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Rochester Institute of Technology
Computer Science Department

Context Sensitive Optical Character Recognition
using
Neural Networks and Hidden Markov Models

by
Steven C. Elliott

A thesis, submitted to
The Faculty of the Computer Science Department in partial
fulfillment of the requirements for the degree of
Master of Science in Computer Science

Approved by: Professor P. G. Anderson

Professor R. T. Gayvert

Professor J. A. Biles

February 13, 1992

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Title: Context Sensitive Optical Character Recognition using Neural Networks and Hidden Markov Models

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ABSTRACT

This thesis investigates a method for using contextual information in text recognition. This is based on the premise that, while reading, humans recognize words with missing or garbled characters by examining the surrounding characters and then selecting the appropriate character. The correct character is chosen based on an inherent knowledge of the language and spelling techniques. We can then model this statistically.

The approach taken by this Thesis is to combine feature extraction techniques, Neural Networks and Hidden Markov Modeling. This method of character recognition involves a three step process: pixel image preprocessing, neural network classification and context interpretation.

Pixel image preprocessing applies a feature extraction algorithm to original bit mapped images, which produces a feature vector for the original images which are input into a neural network.

The neural network performs the initial classification of the characters by producing ten weights, one for each character. The magnitude of the weight is translated into the confidence the network has in each of the choices. The greater the magnitude and separation, the more confident the neural network is of a given choice.

The output of the neural network is the input for a context interpreter. The context interpreter uses Hidden Markov Modeling (HMM) techniques to determine the most probable classification for all characters based on the characters that precede that character and character pair statistics. The HMMs are built using an *a priori* knowledge of the language: a statistical description of the probabilities of digrams.

Experimentation and verification of this method combines the development and use of a preprocessor program, a Cascade Correlation Neural Network and a HMM context interpreter program.

Results from these experiments show the neural network successfully classified 88.2 percent of the characters. Expanding this to the word level, 63 percent of the words were correctly identified. Adding the Hidden Markov Modeling improved the word recognition to 82.9 percent.

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1.0 Introduction

This thesis investigates a method for using contextual information in text recognition. This is based on the premise that, while reading, humans can use context to help identify words garbled by misspelling, bad penmanship, bad printing etc., by examining the surrounding characters and then selecting the appropriate character. The correct character is chosen based on familiarity of the language and spelling techniques. The reader routinely uses knowledge about the syntactic, semantic and featural dependencies between characters and between words [1].

The use of knowledge about dependencies between characters within words is explored in this Thesis. The method we use in this Thesis does not explore the dependencies between words but our method could easily be expanded to include "global context".

This paper proposes a method for pattern recognition combined with the knowledge of the character context to successfully interpret handwritten digits combined as words. Two aspects of this recognition process are investigated: the recognition of the individual patterns (characters) and the combination of the patterns into specific words.

Pattern recognition has traditionally been grouped into two general categories: the "statistical" or "decision theoretic" approach and the "structural/syntactic" approach [2]. The statistical or decision theoretic approach is often referred to as a geometric approach. This methodology focuses on how a pattern is constructed and how that pattern maps to the object that it represents.

Within the geometric approach, patterns are described by their components, which can be viewed as vectors in a coordinate space of N dimensions. Each pattern then corresponds to a point in that space. With this type of representation, familiar mathematics become available for pattern recognition. Euclidean distances between two points become a similarity metric for characters. Two patterns that represent similar or identical objects would be expected to be very close to each other in pattern space; however it is usually necessary to replace the pixel arrays with feature vectors.

The relationship between the geometric description of a pattern and the object being represented has also been studied. These relationships take

on one of three classifications. The relationship between a pattern and the object is deterministic if there is a one to one, or a many to one relationship between the pattern or patterns and the object being represented. A non-deterministic relationship exists if a pattern can represent more than one object (or class). The non-deterministic relationship is probabilistic if different probabilities can be attached to the various relationships. A representation is stochastic if there is a finite probability that an object can be represented by points anywhere in the pattern space. These relationships are shown graphically in Figure 1.

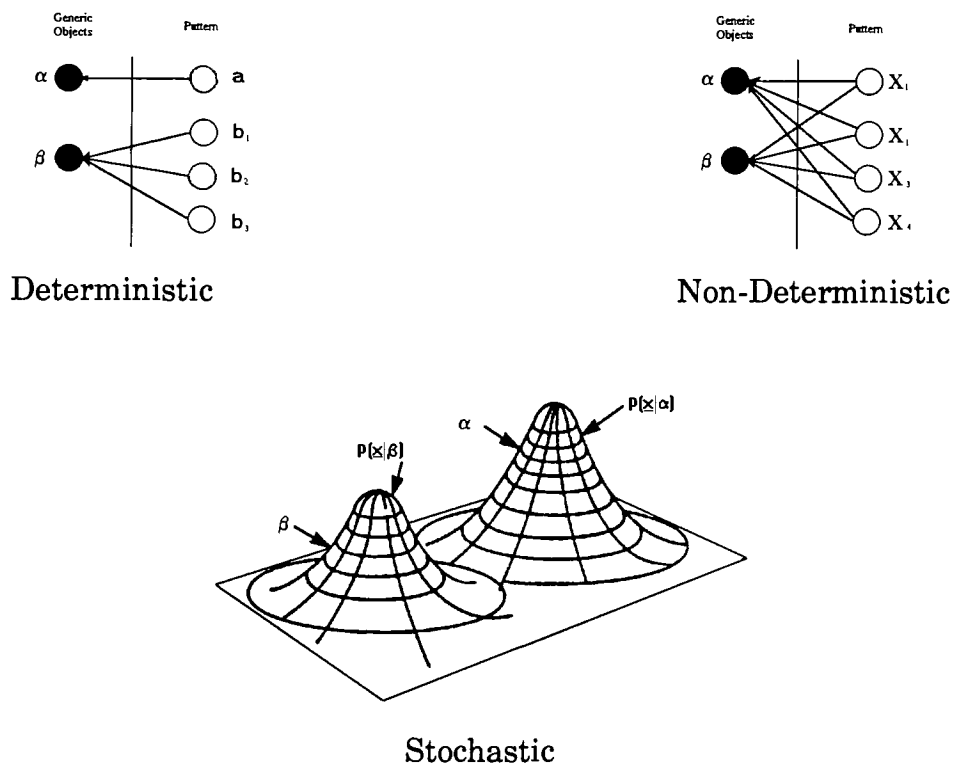


Figure 1

In character recognition of machine printed text, if only a single font is used, and the system is completely free of noise, then each pixel array would map to a single object. A deterministic geometric representation would be realized. If multiple fonts were used, multiple pixel arrays would represent the same object (i.e., different version of the letter "A"). In this case, a deterministic representation is also realized. In the case of recognition of handwritten characters, it is possible that very similar patterns represent

different objects (such as the confusion between the characters "I", "l" and "1"). This results in the generation of non-deterministic relationships. If finite probabilities can be assigned to each case then the relationship is said to be stochastic.

In the case where non-deterministic or stochastic relationships exist, additional intelligence must be built into the system to differentiate between similar patterns. The use of this intelligence is referred to as context directed pattern recognition [3]. Context directed pattern recognition can be either syntactic or stochastic in nature. To use the syntax of a language for pattern recognition, we need to have the production rules which were used to generate the language. This approach has been taken with the use of Augmented Transition Networks (ATN). Using this method, characters are represented as nodes. The transition, or arc, from one node to another can only be completed if the conditions imposed on those arcs have been met. One major difficulty associated with the use of this type of context in pattern recognition is determining how the grammar is to be inferred.

The stochastic approach to context directed pattern recognition is not based on the production rules that generate the language, but rather is based on the statistical make-up of the language. This approach uses the statistics which indicate what characters occur and what order those characters occur. This statistical knowledge of the language can be obtained from the language without knowing any of the syntax or production rules that were used to generate the language. The use of Hidden Markov Models best describes this type of context directed pattern recognition.

For this Thesis, we developed an artificial language which consisted of 100 words, each 5 characters in length. The characters for the words are the digits 0 thru 9. These digits were each handwritten, scanned and then digitized. The statistical characteristics of the language was determined and used as part of the pattern recognition process.

The approach taken by this Thesis was to combine three separate recognition techniques into a single system, utilizing the benefits from each technique. These three techniques were: feature extraction, neural networks and Hidden Markov Modeling. The feature extraction process looked within each input pixel map for sub-features that would be useful to characterize each digit. The neural network classified the features into a list of strengths for each character. The Hidden Markov Model examined the combined

characters as words and, based on its knowledge of the language, helped to resolve the correct word classification.

The feature extraction algorithm examined the original pixel maps for features corresponding to evidence for lines (strokes) at various places in four orientations in the image. The output of the feature extraction algorithm was a feature vector representative of the original image. The feature vectors were used as input into a neural network.

The neural network was used to perform the initial classification of the characters. The training data for the neural network consisted of half of the handwritten character database, while the second half of the database was used for testing purposes.

The neural network selected the digit most closely identified by the feature vector. The neural network had ten output nodes, each output node represented a specific digit. The magnitude of the output value was translated into the confidence of the neural network for that classification. The greater the magnitude, the greater the confidence. These confidences for each classification were recorded for use in the next step of the process.

The output of the neural network was then used by the context interpreter. The context interpreter used Hidden Markov Modeling techniques to determine the most probable classification for all characters. The HMMs were built using an *a priori* knowledge of the language - a language model. The model included the initial state probabilities (the probability a digit was the first digit of a word) and the transition probabilities for a specific digit to follow another digit within the word (digram statistics). The context interpreter examines the probabilities of all of the characters within word boundaries. The output of the HMM was a sequence of digits that best correspond to the input of observed digits.

The system architecture is shown in Figure 2.

System Architecture

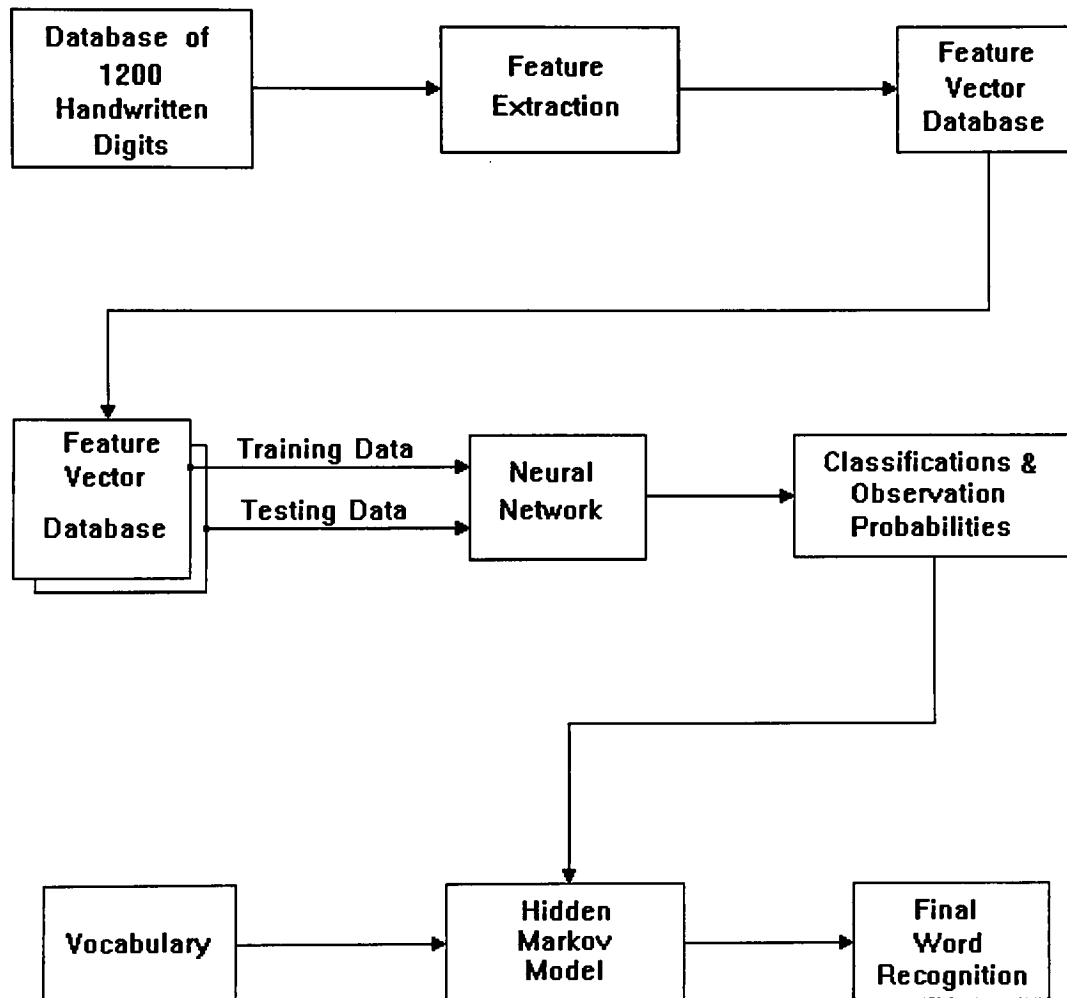


Figure 2

2.0 Artificial Language Generation

Input into the system was from a database, supplied by Bell Laboratories [4], consisting of 1200 handwritten digits. The database was generated by having 12 individuals write the set of digits (0 thru 9) ten times. Each set of digits 0 through 9, for each individual was considered an attempt. Each digit was labeled according to who wrote it and during which attempt the digit was created. The attempts were labeled "A" through "J". This resulted in 120 distinguishable attempts of the 10 digit set. These samples were then scanned and normalized into 1200 separate 16 by 16 pixel maps. The maps were then converted into an ASCII readable format. Within the maps, a "#" character represents a logical 1 (black pixel), while the " " (space) character represents a logical 0 (white pixel). Examples of the handwritten digits and the normalized pixel maps are shown in Appendix A.

