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Machine Learning for Real-time Detection of Complications during Neurosurgery

While surgical intervention offers the highest cure rate for neurovascular disorders, the complication rate remains high at 15%. The leading cause of complications is reduced cerebral blood flow (CBF) during the procedure, which causes brain tissue damage.1 Intraoperative CBF imaging provides vital information about vascular patency and cerebral perfusion to guide surgical decision-making that mitigates complications, however, the current intraoperative standard-of-care tool for CBF visualization, indocyanine green angiography (ICGA), cannot be performed continuously nor is it sensitive to tissue perfusion. We present on a novel imaging and computer-aided diagnosis (CAD) platform for real-time detection of complications related to cerebral blood flow during neurosurgery. Our platform is an optical imaging system augmented by machine learning algorithms. It utilizes the optical imaging technique laser speckle contrast imaging (LSCI), which produces real-time and continuous blood flow and perfusion images without injected dyes or tissue contact. We use the nnUNet framework adapted to our specific LSCI imaging modality to perform accurate, real-time segmentation of brain vessels, cortical tissue, and other structures. nnU-Net's self-configuring nature makes it ideal for surgical settings. We used intraoperative data from neurosurgery to apply nnU-Net for multiclass segmentation of LSCI during neurosurgery from n=6 patients including 109 training/validation images and 28 testing images. We achieved a mean Dice score of 0.695 and IoU of 0.570 on the test set. Class-wise Dice scores were 0.513 for blood vessels, 0.650 for cortical tissue, and 0.923 for non-vessels/non-tissue. These results indicate promising performance and we will present our plans for future optimization and initial results for applying the CAD platform for realtime detection of complications.

Keywords
nnU-Net, blood flow imaging, laser speckle contrast imaging, computer-aided diagnosis

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Biography

Dr. David Miller is an Assistant Professor of Neuroengineering at the University of Oklahoma (OU) Biomedical Engineering Department and adjunct Assistant Professor within the OU Department of Neurosurgery. Dr. Miller received his PhD in Biomedical Engineering from UT Austin, where he was an NSF Graduate Research Fellow. He completed a postdoctoral fellowship at Massachusetts General Hospital and Harvard Medical School. At OU, Dr. Miller leads the Translational Neuroimaging Lab which focuses on developing and translating novel neuroimaging and neuroengineering technology to better understand and treat brain diseases.

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