain tumors.

**References:**

1. Juvekar, P., Bastos, D. C. A., Bi, W. L., Golby, A. J., & Others. (2022). Continuous Mapping of Brain Tumor Resection Progression During Surgery. Neurosurgery, 68(Supplement\_1), 64-65.

2. Scheufele, K., Subramanian, S., & Biros, G. (2020). Automatic MRI-Driven Model Calibration for Advanced Brain Tumor Progression Analysis. arXiv: Medical Physics.