These digits provided the basis for the generation of the artificial language. The language vocabulary consisted of 100 words, each word was 5 digits in length. The language was generated by first selecting an initial character probability. This determined the first digit for each word. The initial probabilities, shown in Figure 3, were chosen at random.

Digit	Initial Probability
0	.05
1	.20
2	.05
3	.05
4	.00
5	.10
6	.25
7	.04
8	.01
9	.25

Figure 3 -- Initial Probabilities

In addition to the initial probabilities, the transition probabilities were selected. This information indicated with what probability one digit would follow another digit within a word. This only applies within words and does not cross word boundaries. For example, a "2" will follow a "1" ten percent of the time, while a "1" will follow a "2" only five percent of the time. These values were chosen arbitrarily in order to provide some type of selection process. The transition probabilities are shown in Figure 4. The digits down the left side are the first of a pair, while the digits across the top are the second.

	0	1	2	3	4	5	6	7	8	9
0	0.10	0.00	0.00	0.10	0.05	0.05	0.05	0.05	0.10	0.50
1	0.05	0.10	0.10	0.05	0.10	0.00	0.05	0.05	0.45	0.05
2	0.00	0.05	0.35	0.00	0.00	0.00	0.00	0.45	0.00	0.05
3	0.10	0.05	0.00	0.05	0.15	0.05	0.50	0.05	0.00	0.05
4	0.10	0.10	0.05	0.05	0.05	0.45	0.10	0.05	0.05	0.00
5	0.10	0.05	0.00	0.05	0.45	0.10	0.05	0.10	0.05	0.05
6	0.00	0.05	0.05	0.70	0.00	0.00	0.00	0.10	0.10	0.00
7	0.10	0.00	0.60	0.00	0.05	0.05	0.10	0.00	0.05	0.05
8	0.05	0.40	0.05	0.05	0.20	0.05	0.05	0.05	0.10	0.00
9	0.45	0.05	0.05	0.05	0.00	0.10	0.10	0.00	0.00	0.20

Figure 4 -- Transition Probabilities

A program was written to use the data from Figure 3 and Figure 4 to generate the artificial language. This language is shown in Appendix B.

The data from Figure 3 and Figure 4 was also used for the Hidden Markov Modeling, this is discussed in section 3.3.

The database of handwritten digits was used to generate the words used in the artificial language. Attempts A thru E were used for training of

the neural network. while attempts F thru J were used for testing of the neural network and the context interpreter. All of the digits in all of the attempts were passed through the feature extraction algorithm.

To generate the test data, using the 5 attempts (F through J) from the 12 individuals resulted in 60 unique attempts at writing the digits 0 thru 9. Each of these attempts were applied to the 100 word vocabulary to obtain a test case set of 6000 words on which the context sensitive recognition process was run.

3.0 Project Description

3.1 Feature Extraction Sub-System

The first process within the recognition system is the feature extraction sub-system. Feature extraction allows for statistical character recognition. With this method, the classification of the patterns was based on selected features which have been extracted from the original pixel map, rather than template matching of the pixel maps themselves. This makes the system more tolerant of minor variations [5]. Pixel map matching would be effective if the distortions were of the "salt and pepper noise" type. Handwritten characters have "plastic distortion".

The difficulty with feature extraction is knowing what features to extract and how those features should be represented. The selection of these features was largely empirical and ad hoc, and drew upon our knowledge of the problem.

Four primitive features were selected for extraction from the original patterns. All of the features were lines, each with different slopes. These features, known as Convolution Kernels for Feature Extraction, are shown in Figure 5. These features were implemented because of their simplicity. Additional features such as line intersection, horizontal lines, etc. could be implemented as part of any future research project.

The feature extraction algorithm maps the original pixel array from feature space to decision space. From the decision space, the output vectors were mapped to the appropriate objects. Classification of the pattern was then based on the output feature vector rather than the pixel map.

The feature extraction algorithm used here is similar to convolutions, a signal processing technique. Convolutions are common and powerful techniques for filtering images. A convolution is a specially designed filter (matrix) that is combined together with a portion of an image to compute a transformed pixel value. The filter, or convolution kernel, is centered on each pixel in the initial pixel map. The sum of the product of the filter and the underlying image is computed. The result is a transformed value of the center pixel. The filter is then moved to the next pixel and the process is repeated. Some special processing may be needed to take into account the peculiarities of pixels near the edges of an image.

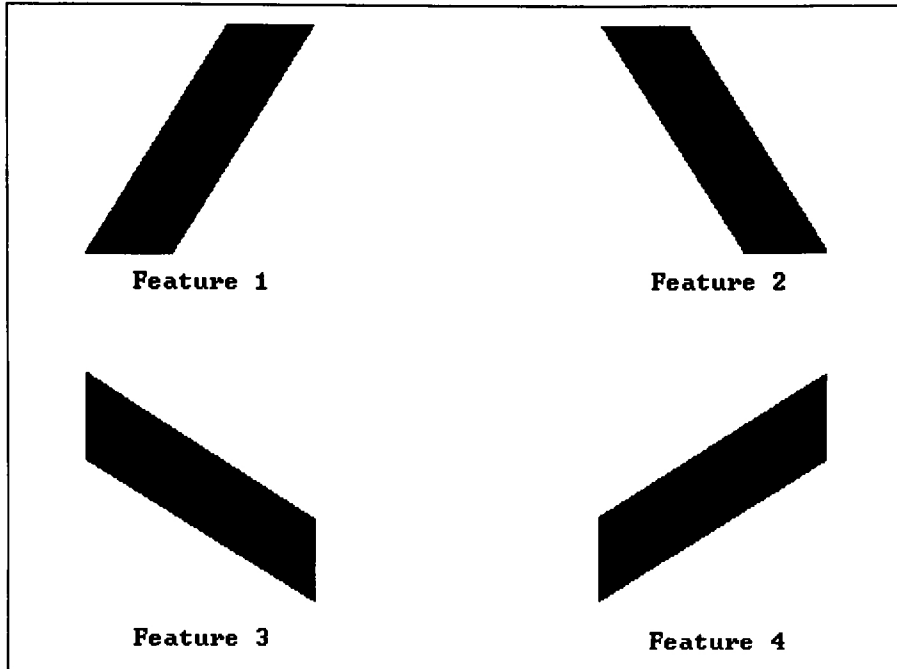


Figure 5

The convolution of the filter and image is determined by computing the point to point product of the corresponding elements of the filter and the portion of the image which is being overlaid, and then summing those products.

By properly selecting kernels for a filter, the convolutions can detect lines, edges, create high and low pass filters, and variety of other functions [6].

The feature extraction algorithm presented here applies four filters to the original pixel image. The four filters represent the four features which are being extracted from the original image. Each filter is designed to determine if the feature it represents is present in the underlying portion of the pixel map. Each filter is represented by a 4 by 4 matrix, whose values are designed to detect the desired features.

The original pixel maps were divided into sixteen 4 by 4 pixel areas as shown in Figure 6. The four feature filters are applied to each area. Each filter is overlaid over the designated area. The pairwise products of the filter value and the underlying pixel value are summed. If this summed value is

greater than 4 but not divisible by 4, then the feature is present, otherwise the feature is not present.

All sixteen areas of original pixel map were overlaid with the four feature filters to provide a feature vector made up of 64 elements. Each element represents the presence of a specific feature (or evidence of a stroke) within a specific area. The elements of the output feature vector are binary values, with a 1 indicating the presence of the feature and a 0 indicating that the feature was not present.

0	3	7	13	15
1	2	3	4	
5	6	7	8	
9	10	11	12	
13	14	15	16	

Figure 6

Each primitive feature was confined to the 4 by 4 window; that is, no features crossed windows or wrapped around at the edges. Unlike the image processing convolutions, the filters do not center on a single pixel but examine the entire area of the filter. The filters are moved from area to area (4 pixel row increments), in the order shown in Figure 6, instead of moving from pixel to pixel. No mirroring of pixels was performed at the edges.

Using this technique, a 16 by 16 pixel map (256 elements) was represented by a 64 bit vector, thus providing a 4 to 1 compression ratio. This compression was convenient for use of the feature vector as input into the neural network.

Our convolution kernels were chosen empirically and are the result of various testing. No formal proof is provided on how or why these values appear to work. The matrices are shown in Figure 7.

0	0	4	4
0	0	0	0
0	0	0	0
1	1	0	0

Feature 1

4	4	0	0
0	0	0	0
0	0	0	0
0	0	1	1

Feature 2

4	0	0	0
4	0	0	0
0	0	0	1
0	0	0	1

Feature 3

0	0	0	4
0	0	0	4
1	0	0	0
1	0	0	0

Feature 4

Figure 7

Each of the overlay filters were applied to all of the quadrants. The general notation for this calculation shown symbolically is:

$$Q = \sum_{i=0}^3 \sum_{j=0}^3 W_{ij} F_{ij}$$

where:

i, j = relative row and column coordinates

W = window area of original pixel map

F = convolution kernel

Q = summation of pairwise product

The value Q was then tested to determine if the particular feature was present.

$$V_k = \begin{cases} 1 & \text{if } Q > 4 \text{ AND } Q \neq 8) \\ 0 & \text{otherwise} \end{cases}$$

Where V_k is the k th component of the feature vector.

The feature vector was then used as the input vector into the neural network for training and classification purposes.

3.2 Neural Network Classification

Artificial neural networks have been widely used in pattern recognition applications. Various paradigms have been used. The different network models are specified by:

1. Network topology: the number of neurons and how the neurons are interconnected.
2. Node characteristics: the type of non-linear transfer function used by the neuron for calculating the output value.
3. Training rules: specify how the weights are initially set and adjusted to improve performance of the network.

3.2.1 Hopfield Network

One such paradigm is the Hopfield network [7]. The Hopfield network is a hand programmed associative memory. It is composed of a single, fully recurrent layer of neurons that act as both input and output. The diagram of a Hopfield network is shown in Figure 8.

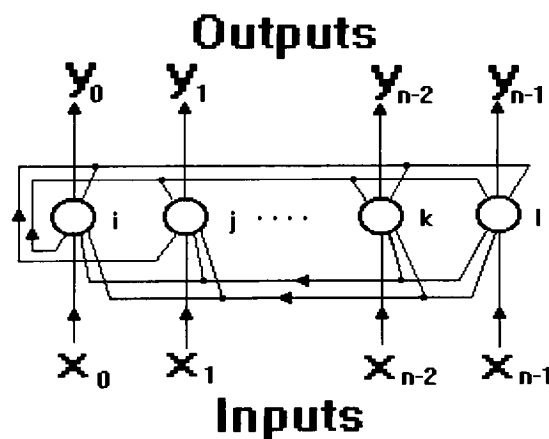


Figure 8

The output of the neurons is passed back as input to the neurons, thus being referred to as feedback network. The neurons are symmetrically

connected, i.e., for all i and j , $W_{ij} = W_{ji}$, and $W_{ii} = 0$, where W_{ij} is the synaptic weight connecting neurons i and j . The neurons are updated by the rule

$$x_j = f(\sum W_{ij}x_i) \quad (\text{Eq. 1})$$

where x_i is the output of neuron i . The function f is generally non-linear; such as signum, tanh or the sigmoid $y = (1 + e^{-x})^{-1}$

The non-linear function compresses the output so that it lies in the range between 0 and 1 or between -1 and +1. This is sometimes referred to as the squashing function.

The Hopfield network does not learn through execution of the net. The weights must be set in advance. The weight matrix is created by taking the outer product of each input pattern vector with itself, and summing all of the outer products, and setting the diagonal to 0.

The Hopfield network can complete or restore corrupted patterns by matching new inputs with the closest previously stored patterns. The input pattern vector is applied to the network node. The network then cycles through iterations until it has converged. Convergence is when the outputs of the network no longer change on successive iterations. Hopfield proved that convergence is always guaranteed.

The Hopfield network has two major disadvantages. The first is the number of patterns that can be stored. It has been shown that the maximum number of patterns recalled is generally limited by $n/(2\log n)$, where n is the number of nodes [8].

The second limitation is that an input pattern will be unstable and the output will be incorrect if one stored pattern is highly correlated with another pattern. This results in incorrect classifications or associations.

3.2.2 Back Propagation Network

The back propagation model or multi-layer perceptron is a neural network that utilizes a supervised learning technique. Typically there are one or more layers of hidden nodes between the input and output nodes. See Figure 9.

The multiple layers allow for the creation of complex contours defining decision regions. A single layer perceptron can only create a half plane bounded by a hyperplane decision region. A two layer (single hidden layer between input and output) perceptron easily allows for the creation of convex decision regions, while a three layer (multiple hidden layers) perceptron allows for the creation of arbitrarily complex regions limited by the number of hidden nodes. More difficult to see is that any decision boundary can be achieved with a 2 layer network, but this can be very complex.

