Convolutional Neural Network Based on Random Kernels for Analyzing Visual Imagery

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Abstract : The machine learning techniques based on a convolutional neural network (CNN) have been actively developed and successfully applied to a variety of image analysis tasks including reconstruction, noise reduction, resolution enhancement, segmentation, motion estimation, object recognition. The classical visual information processing that ranges from low level tasks to high level ones has been widely developed in the deep learning framework. It is generally considered as a challenging problem to derive visual interpretation from high dimensional imagery data. A CNN is a class of feed-forward artificial neural network that usually consists of deep layers the connections of which are established by a series of non-linear operations. The CNN architecture is known to be shift invariant due to its shared weights and translation invariance characteristics. However, it is often computationally intractable to optimize the network in particular with a large number of convolution layers due to a large number of unknowns to be optimized with respect to the training set that is generally required to be large enough to effectively generalize the model under consideration. It is also necessary to limit the size of convolution kernels due to the computational expense despite of the recent development of effective parallel processing machinery, which leads to the use of the constantly small size of the convolution kernels throughout the deep CNN architecture. However, it is often desired to consider different scales in the analysis of visual features at different layers in the network. Thus, we propose a CNN model where different sizes of the convolution kernels are applied at each layer based on the random projection. We apply random filters with varying sizes and associate the filter responses with scalar weights that correspond to the standard deviation of the random filters. We are allowed to use large number of random filters with the cost of one scalar unknown for each filter. The computational cost in the back-propagation procedure does not increase with the larger size of the filters even though the additional computational cost is required in the computation of convolution in the feed-forward procedure. The use of random kernels with varying sizes allows to effectively analyze image features at multiple scales leading to a better generalization. The robustness and effectiveness of the proposed CNN based on random kernels are demonstrated by numerical experiments where the quantitative comparison of the well-known CNN architectures and our models that simply replace the convolution kernels with the random filters is performed. The experimental results indicate that our model achieves better performance with less number of unknown weights. The proposed algorithm has a high potential in the application of a variety of visual tasks based on the CNN framework. Acknowledgement—This work was supported by the MISP (Ministry of Science and ICT), Korea, under the National Program for Excellence in SW (20170001000011001) supervised by IITP, and NRF-2014R1A2A1A11051941, NRF2017R1A2B4006023.

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