Neural Networks Course Project

CSEN 1121: Computational Intelligence and Neural Networks

Creating a Neural Network Architecture Project Report

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1 City Chosen Information

Farafra is one of the five oases located in the Western Desert of Egypt. Here are some interesting details about Farafra City:

1. `Location:` Farafra is situated in Al-Wadi Al-Gadid (The New Valley Governorate), the largest governorate in Egypt in terms of space. It is 170 kilometers from the Bahaerya Oasis, 627 kilometers from Cairo, and 370 kilometers to the southwest of Marsa Matruh and the Mediterranean Sea. As a result of the distance between major cities, Farafra is known for its tranquility, making it a peaceful destination for those seeking solitude and a break from the hustle and bustle of city life.

2. `White Desert:` One of the most famous attractions near Farafra is the White Desert (also known as the Sahara el Beyda). The landscape is characterized by surreal, wind-carved rock formations that resemble many unique different shapes. The rocks and sands in the White Desert give the area its distinctive white color, creating a breathtaking and otherworldly environment.

3. `Agriculture:` Despite being located in the desert, Farafra has some agricultural activities. The cultivation of date palms and olive trees is common, and the oasis benefits from underground water sources.

4. `Springs & Wells:` Farafra has natural hot springs, such as Bir Setta (sixth well), Bir Sab'a (seventh well) and El-Mufid lake, which are believed to have therapeutic properties. These springs are popular among locals and visitors alike for relaxation and health benefits.

5. `Cultural Festivals:` Farafra hosts cultural festivals, where locals showcase their traditional music, dance, and crafts. These events provide a great opportunity for visitors to immerse themselves in the rich cultural heritage of the oasis.

Visiting Farafra offers a unique experience, allowing travelers to explore the stunning landscapes of the White Desert, engage with the local culture, and enjoy the peaceful ambiance of this oasis in the Egyptian desert.

2 Project Details

1. `Dataset:`
   - `Bank Note Authentication Dataset:` Four Inputs, One Output Label
   - `Blood Transfusion Service Center Dataset:` Four Inputs, One Output Label
2. `Initialising The Neural Network:` The neural network model is initialised by choosing number or neurons in each of: the input layer, the hidden layer and the output layer (4,10,1 here respectively).
3. `Initialise Weights:` The weights between the neurons of the input layer and hidden layer and the neurons between the hidden layer and output layer and the biases of each neuron are initialised randomly.
4. `Splitting:`
   - `Training:` Takes a percentage (70% here) of the dataset so that the neural network can train on and change weights.

- `Validation:` Takes percentage (20% here) of the dataset so that the neural network can validate and check if the changed weights after an epoch resulted in better accuracy or worse.
- `Testing:` Takes percentage (10% here) of the dataset so that the neural network can be tested after the final epoch to check its accuracy on new data to identify if the network is good or if it over-fits or under-fits.
- `Batches:` Training data is split into batches (100 sample per batch here) so multiple iterations of forward and backward propagation happen per epoch.

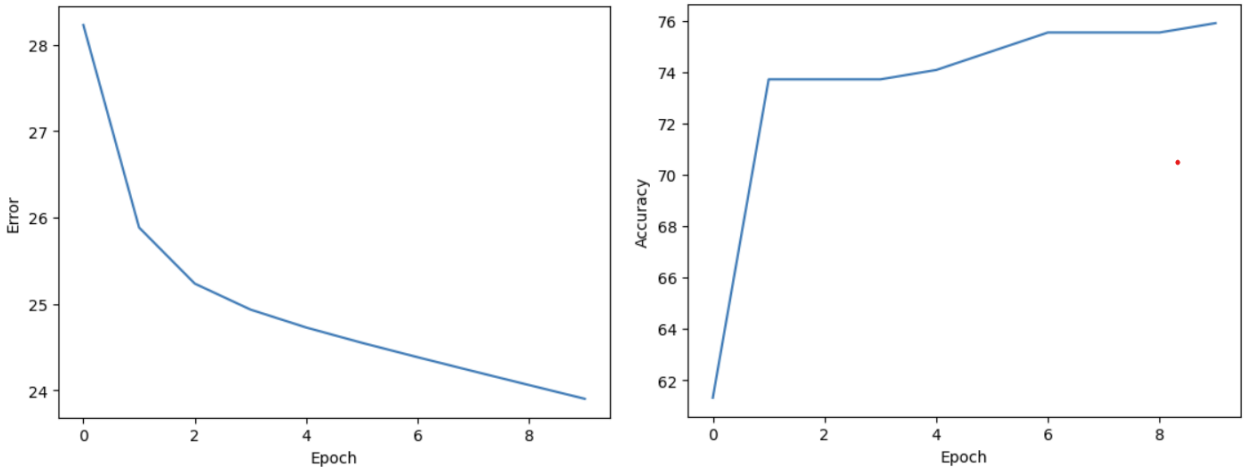
5. `Training Function:` The function takes in Labeled Input Matrix or training set, weights matrix, batch size and alpha (learning rate). The training set is split into batches according to batch size and each batch is stored.
   - `Forward Pass:` Takes a single batch and the weights matrix. The label column of the batch is removed from batch and stored in an array. Afterwards, a single forward pass is done on this batch and returns the first layer y values (matrix output of hidden layer), second layer y values (matrix output of the output layer) and error mean squared.
   - `Backward Pass:` Takes the same batch, alpha, first layer y values, second layer y values and weights matrix. The label column of the batch is removed from batch and stored in an array named truth value. With these inputs, we average the values of the first layer y values, the second layer y values, the truth value and the batch to be able to do a back propagation. This outputs a new weights matrix with the updated weights and biases of the neural network.

