University of Dayton

School of Engineering

Department of Electrical and Computer Engineering

ECE 477/595: Artificial Neural Networks

Project 7: Bidirectional Associative Memory (BAM) Neural Network

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Methodology

Loading Steps

- The user may use orthogonal patterns by using the output of the function “orthoimages_with_dim”. These patterns have been built using the fact that two orthogonal patterns have a null dot product.

Bidirectional Associative Memory (BAM) Neural Network

1. Input each $X^s; s = 1,2, \dots, P$. $(N \times 1)$
   Where X: $(N \times P)$
   Input each $Y^s; s = 1,2, \dots, P$. $(M \times 1)$
   Where Y: $(M \times P)$

2. Initialize the weight matrix:
   $W = X \cdot Y^T;\ (N \times M)$
   $V = Y \cdot X^T;\ (M \times N)$

3. Loop over the patterns: $s = 1,2, \dots, P$

   a. Apply a distorted version of X^s and Y^s:
      $Net = W^T \cdot X^s; (M \times 1)$

   b. Compute the output by thresholding:
      $$Y^{new\_s} = \begin{cases} +1; & Net > 0 \\ Y^s; & Net = 0 \\ -1; & Net < 0 \end{cases}$$
      Where Y^{new_s}: $(M \times 1)$

   c. Compute the corrected X^s:
      $Net\_new\_s = V^T \cdot X^s$
      $$X^{new\_s} = \begin{cases} +1; & Net\_new\_s > 0 \\ X^s; & Net\_new\_s = 0 \\ -1; & Net\_new\_s < 0 \end{cases}$$
      Where X^{new_s}: $(N \times 1)$

   d. Compute the energy function:
      $E = V^T \cdot W^T \cdot X^{new\_s}$
      Where E: (1×1)

   e. Replace the input with the output:
      $X(t+1) = X^{new\_s}(t)$
      $Y(t+1) = Y^{new\_s}(t)$

   f. Measure the change of the energy between the current time step and the previous one:
      $Change = E(t) - E(t-1)$

   g. Increase the iteration number:
      $Iteration = Iteration + 1$

   h. Repeat steps 3-a to 3-f until the $Change = 0$ or if $Iteration > 100$.

i. Save the retrieved pattern as the final output and store it.

4. Compute the error matrix between each actual pattern pair and retrieved pattern pair, then plot it vs each pattern pair number:

$$Error\_X_s = \frac{1}{N}\sum_{i=1}^{N} |Acutal\_X_i^s - Retrieved\_X_i^s|$$

$$Error\_Y_s = \frac{1}{N}\sum_{i=1}^{N} |Acutal\_Y_i^s - Retrieved\_Y_i^s|$$

Results

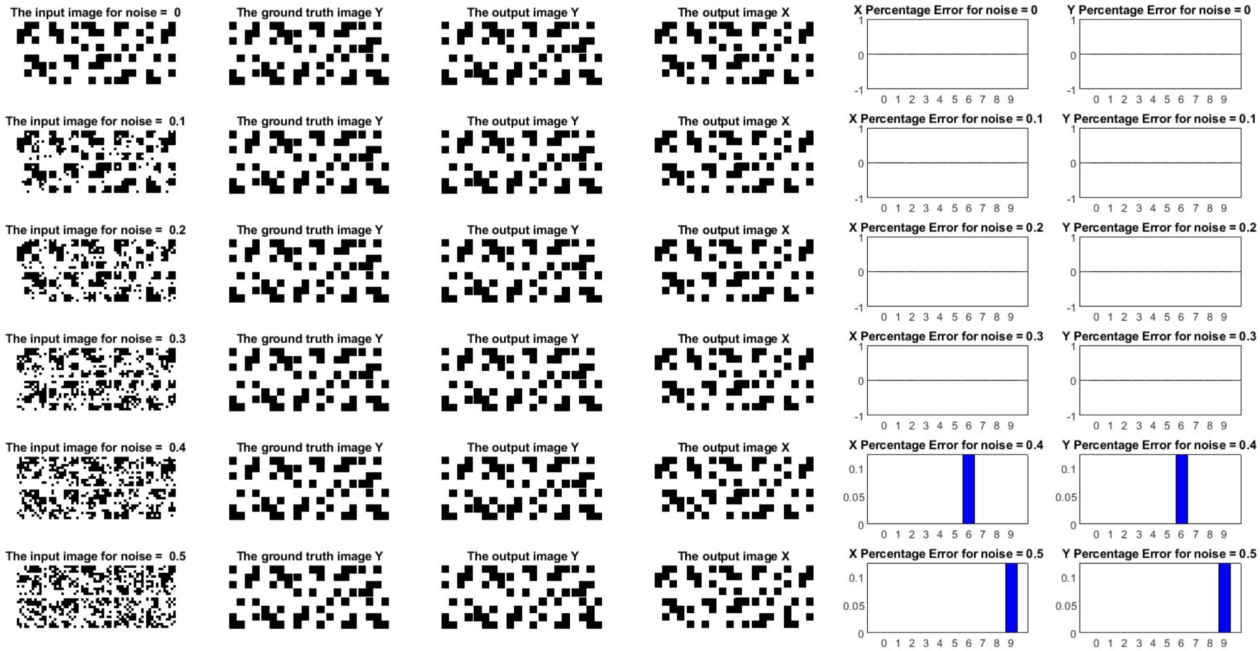

Figure 1: Pattern Pair Association Using BAM - 10 Training Orthogonal Pattern Pairs; Medium Noise

Conclusion/Comments

The goal of this assignment was met, and a Bidirectional Associative Memory (BAM) Neural Network based pattern pair association algorithm was developed. Some points may be discussed below:

- When orthogonal pattern pairs are used, and for relatively low noise levels, all patterns were correctly retrieved, with no errors. This is one practical reason to believe that orthogonal patterns are required for the algorithm to function properly.

- As the noise level increases, the retrieved patterns become less like the actual ones. This is obviously logical because more noise will make it more difficult to retrieve the exact patterns.

- Even with high noise levels, some patterns could still be retrieved correctly while the human naked eye can't even relate the distorted pattern to the actual one.

- The errors become different than zero when the noise intensity becomes more than or equal to 0.4.

- The X errors are almost the same as the Y errors. This is logical since X will highly affect Y.

- The algorithm is quick and simple to implement, with numerous applications.