Machine Learning Project

Course Code: CS5439

Course Instructor: Dr. Akshay Deepak Sir

Group No. – 25

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Acknowledgement

We would like to express our deepest gratitude to **Dr. Akshay Deepak Sir** who provided us the golden opportunity to undertake this project as a part of academic learning. We are also very grateful to both the course coordinators **Mr. Ashish Ranjan** and **Md. Shah Fahad** who helped us in the selection of the research journal.

This project provided us ample opportunities to learn and understand different aspects related to artificial neural networks. We all learnt about a completely new artificial neural network called **Self Organizing Maps**.

"No one who achieves success does so without acknowledging the help of others." Thus, we thank everyone once again for the successful completion of this project and the learning that we got while making this project.

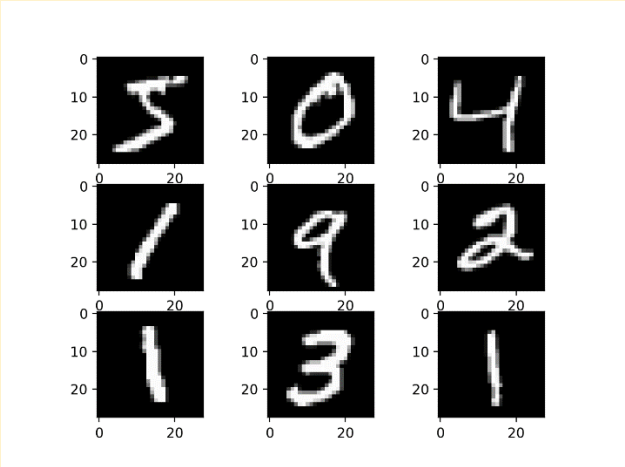
- Navjot Singh
- Vishal Raj
- Saksham Srivastava

Details of the Research Paper

- **Title of the Research Paper:** *Deep Convolutional Self-Organizing Map Network for Robust Handwritten Digit Recognition*
- **Authors:** *SALEH ALY (Associate Member, IEEE) and SULTAN ALMOTAIRI*
- **University:** This research work was supported by *the Deanship of Scientific Research at Majmaah University under Grant RGP-2019-24*
- **Date of Publication:** This research paper was *accepted on June 5, 2020* and *published on June 8, 2020*
- **IEEE ACCESS:** 2020.3000829
- **Electronic ISSN of Research Paper:** 2169-3536
- The research paper proposes a Deep Convolutional Self Organizing Maps (DCSOM) network comprising of a cascade of Self Organizing Map layers to classify handwritten digits efficiently.
- **Click to view paper:** **Research_Paper.pdf**

Description of Dataset

- MNIST Database is used in the research paper
- MNIST stands for Modified National Institute of Standards and Technology
- MNIST Database is a subset of a larger set available from NIST



- In our implementation, we have imported the dataset from keras.datasets
- MNIST Dataset contains *small square 28×28 pixel grayscale images of handwritten single digits between 0 and 9*
- MNIST Dataset also contains label for each image
- Number of Training samples used = 60,000
- Number of Testing samples used = 10,000

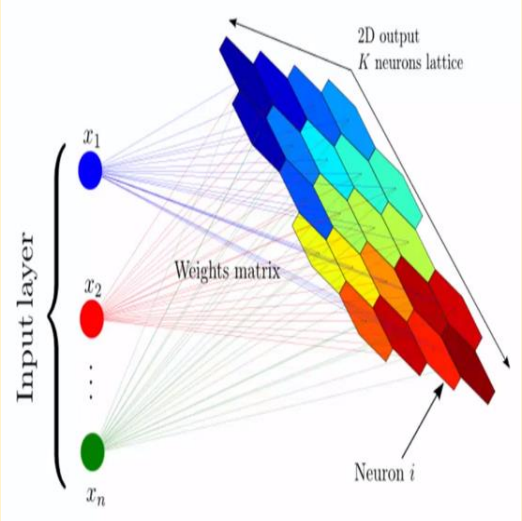
Brief Introduction to Self Organizing Maps

Self Organizing Maps or Kohenen's map is a type of artificial neural networks introduced by Teuvo Kohonen in the 1980s.

SOM is trained using unsupervised learning, it is a little bit different from other artificial neural networks, SOM doesn't learn by backpropagation with Stochastic Gradient Descent, it uses competitive learning to adjust weights in neurons.

This type of artificial neural networks in dimension reduction to reduce our data by creating a spatially organized representation, also it helps us to discover the correlation between data.