6. `Error Function:` Takes in the actual outputs vector (output of our model) and target output vector (true label) and returns an error vector (vector with which input had true or false output) and error (total error mean squared) and accuracy by checking what percentage of equality between actual and target. The actual outputs vector is passed through a threshold (0.5 here) to round the output to the 0/1 labels.

7. `Validation Function / Testing Function:` Both functions are the same code hence only one is written in code (test_Farafra). Takes in validation set or testing set and weights matrix. The function does a single forward pass on the set, then calculates and returns the error vector, error and accuracy using error function.

8. `Complete Function Farafra:` Takes in dataset, input (number of neurons in input layer), hidden (number of neurons in hidden layer), output (number of neurons in output layer), t (training size split), v (validation size split), s (testing size split), batch size, epochs, alpha. This is the function which calls all the above functions to create the whole model from start to finish. Weights are initialised then the dataset is split then a loop that loops on training function and validation (named test_Farafra) depending on number of epochs. In each epoch, the error and accuracy from validation are stored for visualisation reasons. After the epochs are done, a test is done using testing set with the weights from the final epoch to give final error and accuracy. Returns are error (after each epoch), accuracy (after each epoch), error vector (after test) , error (after test), accuracy (after test).

At the end, the error and accuracy after each epoch are plotted on a line graph to see how they changed after each epoch and the error vector, error and accuracy of test are printed.

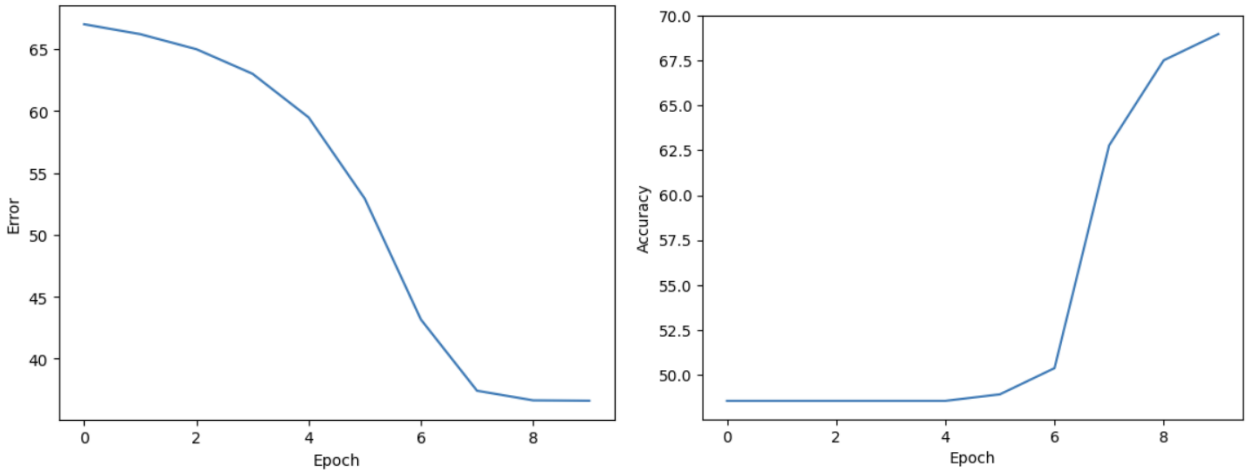


(a) Error Change (b) Accuracy Change

Figure 1: Training Changes

```
Testing Error Vector: [ True  True  True  True  True  True  True False  True  True  True  True
  True  True  True  True  True False  True False  True  True  True  True
  True  True  True False  True  True  True  True  True False  True False
 False  True  True  True  True  True  True False  True  True False  True
  True  True  True  True False False False  True  True  True  True  True
  True  True  True  True  True  True  True  True  True  True  True  True
 False  True False  True  True False  True  True  True  True  True  True
  True  True False  True  True  True  True  True  True  True  True  True
  True  True  True False  True  True  True  True  True False  True  True
  True  True  True  True  True False  True False  True  True  True False
 False  True  True  True  True  True  True  True  True  True False  True
  True  True  True False  True  True]
 Testing Error: 10.725533403602448
 Testing Accuracy: 82.6086956521739
```

Figure 2: Test Results



(a) Error Change (b) Accuracy Change

Figure 3: Training Changes

```
Testing Error Vector: [ True  True  True  True  True False  True False  True False  True  True
  True False  True  True  True  True  True False False  True False  True
 False  True  True  True False  True  True  True  True False False  True
  True False  True  True  True  True  True False False  True  True  True
 False  True  True  True False False  True  True  True False False  True
 False False  True  True  True  True  True False False  True  True  True
  True  True False  True False False False  True  True  True  True False
  True  True  True  True  True  True False False  True  True  True False
  True  True False  True  True  True False  True  True  True  True  True
  True False  True False  True  True  True  True  True  True False  True
 False False  True  True  True  True  True False False  True  True  True
  True  True  True  True  True  True]
 Testing Error: 17.91458522763596
 Testing Accuracy: 71.01449275362319
```

Figure 4: Test Results