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Using Deep Neural Networks to Advance Brain Research

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Abstract

The human brain is the most complex organ in the body. Currently, there are no effective treatments for brain disease, for example, concussion, tumors, and stroke. The complexity of the brain has made it difficult for biologists to develop new treatments. So, how can electrical engineers and computer scientists help? In this talk, I will describe the application of engineering technologies, including multi-spectral imaging, image processing, and machine learning, that can allow biologists to extract comprehensive measurements of cellular alterations in brain tissue. These measurements can be used to assist drug discovery by allowing biologists to quantify cellular changes caused by brain injury, therapeutic interventions, and drug side-effects.

In my lab, we are developing a next-generation brain histology platform that is based on imaging and analyzing whole brain sections using 10 – 100 molecular markers at a time, sufficient to analyze all the major brain cell types and their functional states over extended regions. Analyzing 100-plex whole-brain-slice mosaics is challenging due to their complexity, variability, and sheer size (~terabytes). While deep neural networks offer unprecedented potential for automated image analysis, they are also accompanied by new and unfamiliar challenges. This talk will describe our progress, challenges (both met and unmet), and emerging strategies for successfully integrating signal reconstruction, deep neural network based cell detection and phenotyping, and high-dimensional data analysis approaches to generate reliable quantitative readouts of cellular alterations at multiple scales ranging from individual cells to multi-cellular units, large cellular ensembles (e.g., cortical layers), and atlas-mapped brain regions for comparative analysis.

Speaker Biography

Badri Roysam, Fellow IEEE, Fellow AIMBE, is the Hugh Roy and Lillie Cranz Cullen University Professor, and Chairman of the Electrical and Computer Engineering Department at the University of Houston. From 1989 to 2010, he was a Professor at Rensselaer Polytechnic Institute in Troy, New York, USA, where he directed the Rensselaer unit of the NSF Engineering Research (ERC) Center for Subsurface

Sensing and Imaging Systems (CenSSIS ERC), and co-directed the Rensselaer Center for Open Source Software (RCOS). He received the Doctor of Science degree from Washington University, St. Louis, USA, in 1989. Earlier, he received his Bachelor's degree from the Indian Institute of Technology, Madras, India in 1984.

Badri's research is on the applications of multi-dimensional image processing, machine learning, artificial intelligence, bioinformatics, and high-performance computing to problems in fundamental and clinical biomedicine. He collaborates with biologists, physicians, and imaging researchers. His work is informed by diverse applications including cell-based cancer immunotherapy, drug discovery for traumatic brain injury, retinal diseases, neural implants, learning and memory impairments, binge alcohol, tumor cell phenotyping, stem-cell biology, stroke research, and neurodegenerative diseases.