Electrical & Computer Engineering

D E F E N S E

Louisiana State University

Explainable Machine Learning for the Detection of Pancreatic Ductal Adenocarcinoma (PDAC) and Classification of Mental Tasks: A Crucial Contribution to the Field of Medical Diagnostics and Neuroscience

a dissertation to be defended by

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Abstract—Identifying the reasoning behind machine learning model predictions is crucial in determining confidence if a medical expert wants to embark on a cancer cure based on a diagnosis prediction. In our work, detecting Pancreatic Ductal Adenocarcinoma from fluorescence and Raman spectrums using explainable machine learningcould open a new door for defining a standard procedure for early detection. PDAC is a type of pancreatic cancer that is one of the primary causes of cancer-related deaths, with less than 10% of the five-year survival rate. A supervised machine learning-based method for detecting PDAC using explainable spatial, statistical, impulse, and peak features obtained from the fluorescence and Raman spectrums has been explored for the first time in the literature. Empirical mode decomposition of extended coefficient features confirmed the presence of substantial indocyanine green fluorescence peaks in cancer data samples. This relevance can greatly improve the precision of chemotherapy treatments for early-stage PDAC. Meanwhile, explainable features derived from the Raman spectrum have Mutations in Kirsten rat sarcoma viral oncogene homolog (KRAS) and tumor suppressor protein 53 (TP53) were successfully identified in the fingerprint region for the first time in the literature. PDAC and normal pancreas are classified using a nonlinear support vector machine with 98.5% accuracy from the Raman spectrum, whereas, in the case of fluorescence classification, accuracy remained at 100% using alinear support vector machine. Similarly, we propose an explainable machine learning approach for classifying mental arithmetic tasks based on resting brain states, distinguishing good from bad calculations using Electroencephalography. (EEG). Mental arithmetic can assist in assessing neurodevelopmental disorders caused by atypical brain development. Additionally, the generalizability and reproducibility of EEG-based Applications leveraging cortical activity observed through EEG are significantly limited by inter-subject variability, thereby constraining the utility of EEG in daily life. We obtained explainable feature sets directly mapped on the human brain to identify brain areas and changes in brain rhythms involved in mental arithmetic tasks. We beat the state of the art and achieved 98.33% generic classification accuracy for resting vs. calculation and good vs. bad calculation states of the brain. Our method handled inter-subject variability well and achieved a significantly high classification accuracy of over 97%.

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