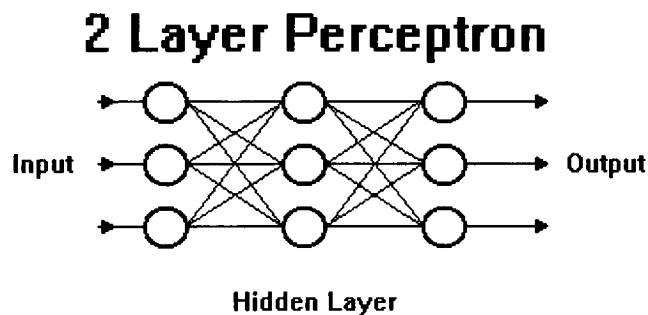


Figure 9

The use of the back propagation training algorithm requires the use of a non-linear, differentiable transfer function within each node. The sigmoidal function described above fills these requirements.

The back propagation training algorithm is a supervised learning technique. Input vectors are matched with the desired output vectors. These pairs are referred to as the training pairs. The network is trained using a database of such pairs.

To train a multi-layer perceptron using back propagation, the general algorithm is as follows:

1. Set the initial starting synaptic weights to small random values.
2. Apply the input vector from the training pair to the network.
3. Propagate the vector through the network using the non-linear transfer function to calculate the output of the network. The calculations are performed on a layer by layer basis.
4. Calculate the error value, which is the squared difference between the actual output and the desired output vector from the training pair.
5. Propagate the error signal back through the output, hidden and to the input layers adjusting the weights to minimize the error.
6. Iterate steps 2 through 5 for all of the training pairs within the training set until the error level for the entire set is acceptably low.

In more specific terms, the neurons are initialized to the input values. The states of all other neurons (x_j) in the network are determined by:

$$x_j = f(\sum W_{ij}x_i) \quad (\text{Eq. 2})$$

The nonlinear function f needs to be differentiable, so we use tanh or the sigmoid:

$$y = (1 + e^{-x})^{-1} \quad (\text{Eq. 3})$$

This calculation is done layer by layer with the output of each layer serving as input into the next layer. This continues until the nodes on the output (rightmost) layer have been computed.

The error E of the network is:

$$E = \sum (X_k - t_k)^2 \quad (\text{Eq. 4})$$

Where the sum is over the output nodes, X_k , whose "target" output is t_k (from the training data). Training consists of determining:

$$\Delta W_{ij} = - \alpha (\delta E / \delta W_{ij}) \quad (\text{Eq. 5})$$

where $\alpha > 0$ is the training rate for one pass (epoch) over the training data.

First we adjust the weights of the output layer. The back propagation algorithm uses a technique similar to the "Delta Rule" developed for perceptrons. The "Delta Rule" is shown as:

$$W_{ij}(n+1) = W_{ij}(n) + \Delta W_{ij} \quad (\text{Eq. 6})$$

where:

t_k = target output

X_k = Actual output

δ = error signal

ΔW_{ij} = correction corresponding to the i th input x_i

α = learning rate coefficient

$W_{ij}(n+1)$ = value of the weight after the adjustment

$W_{ij}(n)$ = value of the weight before the adjustment

The back propagation algorithm uses the derivative of the non-linear squashing function $f()$. If $y = (1 + e^{-x})^{-1}$, then

$$y' = y(1 - y) \quad (\text{Eq. 7})$$

Which makes the calculation particularly easy. No new function needs to be evaluated.

The use of the partial first derivative of the error function allows for a simple gradient decent search technique in finding the global minima for the error value.

Training the output layer of the network is fairly straightforward because the target value (desired output half of the training pair) is known.

The following equations show the training process for determining a single weight between neuron (p) in hidden layer (j) to output neuron (q) in the output layer of the network:

$$\delta_q = y_q(1 - y_q)(t - y_q) \quad (\text{Eq. 8})$$

$$\Delta W_{pq} = \eta \delta_q y_p \quad (\text{Eq. 9})$$

$$W_{pq} (n+1) = W_{pq} (n) + \Delta W_{pq} \quad (\text{Eq. 10})$$

where:

t = target output for neuron q

y_q = Actual output of neuron q

δ_q = error signal for neuron q

Δ_i = correction corresponding to the i th input X_i

η = learning rate coefficient

$W_i(n+1)$ = value of the weight after the adjustment

$W_i(n)$ = value of the weight before the adjustment

The adjusting of the weights of the hidden layer is more difficult because the desired output of these neurons is not known. Back propagation trains the hidden layer by propagating the output error back through the network, adjusting the weights at each layer.

The error value (δ) must be calculated without knowing what the desired output of the hidden layer neurons should be. The error value δ is first calculated for each of the output layer neurons. These error values are then propagated through the associated input weights (of the output layer neuron) back to the first hidden layer neuron. These propagated error values are then used to adjust the input synaptic weights for the hidden layer. The same procedure is used again to propagate the error value back to the next hidden layer or to the input layer.

The error values calculated for the output layer (Eq. 8) is multiplied by the weight that connects the output neuron with the hidden neuron. This is done for all the connections between the output layer and the hidden layer neurons. The error value for the hidden layer neuron is calculated by

summing all of the products and then multiplying that value by the derivative of the non-linear sigmoid function (Eq. 7). Calculating the new weight values is same for the hidden layers as it is for the output layers as shown in equations (Eq. 9 and Eq. 10). The equation for determining the hidden layer error value is as follows:

$$\delta_{p,j} = y_{p,j}(1-y_{p,j}) (\sum \delta_{q,k} W_{pq,k}) \quad (\text{Eq. 11})$$

While the back propagation network is much improved over the Hopfield Network for pattern recognition, there are still caveats with the algorithm that must be overcome. The most severe limitation is the length of time required to train a network. For complex problems, the training time could be excessive, or even more serious, the network may fail and may never be trained. The network training failures are usually attributed to one of two sources: network paralysis or local minima.

Network paralysis occurs when the synaptic weights become very large values. This forces the output of the neuron to be large. This is in a region where the derivative of the non-linear sigmoid function would be very small. The smaller this value, the slower the training becomes, until the training appears to be at a virtual standstill.

The Back Propagation uses gradient decent to determine the minimum error value for a neuron. The error surface of a complex network may be filled with many hills and valleys. Local minima occur when the network settles in a shallow valley when there is a much deeper valley (global minima) nearby. There is generally no way of knowing, without time consuming experimentation, what is the right network architecture for a given problem.

3.2.3 Cascade Correlation

In an attempt to overcome the limitations mentioned above for the back propagation learning algorithm, the Cascade Correlation network paradigm was developed [9]. In particular, the problem of slow learning

times was examined. The Cascade Correlation network paradigm was used for this Thesis.

Two major problems were discovered which contribute to slowness of the back propagation learning algorithm. The first problem is the "step size" problem and the second is the "moving target" problem. Several clever strategies were incorporated in the Cascade Correlation algorithm which helped speed up the training times.

A network learns when the error value for each neuron is reduced to an acceptable level. The Back Propagation algorithm uses a partial first derivative (Eq. 7) of the error values with respect to the weights to perform a gradient decent in weight space. The rate that this decent is made is related to the step size. If infinitesimally small steps are taken, then calculating the error values after each step will eventually result in obtaining a local minimum of the error function. While this may work, the time to perform each of the training steps could be infinitely long. If the steps taken are too large, the local minimum may never be reached because the large step might not provide the resolution needed to find the local minimum. If a local minimum is reached, it has been empirically determined that the local minimum will be the global minimum, or at least a "good enough solution" for most problems [10].

In order to choose an appropriate step size, additional information (not part of the original Back Propagation algorithm) is needed. In addition to the slope of the error function, information about its higher order derivatives or curvature in the vicinity of the current point, can be used.

The quickprop algorithm [11] estimates the second order derivative of the error function to update the synaptic weights and determine the local minimum. For use of the quickprop algorithm, two simplifying assumptions were made:

1. Small changes in one weight have little or no effect on the error gradient seen at other weights.
2. The error as a function of one synaptic weight can be approximated by a parabola opening upward.

As part of the algorithm, the first derivative calculated for the previous training cycle is maintained for each weight. Also remembered is the change

last made to each weight. Using the previous slope value, the current slope value and the last weight change, a parabola can be fit to those points and the minimum point of the parabola can be determined analytically.

The procedure for the quickprop algorithm is essentially the same as the steps for the Back Propagation algorithm. The major difference is the calculation used to determine the weight update value. The equation used in the quickprop algorithm is shown symbolically as:

$$\Delta W(t) = (S(t) / S(t-1) - S(t)) \Delta W(t-1) \quad (\text{Eq. 12})$$

where:

$S(t)$ = current error derivative

$S(t-1)$ = previous error derivative

$\Delta W(t-1)$ = previous weight change

The second problem identified as a source of slow learning with Back Propagation is referred to as the "moving target" problem. Each neuron within the hidden layers of the network are feature detectors. The learning process for these layers is complicated by the fact that all the other neurons are also changing at the same time. Each neuron within the hidden layers only see its own inputs and the error signal propagated back to it from the next layers. The error signal that the hidden neuron is attempting to focus in on is constantly changing, therefore causing the hidden neurons to take a long time to settle in and determine the desired local minima.

One of the difficulties with multi-layer perceptrons is determining the number of hidden neurons within the network. The number of neurons must be large enough to be able to form a decision region that is suitable for the given problem. Caution must be taken not to have too many neurons so that the number of weights required cannot be estimated from the available training data.

Prior to Cascade Correlation, the experimenter had to fully specify the network architecture before the training began. It was not known if the chosen number of hidden neurons was too small or too large until the training had finished (or failed).

Cascade Correlation combines two key elements to help solve the "moving target" problem. The first element is the cascade architecture. Using the cascade architecture, hidden neurons are added to the network one at a time as the network is training. Once a neuron has been added, its input synaptic weights are frozen, and only the weights associated with its output to the neuron connected to the next layer are adjusted.

The second element added was an attempt to maximize the magnitude of the correlation between the new neuron's output and the error signal being eliminated.

As new hidden neurons are added, each new neuron receives a connection from all of the network's original inputs and also from all of the previously added hidden neurons. This is a change from previous architectures in which the neurons of one layer were only connected to the neurons of the next layer. The input synaptic weights are frozen when the new unit is added. An example of the Cascade architecture with two hidden nodes is shown in Figure 10

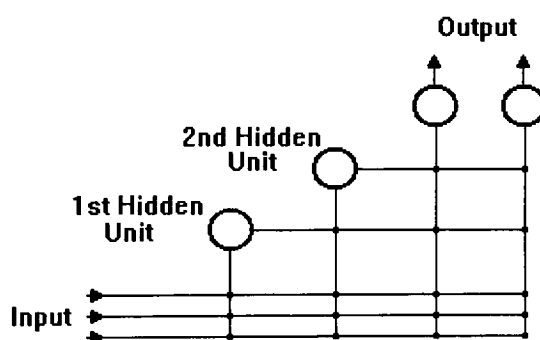


Figure 10

The network begins with no hidden neurons. The network is trained using the quickprop algorithm until the error value reaches a minimum. If this value is acceptable, the training is complete. If the error value is not acceptable, a new unit is added, its input weights are frozen and the output connection weights are then trained using the quickprop algorithm. The process continues again until the training is acceptable, or another unit is added, or the process is halted.

To add a new neuron, the system begins with a pool of candidate units. Each of the candidate neurons are initialized with a different set of random input weights. All of these neurons receive input from all of the network's initial inputs as well as from all of the existing hidden neurons. The outputs of these neurons are not yet connected to the remaining network. A number of passes over the training data is used to adjust the input weights. The goal is to maximize the magnitude of the correlation between the new neurons output and the residual error signal. This correlation (actually co-variance) is:

$$S = \Sigma | \Sigma (V_p - V') (E_{p,o} - E') | \quad (\text{Eq. 13})$$

where:

o = network output at which error signal is measured

p = training pattern

V = candidate neuron output value

E_o = residual output error observed at neuron o

V' = value of V averaged for all input patterns

E' = value of E_o averaged for all input patterns

The correlation value S is maximized using the quickprop training algorithm. When the training is complete for the pool of candidate neurons (patience is exhausted), the neuron with the largest correlation to the error is inserted into the network.

The use of the candidate pool greatly reduces the risk of installing a neuron that was "untrainable". It allows the system to try many different areas in weight space to find a good solution.

The network architecture used for this Thesis was Cascade Correlation. The system had 64 input neurons with 10 output neurons. The 64 input neurons correspond to the feature vector extracted from the original pixel maps. A major purpose of the feature extraction algorithm was data compression. If the feature extraction had not been run, the input layer of the network would have had 256 neurons.

The 10 output neurons correspond to the ten digits 0 through 9. Because this is a classification problem, the target for these 10 neurons each

have one of the output neurons equal to +0.5 and the remaining 9 output neurons equal to -0.5.

The database of 1200 handwritten digits was divided into two separate sets. The first set of 600 was used for training of the network; the second set of 600 digits was used for testing. The original database contained ten attempts by twelve individuals to write the ten digits. The database was split such that each set (training and testing) contained 5 attempts by all twelve individuals at writing the ten digits.

The training of the network required 345 epochs. An epoch is one complete pass through the training data. Upon completion, when there were zero errors, the Cascade Correlation algorithm added only 2 hidden neurons.

Once the network was trained, the test data was used as input into the network. For each input vector, the output of the network was recorded. This included what input pattern was presented to the network, the classification of the vector by the network and the output value for all of the output neurons. This information was kept for use in the next stage of the system, the context interpreter, utilizing Hidden Markov Modeling.

