

## CENTRE FOR SYSTEMS INFORMATICS ENGINEERING SEMINAR

### Rubik's Cube Operator: A Plug And Play Permutation Module for Better Arranging High Dimensional Industrial Data in Deep Convolutional Processes

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#### Abstract

The convolutional neural network (CNN) has been widely applied to process the industrial data based tensor input, which integrates data records of distributed industrial systems from the spatial, temporal, and system dynamics aspects. However, unlike images, information in the industrial data based tensor is not necessarily spatially ordered. Thus, directly applying CNN is ineffective. To tackle such issue, we propose a plug and play module, the Rubik's Cube Operator (RCO), to adaptively permute the data organization of the industrial data based tensor to an optimal/suboptimal order of attributes before being processed by CNNs, which can be updated with subsequent CNNs together via the gradient-based optimizer. The proposed RCO maintains  $K$  binary and right stochastic permutation matrices to permute attributes of  $K$  axes of the industrial data based tensor input. A novel learning process is proposed to enable learning permutation matrices from data, where the Gumbel-Softmax is employed to reparameterize elements of permutation matrices, and the soft regularization loss is proposed and added to the task-specific loss to ensure the feature diversity of the permuted data. We verify the effectiveness of the proposed RCO via considering two representative learning tasks processing industrial data via CNNs, the wind power prediction (WPP) and the wind speed prediction (WSP) from the renewable energy domain. Computational experiments are conducted based on four datasets collected from different wind farms and the results demonstrate that the proposed RCO can improve the performance of CNN based networks significantly.

#### Biography

Dr. Zijun Zhang received his B.Eng. degree in Systems Engineering and Engineering Management from the Chinese University of Hong Kong, Hong Kong, in 2008, and the M.S. and Ph.D. degrees in Industrial Engineering from the University of Iowa, Iowa City, USA, in 2009 and 2012, respectively. He is currently an Associate Professor in the School of Data Science and Associate Director of Centre for Systems Informatics Engineering at City University of Hong Kong, Hong Kong, China. His research focuses on machine learning and computational intelligence methods as well as their applications in renewable energy, facility energy management, transportation systems, and manufacturing processes. He is a senior member of IEEE. He is currently serving as an Associate Editor for IEEE Transactions on Sustainable Energy, IEEE Power Engineering Letters, and Journal of Intelligent Manufacturing, as well as the advisory board member of Patterns: Cell Press.