



Project 5

(Due date: 03/13/2022)

The objective of this project is to use the perceptron learning method and design an artificial neural network (ANN) to train a system for the recognition of handwritten digits (0, 1, ..., 9). Use the three-layer feed-forward network architecture (input layer, hidden layer, and output layer) with the *multilayer perceptron learning* method and the *error back-propagation algorithm* for the recognition of handwritten digits (0, 1, ..., 9).

Design a fully connected network structure of input layer (784 input nodes), hidden layer (number of hidden nodes as specified below), and output layer (10 output nodes).

The input to your multilayer network architecture will be a set of pixels representing a 28×28 image of handwritten digits. The output should indicate which of the digits (0, ..., 9) is in the input image.

Use the MNIST database of handwritten digits available on *Blackboard-Homepage-Handwritten Digits Dataset*.

Select a subset of the MNIST database consisting around 10000 images of handwritten digits (0, ..., 9) for training the system, and use another 1000 images for testing the system. Use the same set that was used for the previous project (project 4) for training and testing your network.

Plot a learning curve that illustrates the mean square error versus iterations.

(One iteration: apply all the training inputs once to the network and compute the mean square error).

Plot the percentage error in testing your handwritten digit recognition system as a bar chart.

(Mean error occurred while testing each digit with the test data).

- **Task #1:** Repeat this experiment for different learning rate parameters (*at least 3 experiments. Start with a large value and gradually decrease to a small value*).
- **Task #2:** Repeat Task #1 for different number of hidden nodes (10, 50, 100, 300, 500).
- **Task #3:** Compare your results with the SVM and SLP results (what you have got from projects 3 and 4).

Notes:

- The project should be implemented in Python.
- Only one single (zipped) file should be submitted through Blackboard for evaluation, which contains:
 - ✓ The project report as PDF file that includes the methodology, equations used, implementation results and discussion, conclusion, appropriate technical references, etc.
 - ✓ The program codes (source files) along with the dataset used.
- **Late submissions will not be accepted.**