The network was able to correctly classify 529 of the 600 test file patterns for a success rate of 88.2 percent. Specific details describing the results are discussed in section 4.0.

3.3 Context Interpreter (Hidden Markov Modeling)

The third and final stage of our system is the context interpreter. This stage uses a knowledge about the dependencies between the characters within the words to help determine the correct classification of the words. This stage is added to the output of the neural network classifier because to date, neural networks are not well suited for dealing with time varying input patterns and segmentation of sequential inputs [12].

The technique for modeling the context of the words is Hidden Markov Modeling (HMM). This is a statistical approach for modeling an observed sequence of patterns. This is in contrast to other models that utilize syntax and semantics to model the context of the desired patterns.

Hidden Markov Modeling techniques have been used for speech recognition problems for numerous years. There are strong similarities between speech recognition and character recognition, which makes the use of Hidden Markov Models a logical choice for optical character recognition.

A Hidden Markov Model is a doubly stochastic process with an underlying stochastic process that is not directly observable (hidden), but can only be observed through another set of stochastic processes that produce the sequence of observed symbols [13].

The HMM is a collection of states with interconnecting transition arcs. Associated with each state is an observation probability. This is the probability of being in any given state at any given time. Associated with the transition arcs are transition probabilities. These define the probabilities of moving from one state to another.

In terms of optical character recognition, the observation probabilities are defined as the probabilities that a specific object is represented by the given input pattern. The higher the probability, the more certain the recognition process for that particular pattern.

The transition probabilities are defined as the probabilities of having one character follow another character within the word. For example, in English, there is a higher probability that the character "U" will follow the character "Q" than the probability that the character "Z" will follow the character "Q".

This type of modeling can easily be expanded to provide global context, knowing the production rules that generate the language being modeled.

Depending on the system being modeled, the "*a priori*" knowledge that is required is sometimes difficult to obtain.

For this Thesis, a single HMM was created and utilized. This model represented the entire language. The transition probabilities were based on all of the words in the language. An alternative approach would have been to create a model for each word, then test the vocabulary against every model. The model that produces the best results is interpreted as the model of the word being recognized. This approach commonly used in speech recognition.

Describing and using HMMs requires the definition of the formal symbolic terms. These are shown in Figure 11. Also shown, in parenthesis, are the descriptions of how these elements were defined for character word recognition.

The variables A , B and Π are the most critical, so for compactness, the HMM (λ) is represented as a function of those three variables:

$$\lambda = (A, B, \Pi)$$

When using HMMs to evaluate and model a specific domain, three problems must be solved for the model to be useful. These problems are evaluation, decoding and training.

The first problem, evaluation, states that, given a model and a sequence of observations, calculate the probability that the observed sequence was produced by the model.

The most straightforward approach to solving this problem is the "brute force" method. This method calculates the probability for every possible state sequence of length T . This procedure quickly becomes unfeasible as the number of states (N) increases and the length of the observation sequence (T) increases. The number of calculations required to determine the probability is $(2T - 1)N^T$ multiplications and $N^T - 1$ additions.

In response to this problem, the forward-backward algorithm was developed [14]. With this procedure, the probability of partial observations up to a given state are calculated from the beginning of the model. Also calculated is the probability of a partial observation back to a given state starting at the output of the model and working back. These two probabilities are summed. The number of calculations required for this algorithm are greatly reduced.

T	= length of observation sequence (number of digits in each word)
N	= number of states (number of different digits available)
M	= number of observation sequences (number of output digits)
Q	= $\{q_1, q_2, \dots, q_n\}$ individual states (individual digits)
V	= $\{v_1, v_2, \dots, v_m\}$ discrete set of possible symbol occurrences; (set of digits 0 through 9)
A	= $\{a_{ij}\}$, a_{ij} , state transition probability (probability one digit following another digit)
B	= $\{b_j(k)\}$, $b_j(k)$, observation probability distribution in state j ; (probability of an input vector representing each specific digit)
Π	= $\{\pi_i\}$, π_i , initial state distribution (probability of each digit being the first digit of a word)

Figure 11

The second problem, decoding, states that given a sequence of observations, what was the optimal path through the model (state sequence) that produced the observation. This uncovers the hidden portions of the model.

The Viterbi algorithm was developed to solve the decoding problem [15]. The formal steps for the Viterbi algorithm are shown in Figure 12.

Viterbi Algorithm

1. Initialization -- Set initial state values

$$\delta_1(i) = \pi_i b_i(O_1), \quad 1 \leq i \leq N$$
$$\Psi_1(i) = 0$$

2. Recursion -- Maximize state sequence

$$\text{For } 2 \leq t \leq T, \quad 1 \leq j \leq N$$

$$\delta_t(j) = \max[\delta_{t-1}(i) A_{ij}] B_j(O_t) \text{ for } 1 \leq i \leq N$$
$$\Psi_t(j) = \operatorname{argmax}[\delta_{t-1}(i) A_{ij}] \text{ for } 1 \leq i \leq N$$

3. Termination -- All states have been traversed

$$P^* = \max[\delta_T(i)] \quad \text{for } 1 \leq i \leq N$$
$$i_T^* = \operatorname{argmax}[\delta_T(i)] \text{ for } 1 \leq i \leq N$$

4. Backtrack -- Determine optimal state sequence

$$\text{For } t = T-1, T-2, \dots, 1$$
$$i_t^* = \Psi_{t+1}(i_{t+1}^*)$$

Figure 12

The algorithm finds the optimal state sequence for the observation sequence. To determine the optimal state sequence, the most likely state is determined at each instance in time (t). The probability is based on the probability of being in the previous state ($\Psi_{(t-1)}(i)$), the transition probability from the previous state to the current state and the observation probability of the symbol in the current state. This value, ($\Psi_t(i)$), is then maximized for all state possibilities. The determination of the optimal state sequences makes

the Viterbi algorithm well suited for dealing with recognition and segmentation.

The Viterbi algorithm was used for this paper to select the best sequence of states for the observed sequences. The net result of this function was the optimal state sequence. The sequence was interpreted as the context directed recognized word. The state sequence corrected mis-classified digits based on the context knowledge of the artificial language.

The third problem, training, examines how to optimize the parameters of the HMM so to maximize the probability of a given observation sequence. This allows for the adjustment of the HMM to best suit the domain.

This is the most difficult problem relating to the HMMs. There is no way to solve this problem analytically. The Baum-Welch algorithm was developed as an iterative technique [16]. The three variables (π , A and B) are re-estimated, then evaluated. If the probability of the observation sequence increases, then the new values are saved. The algorithm guarantees that either the probability improves or a critical point had already been reached where the probability had already been maximized.

In creating the HMM for this application, the initial probabilities (π) used were the same probabilities used to generate the vocabulary. These probabilities are shown in Figure 3. The transition probabilities (A), were determined by examining the vocabulary. The transition probabilities are shown in Figure 13. These are slightly different than the transition probabilities used to generate the language (see Figure 4) because of rounding.

	0	1	2	3	4	5	6	7	8	9
0	0.122	0.00	0.00	0.122	0.073	0.073	0.073	0.073	0.122	0.341
1	0.047	0.116	0.116	0.047	0.116	0.023	0.047	0.047	0.419	0.023
2	0.000	0.059	0.353	0.00	0.00	0.00	0.00	0.500	0.029	0.059
3	0.082	0.082	0.000	0.061	0.143	0.061	0.449	0.061	0.00	0.061
4	0.154	0.115	0.038	0.038	0.077	0.423	0.115	0.000	0.038	0.000
5	0.094	0.062	0.031	0.062	0.312	0.156	0.062	0.094	0.062	0.062
6	0.000	0.034	0.034	0.661	0.017	0.000	0.000	0.119	0.119	0.017
7	0.094	0.000	0.469	0.000	0.094	0.062	0.125	0.031	0.062	0.062
8	0.032	0.355	0.032	0.032	0.194	0.032	0.032	0.097	0.129	0.065
9	0.434	0.038	0.038	0.019	0.000	0.113	0.151	0.000	0.00	0.208

Figure 13

The observation probabilities (B) used for the model were generated from the neural network. The output values from each output neuron were recorded for every input vector. The output values were then normalized and used as the observation probabilities.

A different set of observation probabilities were used for each person's attempt in writing the ten digits. This maintained integrity and uniqueness between attempts. This is based on the premise that an individual's handwriting style will differ from attempt to attempt but will remain fairly constant within an attempt.

Utilizing the output of the neural network this way resulted in 60 separate observation probabilities, which were used in conjunction with the 100 word vocabulary. The words provided the sequence of the symbols while the output of the network provided the observation probability. Using the 100 words with the 60 observation probability matrices resulted in the classification of 6000 unique words.

For this application, a Hidden Markov Model containing 10 states was used. Each state represented a single digit. The model was considered non-ergodic because the state transition network was not fully connected. This is shown in the transition probability matrix where a probability value of 0 indicated that it was not possible to go directly from one state to another state.

Each word in the vocabulary was used as the observed sequence input into the HMM. The Viterbi algorithm was used to determine the optimal path through the model for the given sequence. The output of the Viterbi algorithm was then interpreted as the final classification for the characters in the word and thus the final classification for the word.

The specific results for the HMM are discussed in section 4.3.

4.0 Results and Conclusions

Execution of the entire recognition system required a three step process. The first step was the feature extraction. The neural network program was executed next, and then finally the Hidden Markov Model was created and executed. The next section discusses the results from each step in the process.

4.1 Feature Extraction Results

The feature extraction algorithm was implemented using standard "C" language. The program was designed specifically for this application. Input into this program was the normalized pixel maps saved in ASCII format. The output feature vectors were saved in ASCII format, each in separate files, in a database. The output feature vector consisted of the 64 elements representing the four sub-features for each sub-window of the pixel map. The feature extraction program also appended the desired classification "target" vector to the feature vector. The classification vector values represented the desired output from the neural network output neurons. These vectors were appended so they could be used by the neural network for training and testing purposes. Nine of the ten additional values were -0.5. The remaining value, which corresponded to the desired output, was a +0.5.

The accuracy and effectiveness of the feature extraction algorithm was best measured and determined by the output of the neural network. Certain conclusions can be made by examining the resulting confusion matrix from the neural network. This data shows that the four sub-features used, were not enough to accurately classify all of the input patterns. Two additional sub-features, one being a horizontal line, and the other being a vertical line should be added to the feature extraction algorithm.

An inverse feature algorithm was not developed. The purpose of this algorithm would have been to recreate the pixel maps from the output feature vectors. The recreated pixel map could then be compared to the original map for accuracy and effectiveness. This task is left for future research.

4.2 Neural Network Results

The Cascade Correlation network was used. As mentioned previously, 600 feature vectors were used for training purposes. The remaining 600 vectors were used for testing. The first five attempts by each individual were used for training. The second 5 attempts were used for testing.

The network consisted of 64 input neurons and 10 output neurons. The number of neurons in the hidden layers was determined by the Cascade Correlation algorithm.

The network required 345 epochs to become fully trained. An epoch is defined as one complete pass through all of the training data. At the completion of the training process, the network was able to successfully classify all of the training data with no errors. This process required 65.5 minutes running on a Sun 3/160 workstation. During this training process 2 hidden neurons were added to the network. The first hidden neuron was added after epoch 100. The second hidden neuron was added after epoch 264. With zero hidden units the network was unable to correctly classify 103 of the 600 characters for an error rate of 17.2 percent. With one hidden unit, the network was unable to correctly classify 22 of the 600 characters for an error rate of 3.7 percent. With the two hidden units, the network successfully classified all of the characters presented as training data.

For the testing phase of the neural network operation, a single feature vector was applied to the input neurons. The desired classification, the actual classification and the normalized output neuron values were all recorded. The desired and actual classification values were compared to determine how well the neural net performed as a classifier. The normalized output values were recorded so they could be used by the HMM as the observation probabilities. This process was repeated for all 600 feature vectors used for testing.

The testing set of data was presented to the network. The network was able to classify 529 of the 600 digits correctly for an overall accuracy of 88.2 percent. The accuracy for the twelve individuals varied between 82 percent and 96 percent as shown in Figure 14.

Different approaches were tried for separating the training and testing data. Training the network using half of the available data for each individual and then testing the remaining half, produced the best results.

While this was optimal for these purposes, this may not be feasible in other applications.

A second approach that was tested, was to use all of the handwritten attempts from the first 6 individuals for training, and then use all of the handwritten attempts of the remaining 6 individuals for testing. This approach would be more realistic in those applications where it would be impossible to obtain handwriting samples from all of the individuals that were to be processed. Using this training approach, the network was able to correctly classify 477 of the 600 digits for an accuracy of 79.5 percent.

Individual	Correct	Wrong	Accuracy
Bill	44	6	88 %
Bob	42	8	84 %
Donnie	43	7	86 %
Greg	48	2	96 %
HPG	46	4	92 %
Isa	48	2	96 %
Larry	47	3	94 %
Rich	41	9	82 %
Sara	42	8	84 %
Stuart	41	9	82 %
Tony	41	9	82 %
Wayne	46	4	92 %
TOTAL	529	71	88.2 %

Figure 14

The output classifications were compared to the desired classification. This data was organized into a "confusion matrix", as shown in Figure 15. The first column is the desired output digit. The top row represents the actual output digits. The matrix is filled in with a count for each classification. From this, it can be determined how the incorrect digits were mis-classified. The inconsistencies can be easily identified.