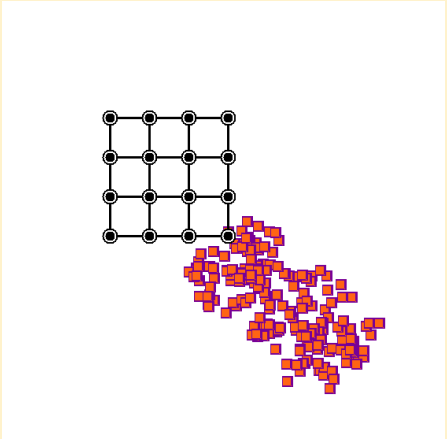
Each neuron is assigned a weight vector with same dimensions as input space. Here, weights are totally different from weights in neural networks. Weights correspond to the coordinates of neuron.



Self Organizing Maps have two layers, the first one is the input layer and the second one is the output layer or the feature map.

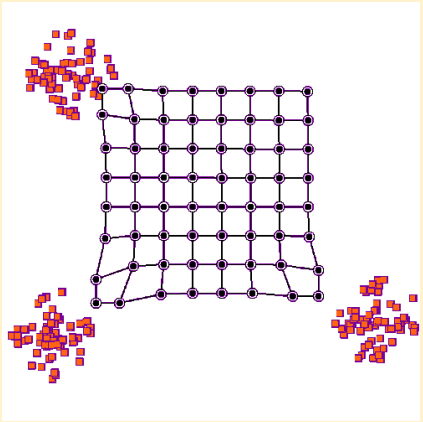
Training of Self Organizing Maps

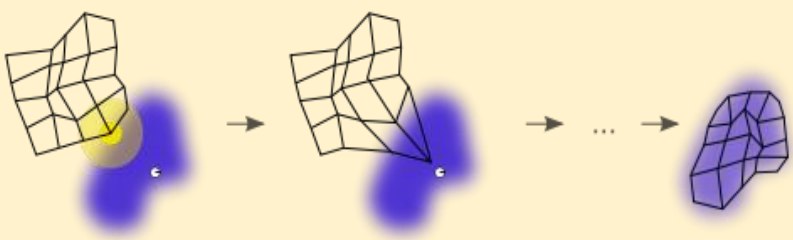
Self Organizing Maps use competitive learning adjust weights in neurons. Competitive learning is based on three processes:



1. **Competition:** Distance between each neuron (neuron from the output layer) and the input data is calculated, and the neuron with the lowest distance is the winner of the competition called as Best Matching Unit(BMU).
2. **Cooperation:** Neighbors of BMU are chosen using neighborhood kernel function which depends on two factors: time (time increments with each new input data) and distance between the winner neuron and the other neuron (i.e., How far is the neuron from the winner neuron).
3. **Adaptation:** Weight updates are calculated for winner and its neighbors and applied to them. Depending on the distance weight updates change.

After the training is over, neurons in SOM network becomes spatially organized in order to represent the dataset on which it has been trained.

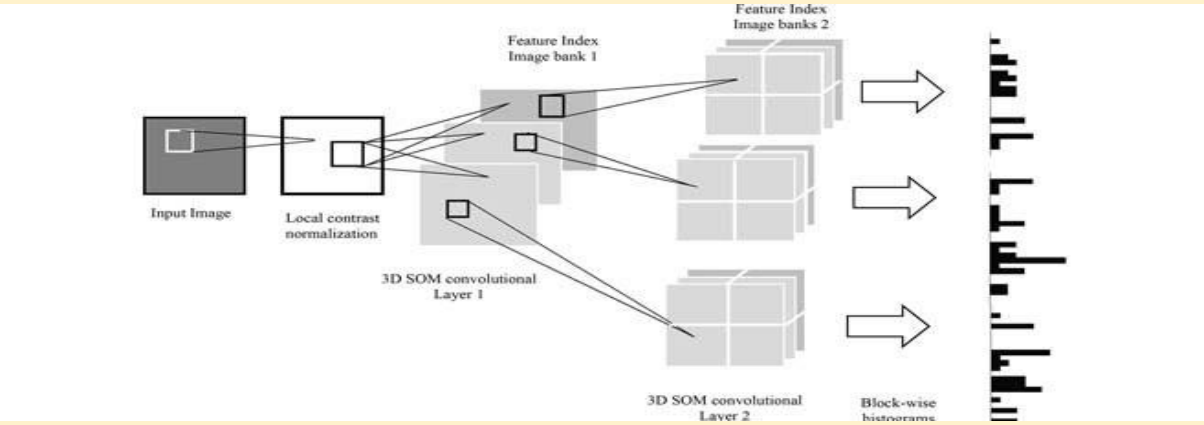




Differences in the model proposed in the Research Paper and Model implemented by us:

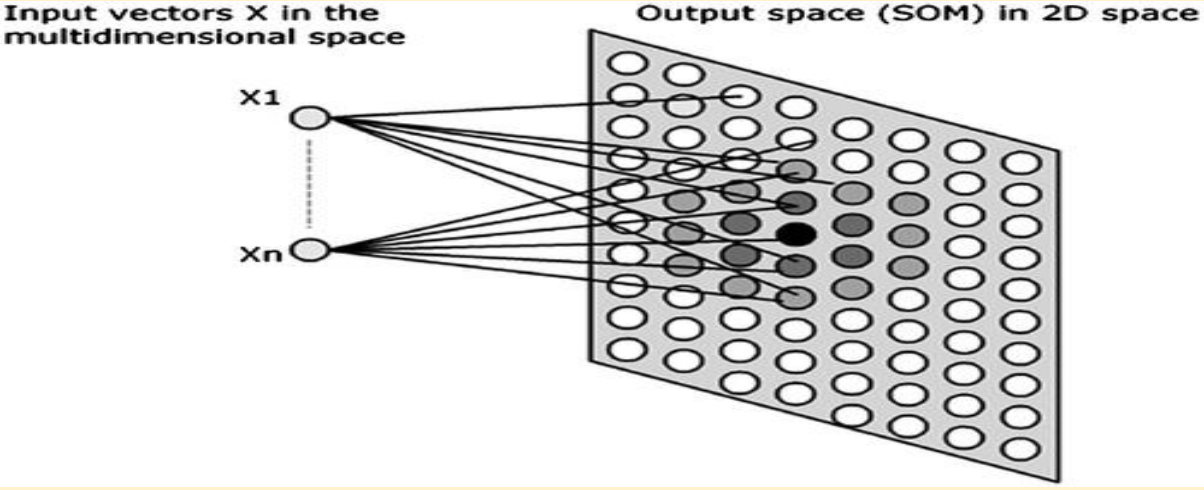
➢ Model Proposed in the Research Paper:

- Deep Convolutional Self Organizing Map Network has been proposed in the paper
- Consists of cascaded 4-D SOM Layers
- Multi-layer feed forward network



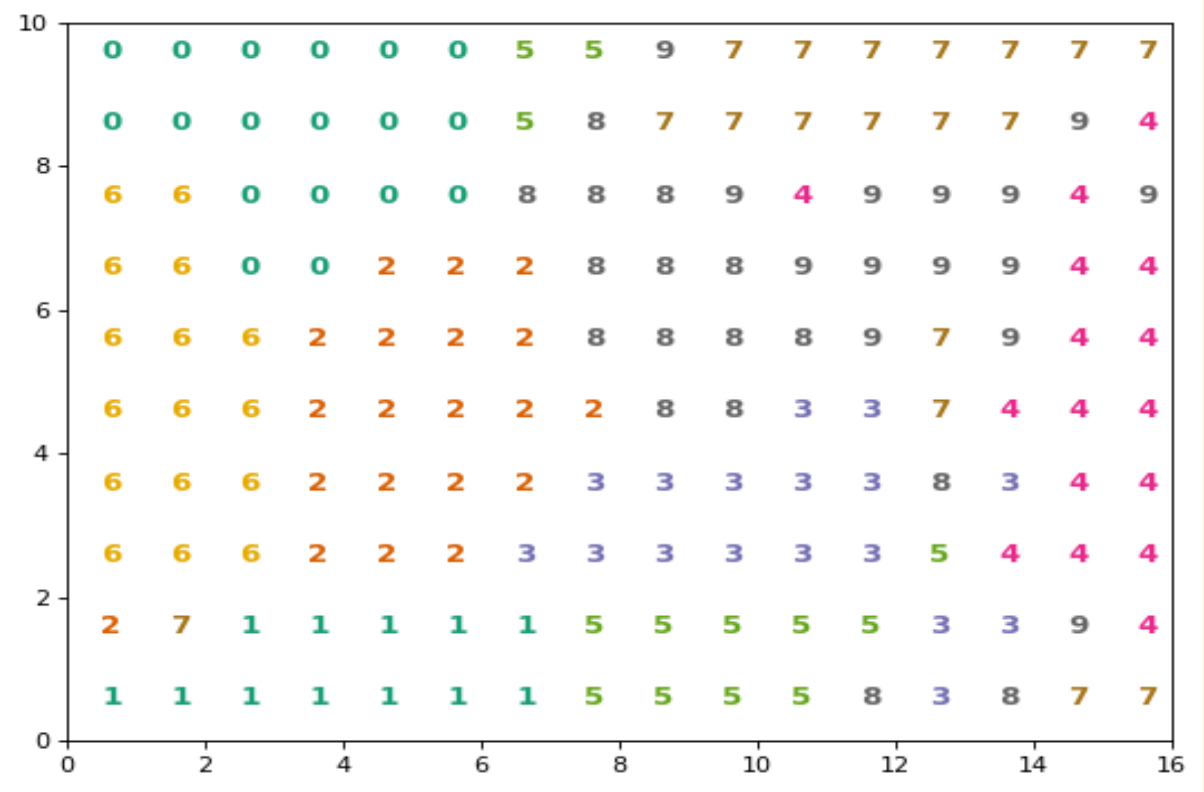
➢ Model Implemented by us:

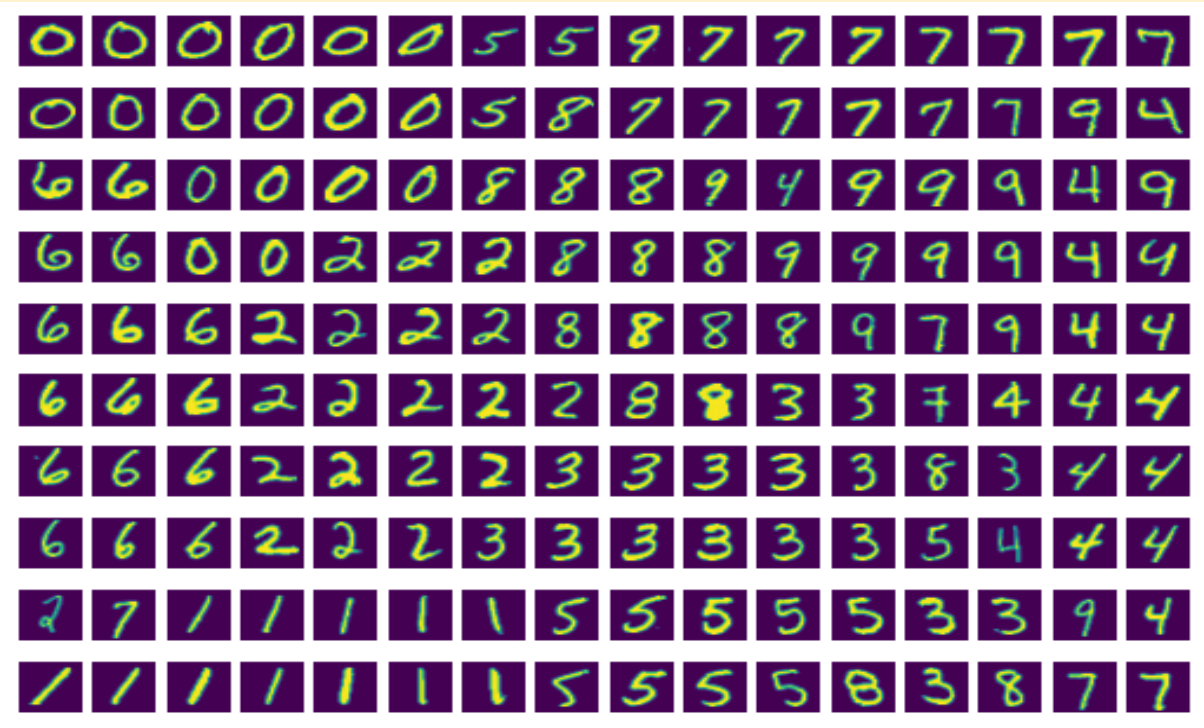
- Consists of one input layer and one output Self Organizing Map Layer
- Consists of 2-D SOM Layer
- Single-layer feed forward network



Some Images of Trained SOM from our code

- Different clusters of digits can be seen in the images
- Images show ear-marked neurons after training





