

### Group 16 Assignment 6 Submission: Sample classification of digits

- a. The accuracy of the trained convolutional neural network is 14.64%. The process took 1min and 11sec to complete its maximum iterations of 116.
- b. The meaning of the used training options (network parameters) are:
  - i. **'sgdm'** means Stochastic Gradient Descent with Moment and it helps accelerate the gradient vectors in the right directions, leading to faster converging.
  - ii. **'initialLearnRate'**, is the initial learning rate. It is the step size used for updating the network during training. As per code, the learning rate specified is 0.001. The learning rate determines how quickly or slowly a network updates its weights.
  - iii. **'MaxEpochs'** is used to define how many times the entire training dataset is passed forward and backward through the neural network. Here, the network is trained for 2 epochs. More epochs can lead to better performance but can also risk overfitting.
  - iv. **'shuffle'**, 'every-epoch' is used to specify that the training data should be shuffled at the beginning of every epoch. Shuffling the data helps ensure that the training process does not become biased by the order of data.
  - v. **'ValidationData'** and **'imdsValidation'** is used to specify the validation dataset used to evaluate the network performance during training. The network will use **'imdsValidation'** for validation.
  - vi. **'ValidationFrequency'** is used to specify how often the network's performance on the validation data is computed. Here, validation accuracy is calculated every 30 iterations.
  - vii. **'verbose'** is used to control the level of detail printed in the command line window during training. When set to 'false', it suppresses detailed output about the training process. This can make output cleaner, especially for larger networks and longer training time.

- viii. **'plots'**, 'training-progress' is used to enable the visualization of training progress plots.
- c. The network consists of 7 layers in total which are image input layer, convolutional layer, ReLU layer, Max Pooling Layer, fully connected Layer, SoftMax Layer, Classification Layer. The ReLU layer introduces non-linearity into the network and helps in preventing the vanishing gradient problem, while the SoftMax layer converts the network's output into a probability distribution enabling classification.
- d. Improving the accuracy of the CNN Model without changing the number of variables or layers can be achieved by the following:
  - i. Increasing the numbers of filters in the convolutional layer as these will help the network learn more features from the data and better performance.
  - ii. Data Augmentation by applying random rotations, translation and reflections to training images. It helps increase the amount of training image for better performance.
  - iii. Decreasing the learning rate schedule will help reduce quick convergence and produce more accurate results.
  - iv. Adding batch normalization can help stabilize and accelerate the training process.
- e. Images can be found in the **'Mytest'** Folder. A new MATLAB file called **'ExerciseSix'** is used to train this deep learning network using test images.
- f. The Numbers of Layers is being increased up to fourth block which Convolution2dLayer, ReLU Layer and maxPooling2Dlayer embedded in each block before flattening and softmaxlayer.
- g. Yes, I was able to increase the accuracy of CNN to 87%. The sign of overfitting is shown by an increase in accuracy of the training datasets as the model memorizes the training datasets. But this does not imply accuracy in test dataset input.