Confusion Matrix

		Actual Neural Net Output									
		0	1	2	3	4	5	6	7	8	9
Desired Output Classification	0	51		1	5	1				2	
	1		60								
	2	1	3	52		1			1	1	1
	3				55		1		2	2	
	4	1		1	1	45	2				10
	5		2		3		54		1		
	6							60			
	7		4						55		1
	8		1	4	3			1	2	47	2
	9		1		1	4			2	2	50

Figure 15

Note: The sum of each row equals 60.

From the confusion matrix, the following observations are made:

Digit 0: Confused mostly with the digit "3". Two sub-features were not detected. The center horizontal element of the "3" and the vertical side elements of the "0" were missing. This could be improved by adding both a horizontal and vertical line sub-features to the feature extraction algorithm (see Figure 5).

Digit 1: Perfect Recognition

Digit 2: Confused mostly with the digit "1". Examination of the incorrectly classified original pixel maps shows the "2" that looks like a "1". The main vertical sections of both digits have similar slopes. The horizontal elements of the "2" are not being detected. It appears the curvature of the top of the "2" was lost due to the resolution of the

scanned image. Adding a horizontal line sub-feature to the feature extraction could improve the recognition for the digit "2".

Digit 3: Confused with both the digits "7" and "8". The vertical elements of the "8" were not detected. The center horizontal element of the "3" was also not detected, confusing it with the "7". Adding horizontal and vertical line sub-features to the feature extraction could improve the recognition for the digit "3".

Digit 4: Confused mostly with the digit "9". The top horizontal element of the "9" was not detected. Adding the horizontal line sub-feature to the feature extraction could improve the recognition for the digit "4" and also for the digit "9".

Digit 5: Confused mostly with the digit "3". The bottom half of the three and the five are very similar. The addition of a horizontal and vertical detector should improve the "5" recognition performance.

Digit 6: Perfect Recognition

Digit 7: Confused with the digit "1". Addition of the horizontal sub-feature should help detect the top horizontal line of the "7".

Digit 8: Confused with the digits "2" and "3". This is similar to the confusion for the digit "3".

Digit 9: Confused with the digit "4". This is the same problem as described for the digit "3".

Based on the results and observations of the confusion matrix, adding both horizontal line and vertical line sub-features to the feature extraction algorithm should improve the performance of the neural network.

While the addition of two sub-features to the feature extraction algorithm sounds like a simple step for improving the performance of the neural network, there are drawbacks that should be considered.

The addition of two sub-features to the feature extraction would increase the size of the feature vectors by 50 percent. The new feature vector would contain 96 elements. This increases the number of input neurons of the neural network to 96. While the specific results are unknown, it could be assumed that the training time would increase, and the number of hidden neurons might also increase.

4.3 Hidden Markov Model Results

The neural network showed an accuracy of 88.2 percent. With this result, one can conclude that for any given input into the neural net, there is an 88.2 percent probability that the character is classified correctly. This probability for classification is for a single digit only. If the domain is expanded to a word with five characters, then the accuracy rating for the entire word would be 88.2 percent for the first character, 88.2 percent for the second character and so on through the fifth character. Expressed symbolically, the probability of all of the characters within the word being classified correctly is:

$$P_w = (P_c)^n$$

Where:

P_w = Accuracy of word recognition

P_c = Accuracy of single character recognition

n = number of characters in the word

For this application, one would then expect an accuracy for word recognition to be:

$$P_w = (0.882)^5$$

$$P_w = 0.534$$

or only 53.4 percent of the words being classified correctly. The purpose of the HMM was to improve this performance.

The 100 word vocabulary was used to generate the input sequences into the HMM. The actual sequences were derived from the output of the neural network. For example, assume attempt 1 for Bill was being tested and the vocabulary word used as a sequence was "54612". The actual neural network output of attempt 1 for Bill was "34612". The sequence 34612 was used as the input observed sequence into the Viterbi algorithm.

The normalized output values of the output neurons for the attempt and person were used as the observation probability for the HMM. Different approaches were tested to determine the optimal values for the observation probabilities. These values worked the best.

The confusion matrix from the neural network was also normalized to provide observation probabilities. This proved to be quite ineffective. While there were more outputs with observation probabilities, the ratio between the correct output and the incorrect outputs was too large.

The program that implemented the HMM also recorded the desired input sequence (vocabulary word), the actual input sequence and the output of the Viterbi algorithm. The output of the Viterbi algorithm was compared to the desired input sequence for accuracy.

The overall results from the HMM are shown below:

Total number of words tested:..... 6000

Total number of words in error (Pre-HMM): 2223

Error Rate (Pre-HMM)..... 37%

Success Rate (Pre-HMM)..... 63%

Total number of words in errors (Post HMM) 1026

Error Rate (Post-HMM) 17.1%

Success Rate (Post-HMM) 82.9%

Total number of words corrected 1197

Correction rate 53.8%

The above statistics show that the use of Hidden Markov Models for adding context information to character recognition improved the overall recognition rate by 19.95 percent.

The results for each individual are shown in Figure 16. The accumulated results for each individual is based on five attempts through the 100 word vocabulary or 500 words. The overall recognition rate for each word is slightly higher than what was expected. The HMM was able to correct 53.8 percent of the words in error.

Individual	Pre-HMM		Post HMM		Percent
	Errors		Errors		Corrected
Bill	171	65.8%	77	84.6%	55.0%
Bob	252	49.6%	128	74.4%	49.2%
Donnie	247	51.0%	115	77.0%	53.4%
Greg	80	84.0%	45	91.0%	43.8%
HPG	119	76.2%	46	90.8%	61.3%
Isa	81	83.8%	58	88.4%	28.3%
Larry	108	78.4%	57	88.6%	47.2%
Rich	272	45.6%	128	74.4%	52.9%
Sara	249	50.2%	111	77.8%	55.4%
Stuart	252	49.6%	96	80.8%	61.9%
Tony	257	48.6%	118	76.4%	54.1%
Wayne	135	73.0%	47	90.6%	65.2%

Figure 16

Upon examining the observation probabilities that were output from the neural network, it was evident why the HMM was unable to correct all of the words. The observation probabilities showed that the neural net misclassified some of the patterns. The observation probabilities for these incorrect classifications were also very close to 1.0. This indicated that while the neural net was wrong, it was sure that the classification that it performed was correct. Through experimentation and changing the observation probabilities, the overall correction rate and performance of the HMM improved. This leads to the assumption that by making the neural

network less sensitive, perhaps the overall performance of the system could be improved.

4.4 Conclusion

The objective of this thesis was to show the feasibility of adding contextual information to text recognition. The above results show that this can be achieved.

The major benefit of the neural network is its ability to classify or recognize patterns. The neural network is not able to "remember" information from the previous classification for use with the current classification problem. This segmentation is one of the limitations of a neural network. Thus, the neural network by itself is not suited for context directed pattern recognition.

The Hidden Markov Model is unable to classify or recognize single patterns effectively. Its strength is in its ability to retain information regarding previous classifications. The HMM is a statistical model of how the language is constructed.

The proposed system utilized the strengths of feature extraction and neural networks for character classification, coupled with the strengths of the Hidden Markov Model to include contextual information. The result is a system that can classify and recognize words based on sub-features within each character and the contextual content between characters.

5.0 Recommendations for Future Research

The concepts reported here were developed using digits as characters and were limited to words which were five characters long. The digits were used because of the availability of the large handwritten database. These concepts need to be expanded into other domains using other types of input. Much work has been done on this in the area of speech recognition.

The results of the proposed system show great promise. Limitations were also discovered that need to be overcome. These limitations provide the

basis for future research. These limitations can be categorized according to their specific sub-system.

The feature extraction methods need to be expanded. The method shown here did not detect horizontal or vertical lines. The addition of these two features should improve the success rate of the neural network, although it may affect the network training times.

Different feature extraction algorithms could also be explored. The major benefits of the algorithm we used was its simplicity and the output vector created provided a 4 to 1 compression ratio of the original pixel map.

The Hidden Markov Model assumed that the language is a Markov source. This method requires an *a priori* knowledge of the statistical structure of the language. This was possible for this Thesis because the language was generated using a pre-determined statistical structure. As this method is expanded across other domains, this knowledge will be more difficult to obtain. If this knowledge can be obtained, its accuracy remains in question. This leads to the conclusion that for some domains, other methods of providing contextual information may need to be explored. This could include hybrid dictionary look-up methods or syntactical grammar checkers

The Hidden Markov Model presented in this Thesis modeled the transitions of the characters for the entire language. This produced a smoothing effect. Future research could focus on creating individual HMMs for each word. The output of the neural network would then be fed into each HMM. The model with the best result would then represent the word the system selected.

The proposed system is used to classify or recognize individual words. This type of system could easily be expanded to the next level of recognition and sentence recognition or natural language processing. Grammars could be incorporated as HMMs, augmented transition networks or various other techniques to ensure classifications not only at the character and word level, but also as complete sentences.

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Appendix A

name *Bill Gardner*

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name BET BEHRINGEN

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style	0	1	2	3	4	5	6	7	8	9
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name Donnie

	0	1	2	3	4	5	6	7	8	9
Attempt A	○	1	2	3	4	5	6	7	8	9
Attempt B	○	1	2	3	4	5	6	7	8	9
Attempt C	○	1	2	3	4	5	6	7	8	9
Attempt D	○	1	2	3	4	5	6	7	8	9
Attempt E	○	1	2	3	4	5	6	7	8	9
Attempt F	○	1	2	3	4	5	6	7	8	9
Attempt G	○	1	2	3	4	5	6	7	8	9
Attempt H	○	1	2	3	4	5	6	7	8	9
Attempt I	○	1	2	3	4	5	6	7	8	9
Attempt J	○	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name *Gray*

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name HPG

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name ISABELLE

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name Larry

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name

Ray

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name SARA A. SOLLA

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name STUART MACHIE

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Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

Style

0	1	2	3	4	5	6	7	8	9
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name Tony

	0	1	2	3	4	5	6	7	8	9
Attempt A	0	1	2	3	4	5	6	7	8	9
Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

