*Convolutional Neural Network (CNN) for Image Classification*

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*Abstract*—This electronic document is a research study on Convolutional Neural Network. This network technique will be used to solve image classification problem. Results will be presented in this document and conclusion will be made based upon experiment results.

Keywords—CNN, Image Classification, Tuning (key words)

# Introduction & background

Science and technology are developing in the fast pace. Especially equipped with advanced computing hardware, algorithm and theoretical foundation, technology starts to lead in people’s daily life and transforms the way it is. One of the common applications is using convolutional neural network to classify images or objects based upon their features.

The team’s research topic is to implement a classical deep learning algorithm, convolutional neutral network (CNN), to realize image classification and further increase accuracy by tuning parameters in the neutral network. Since 1943 when Warren McCulloch, a neurophysiologist, and a young mathematician, Walter Pitts, wrote a paper on how neutron might work, artificial neutral network has been studied. There are thousands of types of specific neural networks proposed by researchers as modifications or tweaks to existing model and even more are still emerging. These models can be categorized into three classes in general, Multilayer Perceptron (MLP), Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN). Each class has its own design purpose and focus. CNN’s ability to develop an internal representation of a two-dimensional image makes it the preferred network for image classification.

The convolutional neural network (CNN) was first proposed in 1960s. Hubel and Wiesel proposed the concept of “receptive field” which observed that neurons were sensitive to moving edge on visual cortex cells of cats. Later in the 1980s, based on concept of “receptive field”, Fukushima and Miyake proposed “neocognitron” which is regarded as the first implementations of CNNs. However, due to lack of proper learning algorithm, CNN was not the main focus in the network. After that, researchers started to use multilayer perceptron to learn features and incorporated backpropagation (BP) algorithm. However, since traditional BP neutral network would have series of problems requiring detailed study, the research on deep neutral network model was stopped. Until Hinton et al found that the artificial neural network with multiple hidden layers addresses those old issues and has great performance in feature learning, deep learning starts to re-gain attention and more and more sophisticated and accurate models were developed and used in daily practice, especially in the fields of OCR, autonomous drive, image recognition and analysis, social media, etc.

In the research, the team will build up a convolutional neutral network from the scratch. Stages include preprocessing images, convolutional layer, activation layer, pooling layer, fully connected layer and forward and backward propagation. Meanwhile, effects brought by parameters, like convolutional matrix, weights, will be studied and compared in terms of network efficiency, accuracy and generality.

# Technique & algorithm

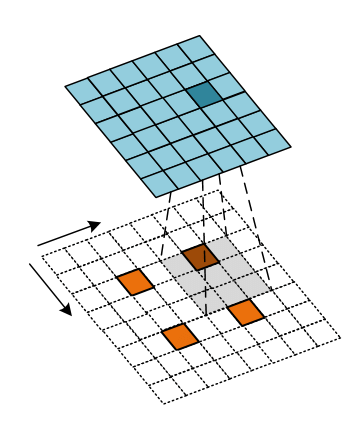
## Convolutional Neutral Network (CNN)

Compared to other image classification algorithms, CNNs do not require extra work on preprocessing images and this means that they can learn the filters that have to be hand-made in other algorithms. Also, CNNs have advantage in dimensional reduction without losing learning features. This could tremendously save computing time. layers including convolution, pooling, activation and fully connection constitute the network and the sequence of each operation could be shuffled according to the need.

## Convolutional Layer

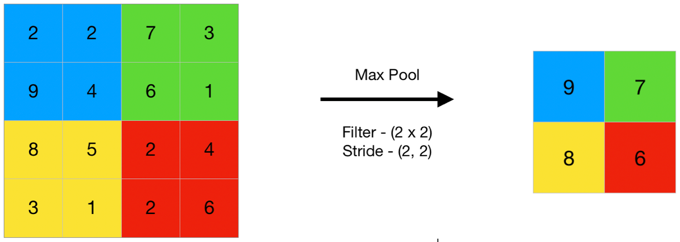
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First layer of CNN normally starts with a convolutional layer. A convolutional layer contains a set of filters whose parameters including height, weight, number of filters are determined through inputs. In general, the height and weight of the filters are smaller than those of the input volume (in research, input is a 2D matrix image with 1 channel, gray image). Each filter is convolved with the input volume to compute an activation map. In specific, the filter is slid across the width and height of input with appointed stride and the dot products between the input matrix and filter are computed at every spatial position. After number of filter’s iterations, the output of convolutional layer is obtained by stacking the activation maps of all filters along the depth dimension. For example, in the research, given the situation that input volume is a uniform a\*a matrix, convolutional filter is chosen to be b\*b matrix and each stride is assigned as c, the final output’s shape after convolutional layer will be (a + c – b) \* (a + c – b).

[](https://www.researchgate.net/figure/Convolution-process-of-transposed-convolution-layer_fig4_340020703)

## Pooling Layer

The purpose of pooling layer in the network is to progressively reduce the spatial size of representation to reduce the number of parameters and computation in the network. Normally, pooling layer will exist in-between convolutional layers and it takes a series input parameter including input volume, number of filters, height, width, stride and padding. Two main techniques in pooling are popular and widely used, average pooling and maximum pooling. In the research, maximum pooling is implemented for down sampling input volume. Maxpooling ensures a lower resolution version of an input signal is created and still contains large portion of key features, without fine detail that might not be as useful to the task.

[](https://www.geeksforgeeks.org/cnn-introduction-to-pooling-layer/)

## Activation Layer

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## Fully Connected Layer

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*a**b* 

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1. G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*
2. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
3. I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
4. K. Elissa, “Title of paper if known,” unpublished.
5. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
6. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
7. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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