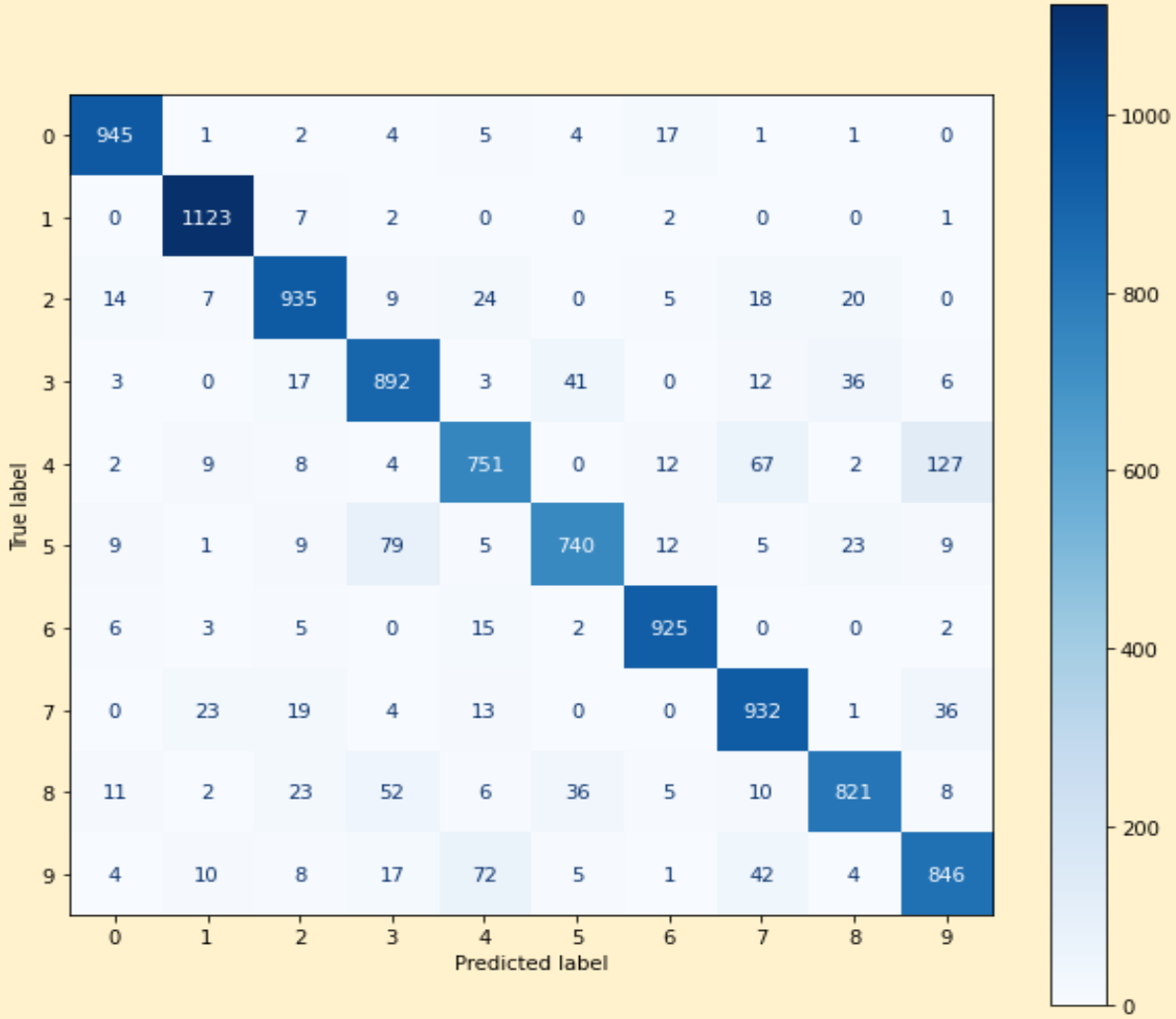
Results mentioned in the Research Paper and Results obtained by us:

- Error Rate for Deep Convolutional Self Organizing Map network mentioned in the paper = 0.57 %
- Accuracy for Deep Convolutional Self Organizing Map network mentioned in the paper = 99.43 %
- Error Rate for 2-D Self Organizing Map Network implemented by us in project = 10.89 %
- Accuracy for 2-D Self Organizing Map Network implemented by us in project = 89.11 %
- Error Rate for Convolutional Neural Network implemented by us in project = 1.20 %
- Accuracy for Convolutional Neural Network implemented by us in project = 98.80 %

- Research Paper states “Experimental results reveal that the performance of Self Organizing Map Network outperforms state-of-the-art methods for classification of handwritten digits and achieve a comparable performance with other complex deep learning architecture for other image variations”.
- Deep Convolutional Neural Networks require huge labeled dataset and high computational resources
- On the other hand, Self Organizing Map Networks are efficient from both the above-mentioned aspects

Results obtained by the implemented models:

- Confusion matrix generated for the test results obtained from the Self Organizing Map Network reveals that the model is mostly confused in the recognition of the digits 4 and 9 which reduces its accuracy
- Number of digits correctly classified by our implemented SOM network = Sum of diagonal elements in confusion matrix = 8,910 out of total 10,000 images used for testing



- Confusion matrix generated for the test results obtained from Convolutional Neural Network has most of the digits classified correctly
- Number of digits correctly classified by our implemented CNN network = Sum of diagonal elements in confusion matrix = 9,880 out of total 10,000 images used for testing