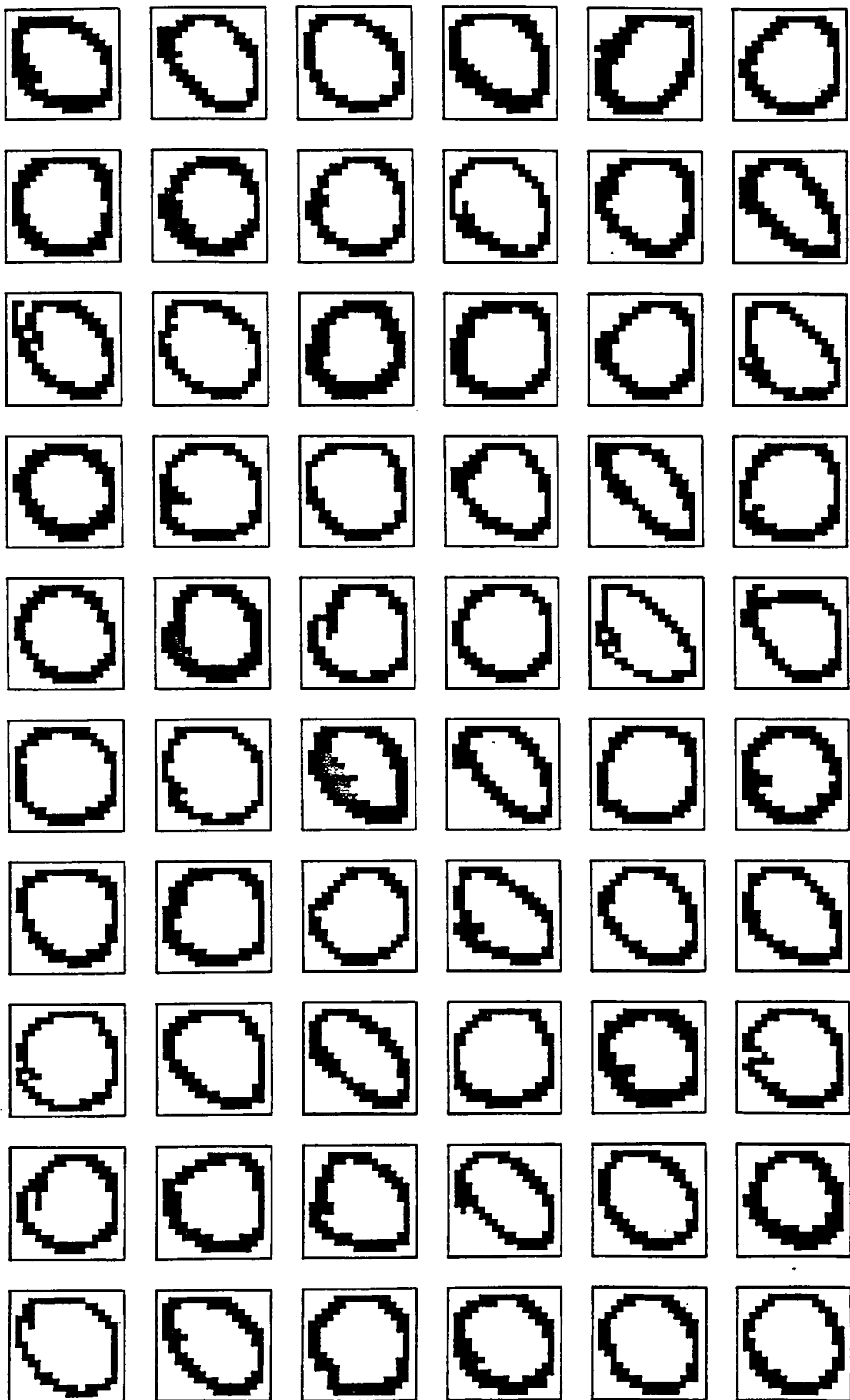
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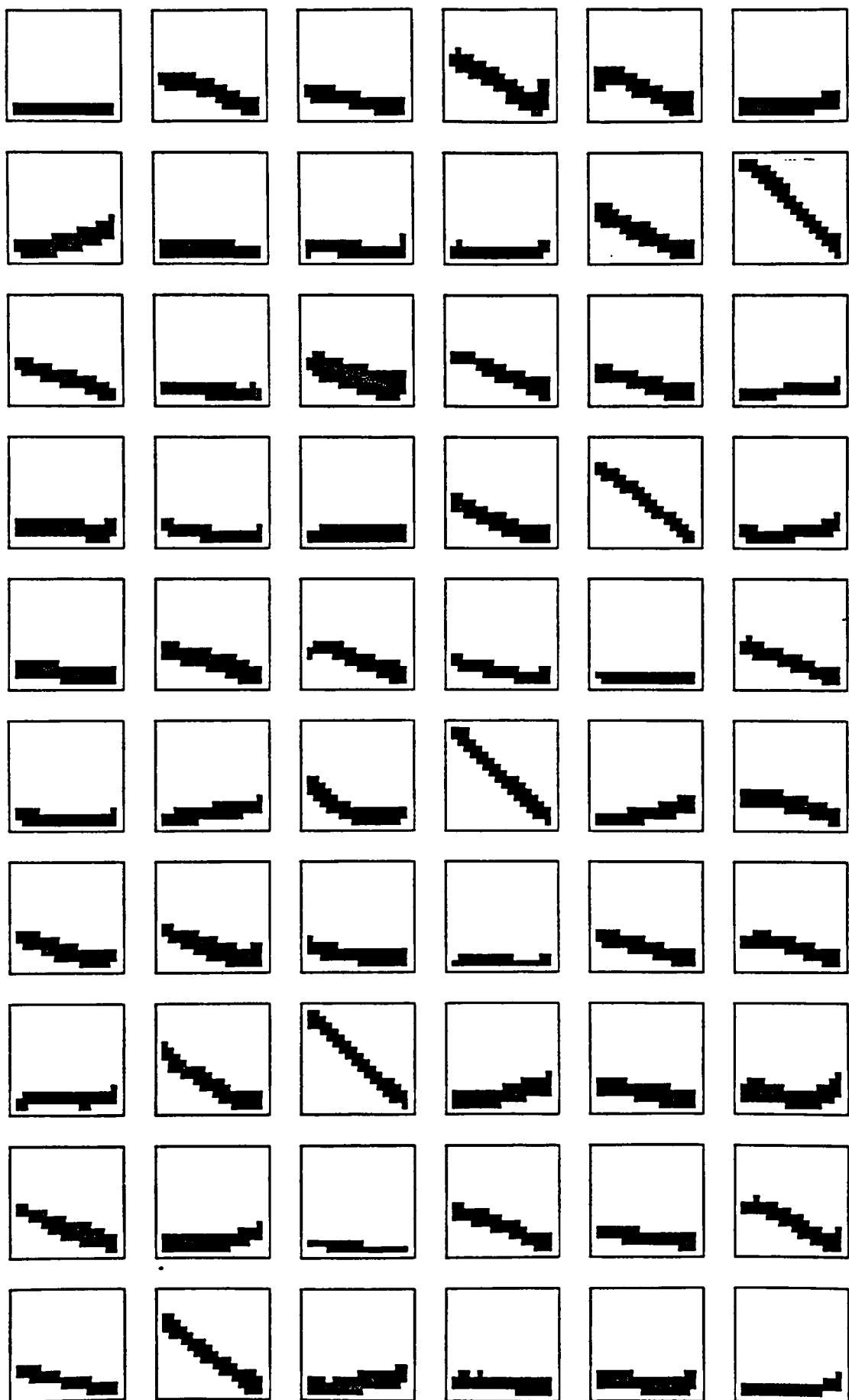
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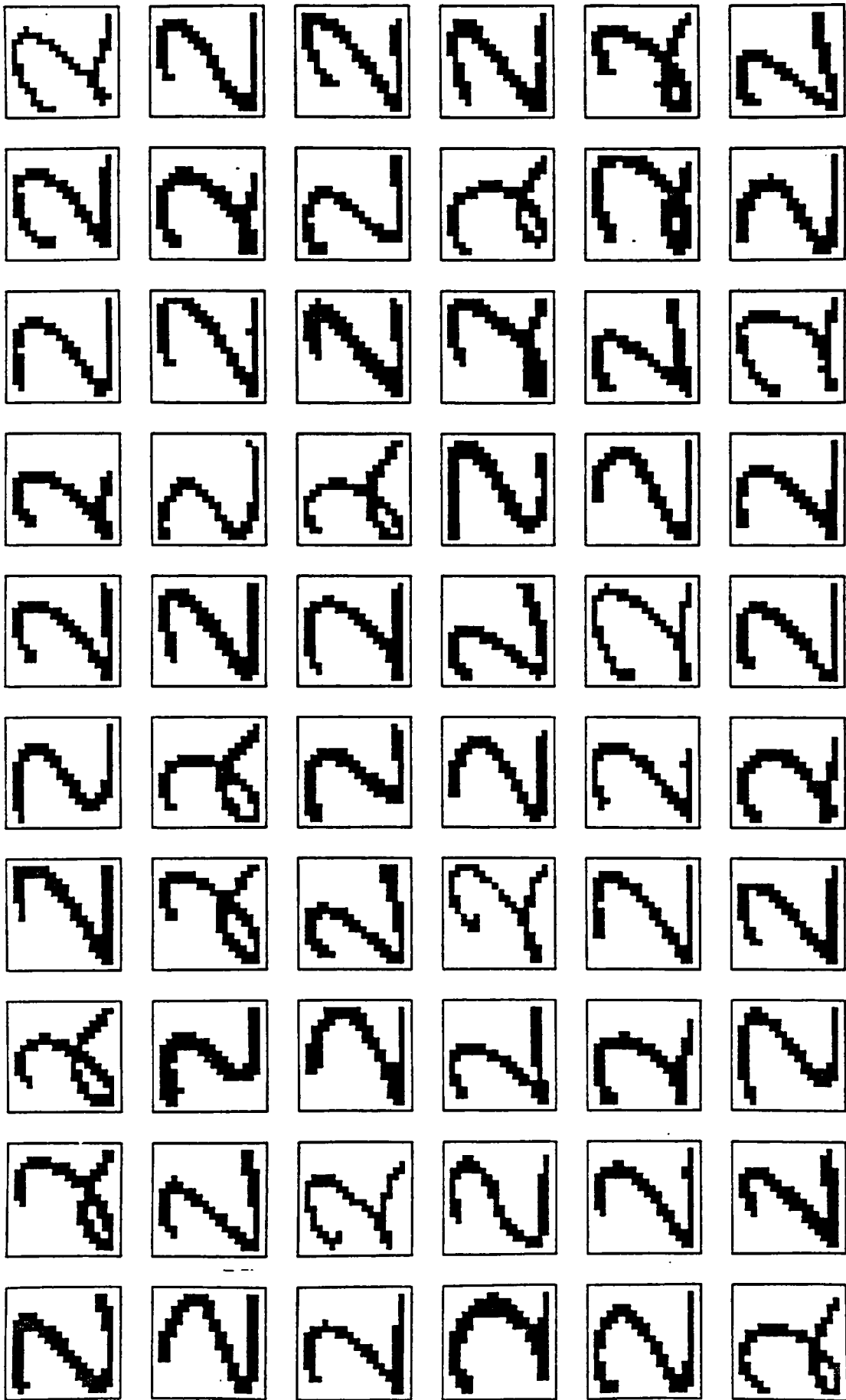
name *wzyu*

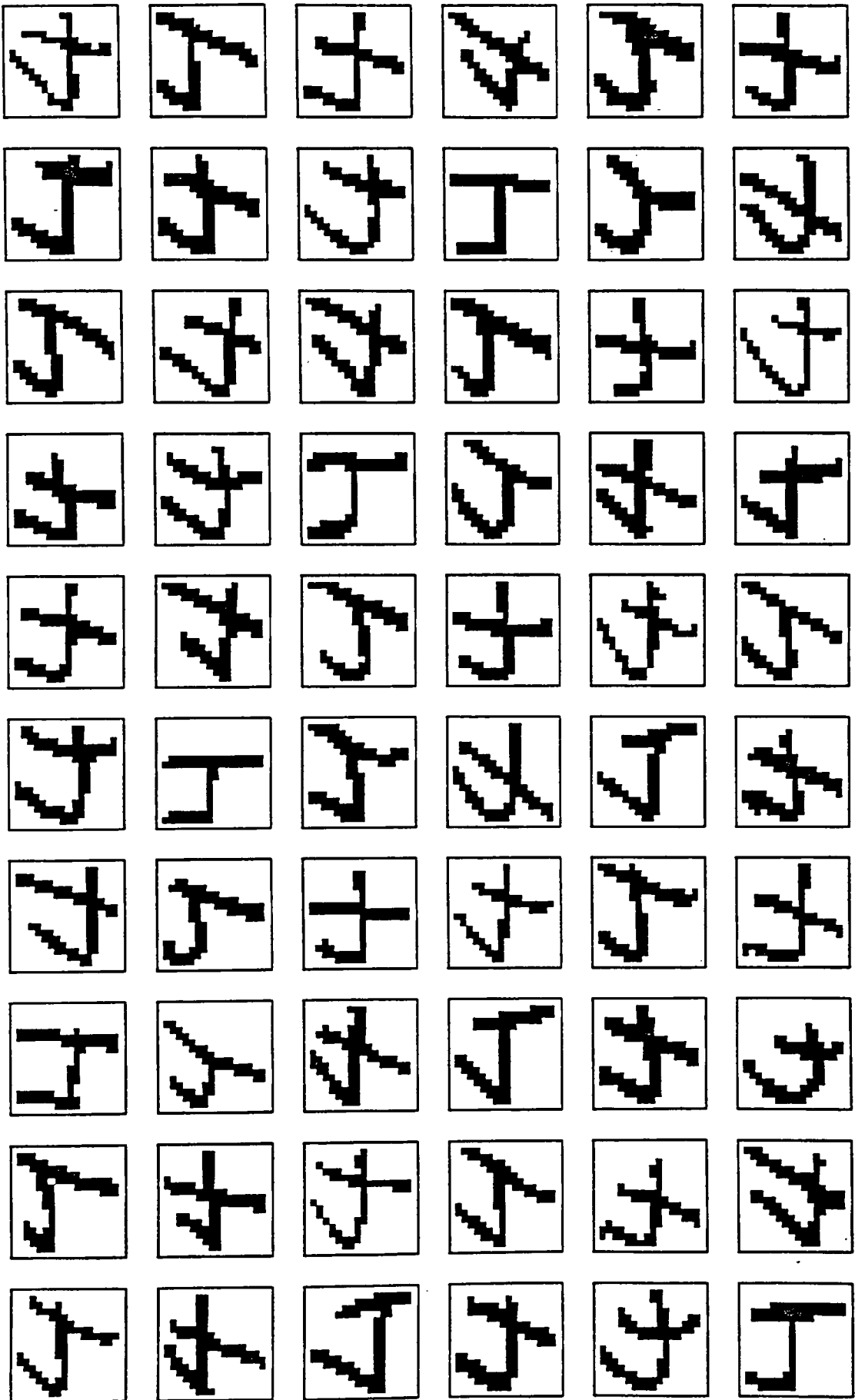
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Attempt B	0	1	2	3	4	5	6	7	8	9
Attempt C	0	1	2	3	4	5	6	7	8	9
Attempt D	0	1	2	3	4	5	6	7	8	9
Attempt E	0	1	2	3	4	5	6	7	8	9
Attempt F	0	1	2	3	4	5	6	7	8	9
Attempt G	0	1	2	3	4	5	6	7	8	9
Attempt H	0	1	2	3	4	5	6	7	8	9
Attempt I	0	1	2	3	4	5	6	7	8	9
Attempt J	0	1	2	3	4	5	6	7	8	9

