Intraoperative Brain Tumor Detection Using Raman Spectroscopy Data and Machine Learning

Pippal, Nikolas (School: Gymnazium Olomouc - Hejcin)

The aim of this research is to detect tumor tissue during brain surgery using data preprocessing and machine learning. Brain tumors are the leading cause of cancer-related death in children in the United States. Gliomas, the most common type of malignant brain tumor, pose significant treatment challenges affecting patient survival rates. Radical and safe resection is the most effective treatment for brain tumor patients. This involves the complete removal of tumor tissue while preserving the healthy brain tissue. The accuracy of tumor detection is crucial for successful surgery. A novel approach for continuous perioperative monitoring of resection boundaries is the use of Raman spectroscopy. This technique evaluates the biochemical composition of tissue through spectral analysis. The spectra obtained during brain surgery are preprocessed by various methods, including the Savitzky-Golay filter, Min-max normalization, rotation, and baseline correction, to optimize results of classification via KNN, Decision Tree, or Random Forest. A new baseline calculation method was developed, which was essential for effective data preprocessing. After preprocessing, a significant difference was found between the spectra of brain and tumor tissue at the Raman shift 1460 cm^-1. The resulting program can accurately distinguish between healthy brain and tumor tissue with an accuracy of 89%, and has a tumor identification accuracy over 96%. This represents a significant improvement in the intraoperative identification of tumor tissue. In conclusion, the combination of Raman spectroscopy, data transformation, and machine learning can be an effective tool for surgeons to achieve radical and safe resection of gliomas, improving patient survival.

Awards Won:

Fourth Award of $500