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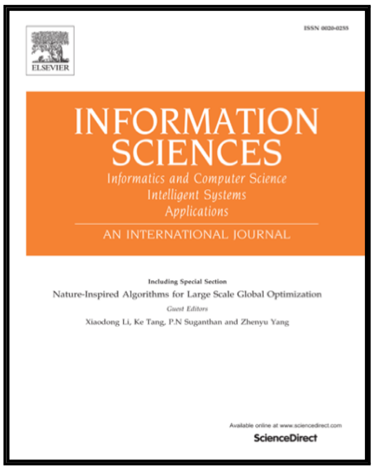

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Convolutional networks with cross-layer neurons for image recognition †

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Abstract

Very deep convolutional networks have recently achieved a series of breakthroughs on several challenging tasks such as the ImageNet or COCO competitions. However, it is difficult to train such deep neural networks. In this paper, we present a novel structure called cross-layer neurons architecture, which has the capability to train effective deeper neural networks. It utilizes cross-layer neurons to synthesize the information (features) learned from all the lower-level layers and send them to the higher-level layers through the cross-layer. Based on this novel architecture, we propose a new deep neural model termed Cross-Layer Neurons Networks (CLNN). It is shown that CLNN can relieve the problem of vanishing gradient. It is also shown that CLNN has the capability of improving the convergence rate of classification. Comparative experiments on several benchmark datasets (MNIST, CIFAR-10, CIFAR-100, SVHN and STL-10) clearly demonstrate that our proposed model is suitable for training deeper networks and can effectively improve the performance by utilizing cross-layer neurons.

Keywords: Deep learning, convolutional networks, cross-layer, cross-layer neurons, deep architecture

1. Introduction

Deep learning [2, 17, 18] is a hierarchical representation approach, which can learn high-level representation from low-level features. During the past years, it has developed into a significant research topic in the field of image representation [23, 24]. The developments have witnessed a great deal of successful applications, such as computer vision [23, 48], speech recognition [7], natural language processing [6] and health care classification prediction [1, 45].

Traditional deep neural models such as Multilayer Perceptron (MLP) [13], Auto-Encoders (AE) [3] and Restricted Boltzmann Machine (RBM) [17] neglect the spatial structure information of the data. When they process the data, they consider it together as a vector, wasting a lot of spatial information. Convolutional Networks (ConvNets) [23], introduced by LeCun et al. [25], are a class of deep neural models. For image classification, ConvNets utilize not only the pixels of an image, but also their correlations of spatial structure. It has been shown that ConvNets can get excellent performances on the tasks of image classification when the training regularization [21, 38] is appropriate. Recently, deeper ConvNets [12, 14, 19, 35, 36, 43] achieve the best performances on the tasks of several challenges, including object detection on ImageNet [34], object segmentation and localization on COCO [29]. Such great achievements may come from a lot of labeled training samples, efficient implementations with GPU or distributed cluster systems, and more appropriate regularization like Dropout [38], DropConnect [46] and Batch Normalization (BN) [21]. Recent works have shown that ConvNets with more layers can get better performance than shallow ones [15, 37]. However,

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