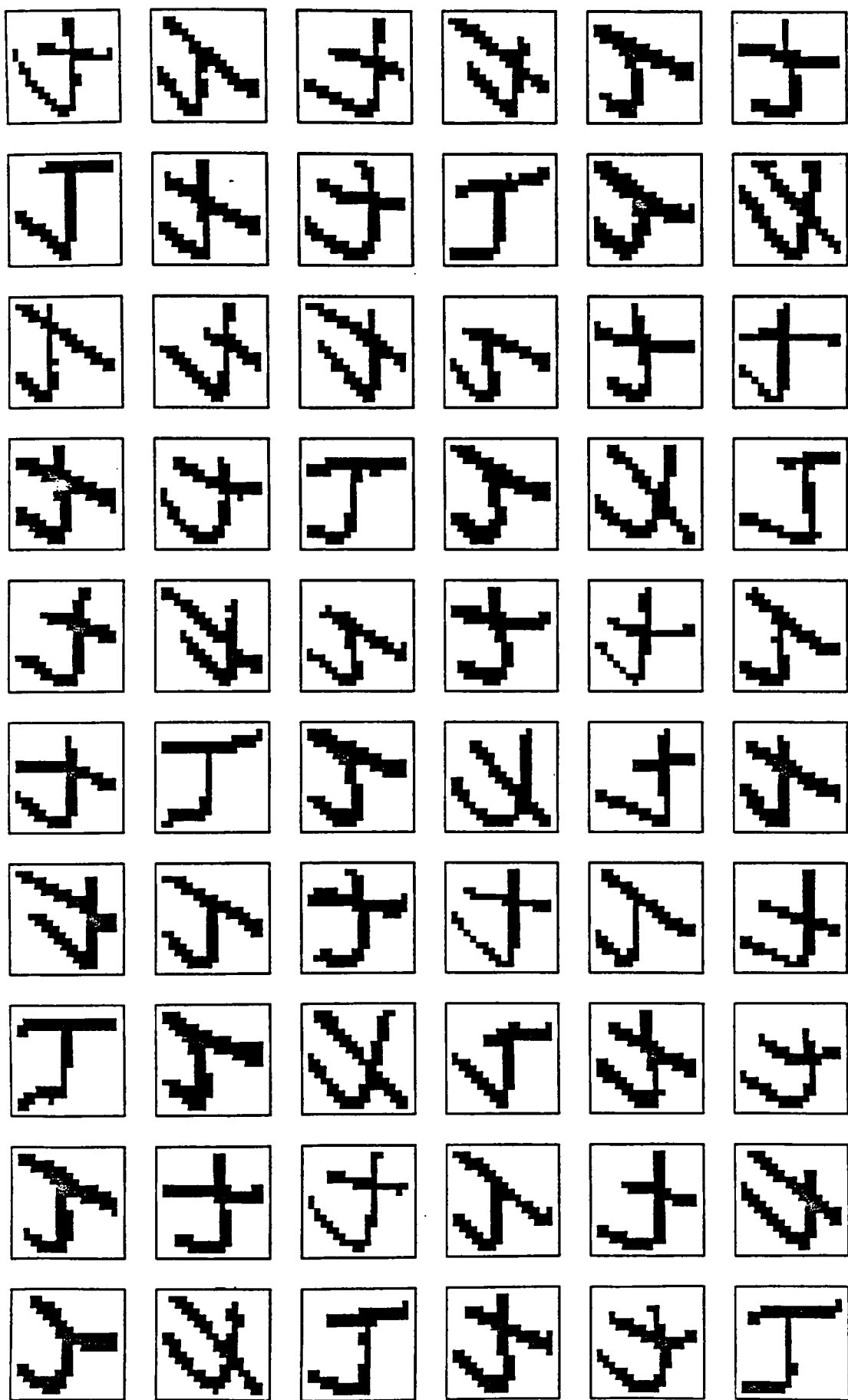
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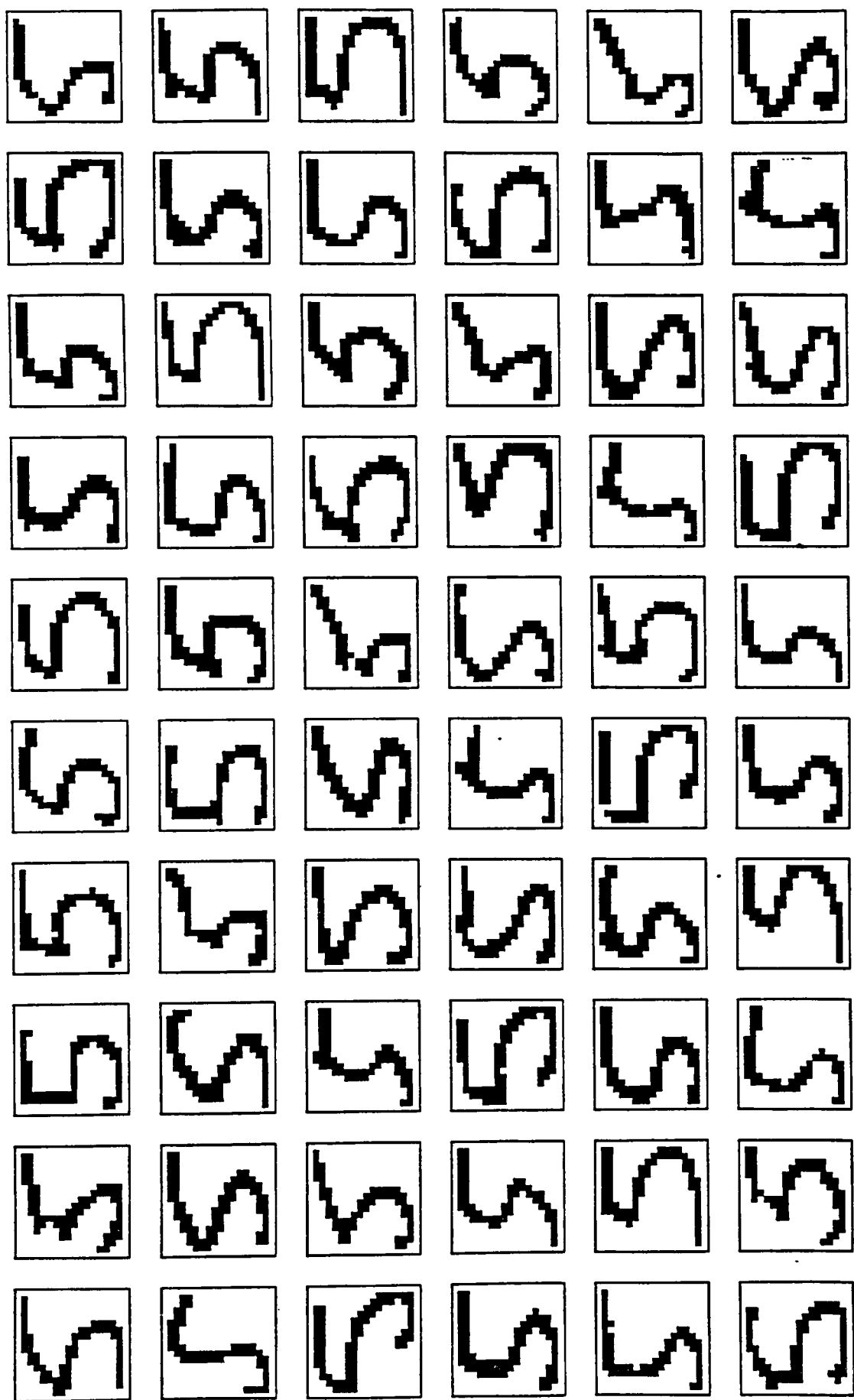


