

CRUNCH Seminars at Brown, Division of Applied Mathematics

Friday – August 30, 2019

Deep Cytometry: Deep learning with Real-time Inference in Cell Sorting and Flow Cytometry

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Deep learning has achieved spectacular performance in image and speech recognition and synthesis. It outperforms other machine learning algorithms in problems where large amounts of data are available. In the area of measurement technology, instruments based on the photonic time stretch have established record real-time measurement throughput in spectroscopy, optical coherence tomography, and imaging flow cytometry. These extreme-throughput instruments generate approximately 1 Tbit/s of continuous measurement data and have led to the discovery of rare phenomena in nonlinear and complex systems as well as new types of biomedical instruments. Owing to the abundance of data they generate, time-stretch instruments are a natural fit to deep learning classification. Previously we had shown that high-throughput label-free cell classification with high accuracy can be achieved through a combination of time-stretch microscopy, image processing and feature extraction, followed by deep learning for finding cancer cells in the blood. Such a technology holds promise for early detection of primary cancer or metastasis. Here we describe a new deep learning pipeline, which entirely avoids the slow and computationally costly signal processing and feature extraction steps by a convolutional neural network that directly operates on the measured signals. The improvement in computational efficiency enables low-latency inference and makes this pipeline suitable for cell sorting via deep learning. Our neural network takes less than a few milliseconds to classify the cells, fast enough to provide a decision to a cell sorter for real-time separation of individual target cells. We demonstrate the applicability of our new method in the classification of OT-II white blood cells and SW-480 epithelial cancer cells with more than 95% accuracy in a label-free fashion.