The Hong Kong University of Science and Technology

Department of Mathematics

PhD THESIS EXAMINATION

Bringing Task-Oriented Physical Laws to Deep Learning in Signal and Image Processing

By

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ABSTRACT

Deep neural networks (DNNs) have shown their power in various fields. For many tasks in image and signal processing, DNNs incorporated with task-oriented physical laws will provide more robust tools than using the general framework of DNNs.

In the first part, we develop an elastic interaction-based loss function for medical image segmentation. Our proposed loss for DNN considers the elastic interaction between the prediction and ground truth. Our method considerably improves segmentation accuracy compared to commonly used pixel-wise loss functions on retinal vessel segmentation datasets. Secondly, we present a global context latent variable model to capture the long-term dependency inside images for lossless image compression. The global context is constructed by a differentiable unsupervised clustering module. Our global context model significantly improves the compression ratio compared to the engineered codecs on three high-resolution image datasets.

Finally, we develop an operator-splitting-based neural network to solve evolutionary partial differential equations (PDEs). Such non-black-box network design is constructed from the physical rules and operators governing the underlying dynamics contains learnable parameters and is thus more flexible than the standard operator splitting scheme. To validate the particular structure inside DOSnet, we take the linear PDEs as the benchmark and explain the weight behavior theoretically. We also apply DOSnet to the Allen-Cahn equation and the nonlinear Schrödinger equation (NLSE) in signal nonlinear compensation for modern optical communications.

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Time : **3:00 p.m.**

Venue : **Room 4504 (Lifts 25/26)**

Zoom ID : **962 2818 6870 (passcode: 044948)** *~ EE opted via online mode.*
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The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).