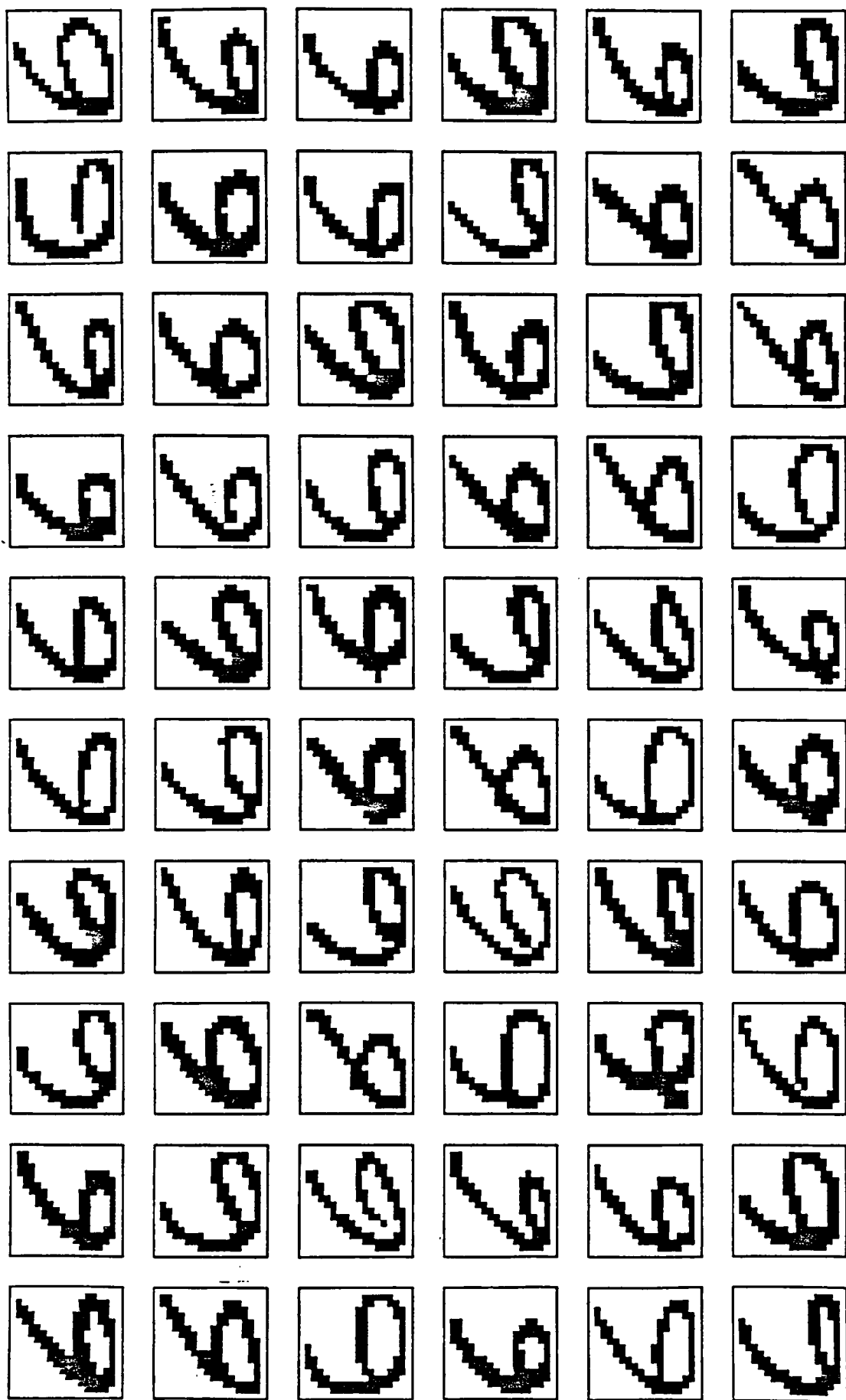


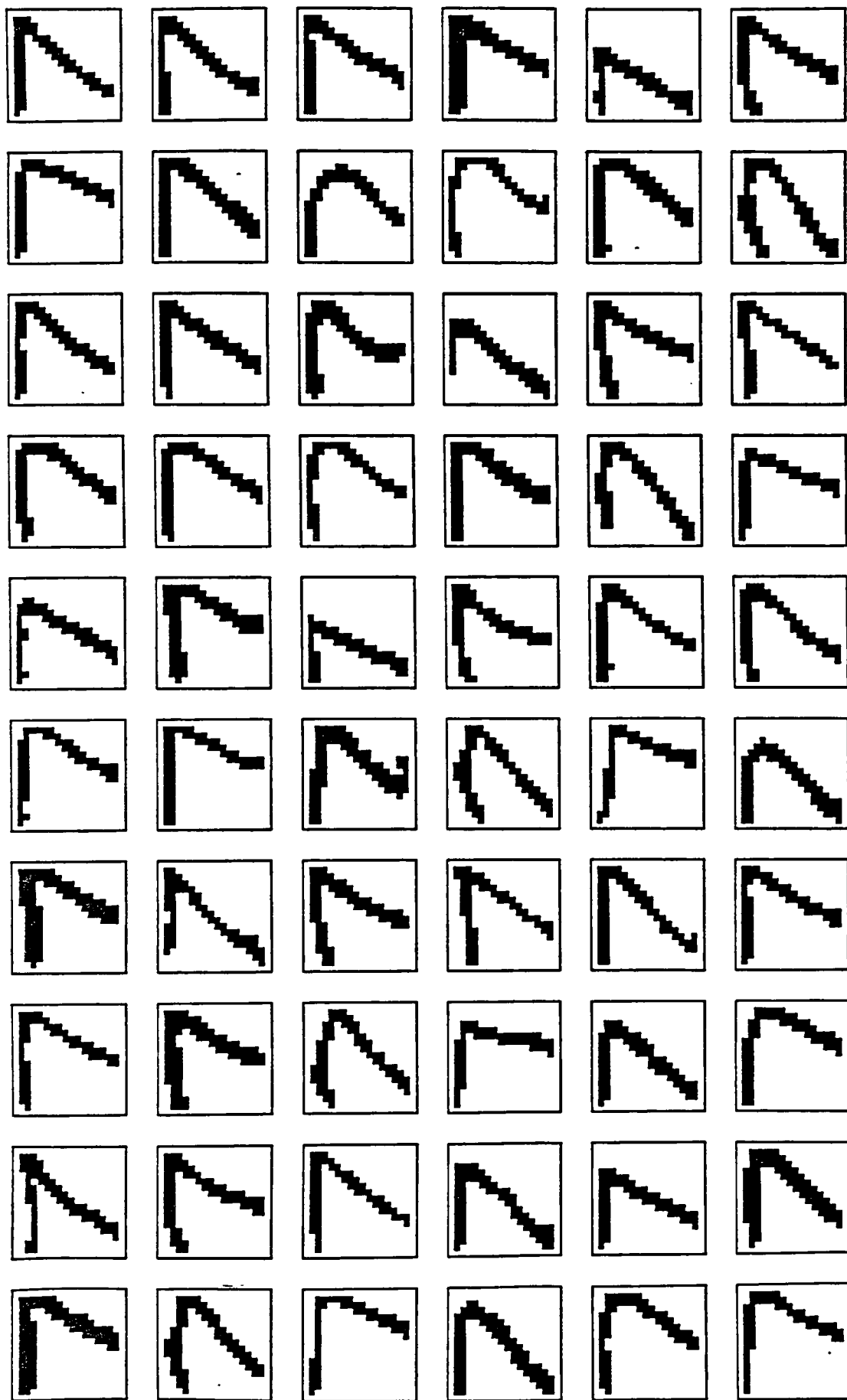


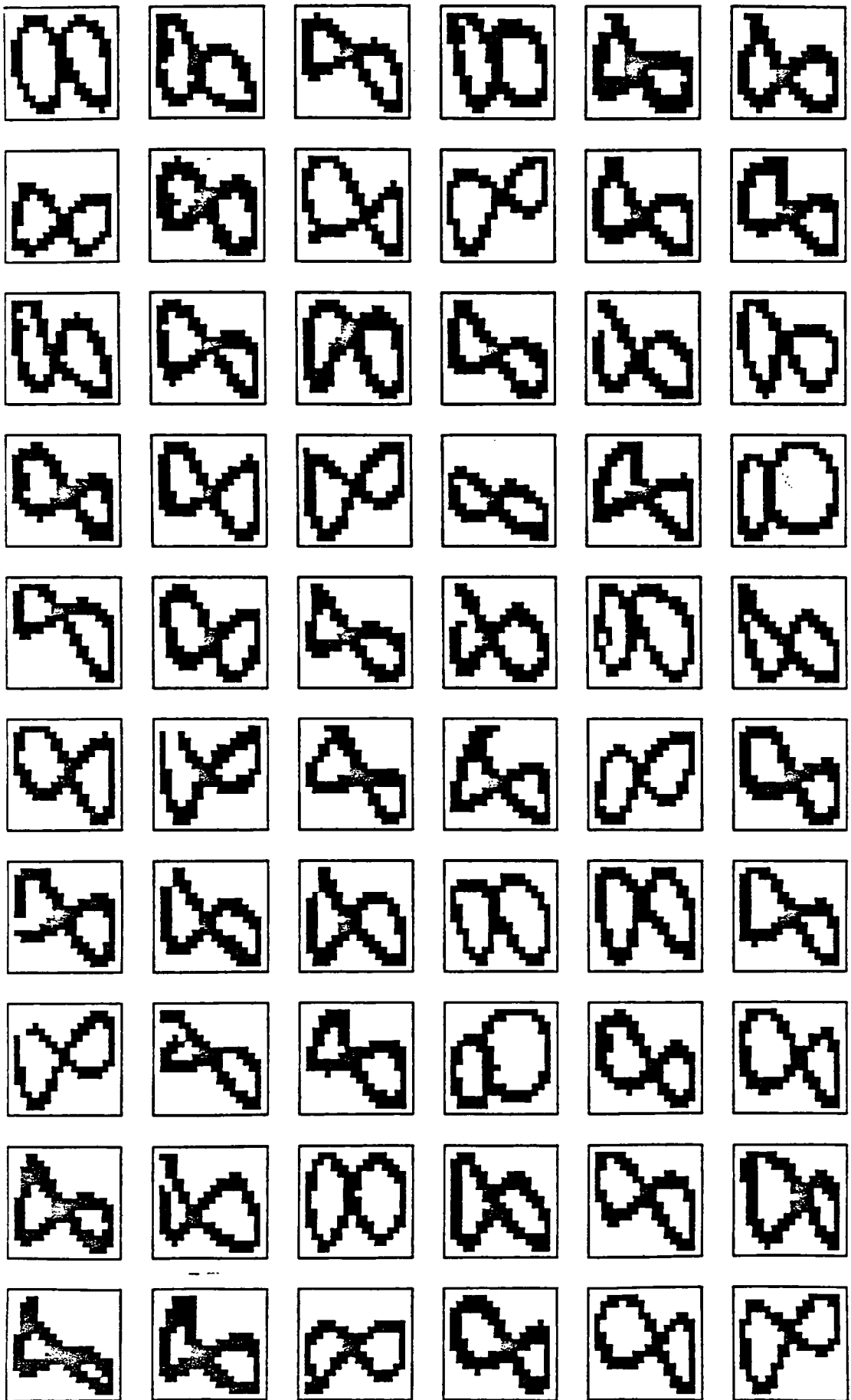


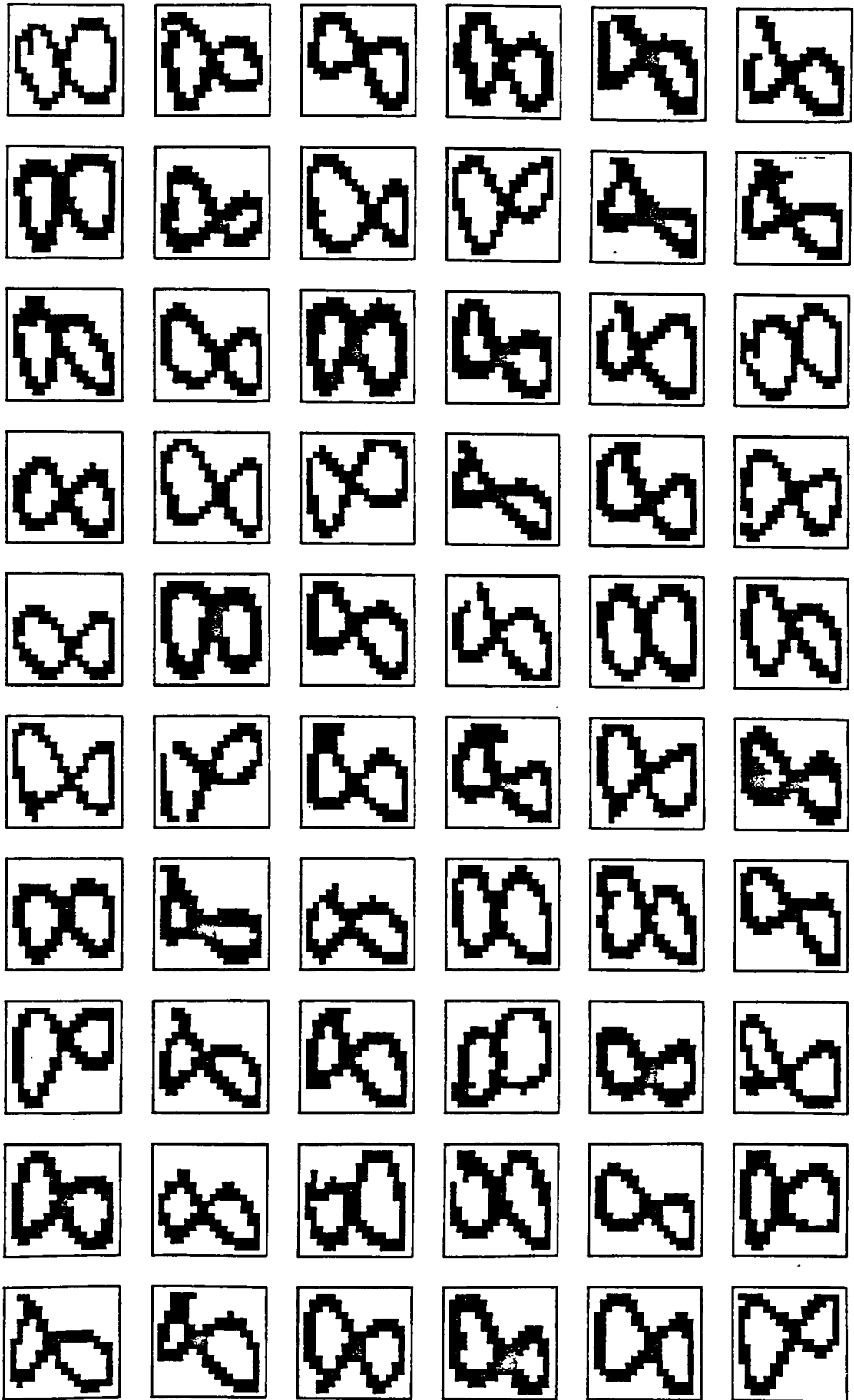


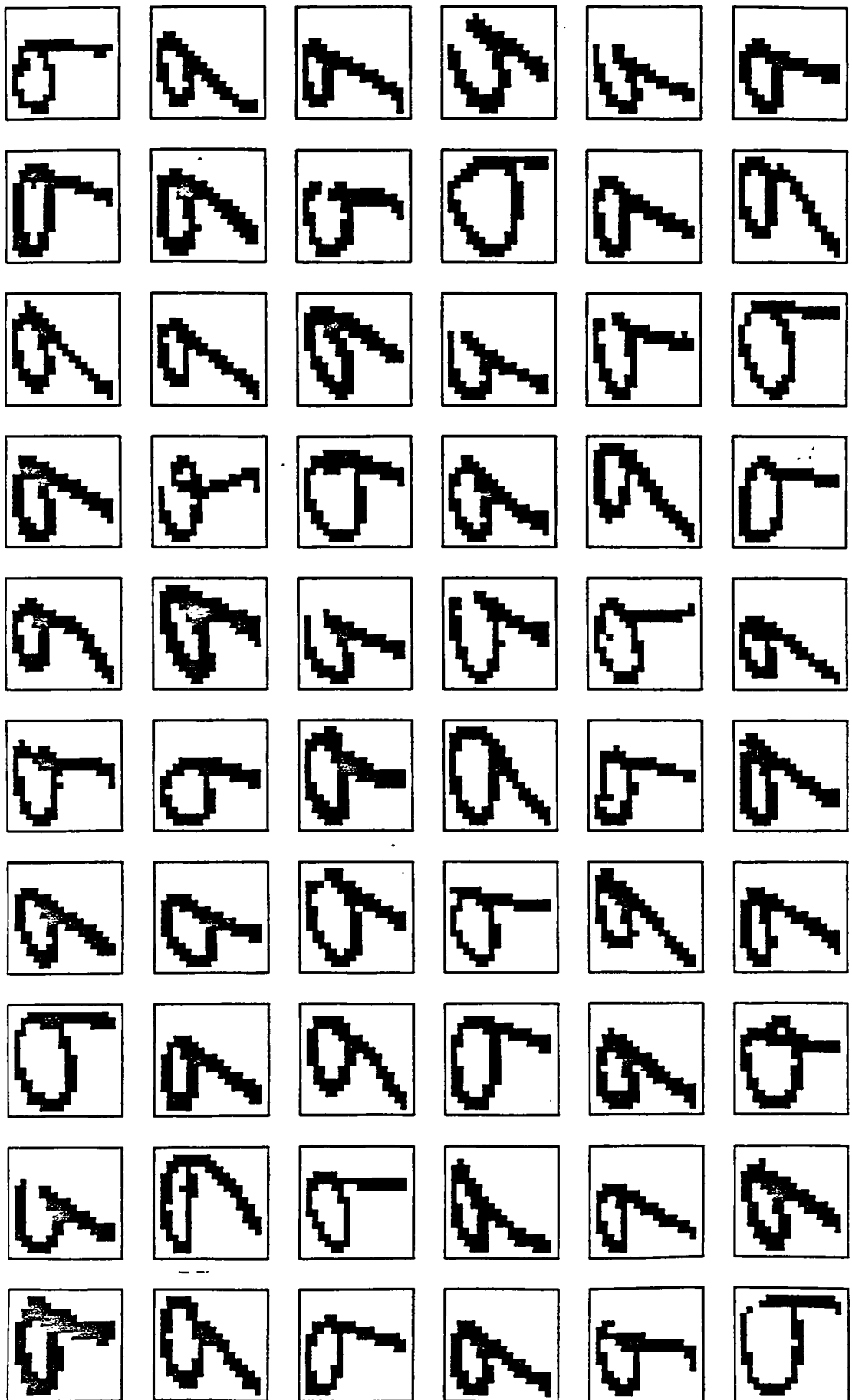












Appendix B

Artificial Language Vocabulary

00367	22272	63187	90090
03399	22274	63411	90445
08729	27053	63456	90550
09009	27227	63545	90636
09999	28088	63627	90768
10990	30906	63630	90846
11818	34578	63631	90896
12745	36343	63634	90909
12751	36363	63635	90968
13722	36840	63636	90964
14090	50354	63639	91170
14163	51463	63672	92703
16727	53957	67218	93458
17684	54545	67276	95221
18107	54612	67727	95455
18115	55404	68122	95548
18181	56379	68187	96314
18227	57275	68544	96333
18363	58454	72296	96909
18405	59142	72795	99041
18681	61222	74500	99063
18818	62784	76308	99090
18881	63037	89272	99559
19672	63134	90072	99963

Appendix C

Neural Network Output Observation Probabilities

This section shows the actual output from the neural network. This page describes the training and testing parameters and results. The remaining pages show the output values. For the output values, column 1 is the desired output, column 2 is the actual output, while columns 3 through 12 are the output values for the digits 0 through 9.

Mon Apr 1 22:58:58 EST 1991

Silent or interactive (s/i)? : 4x4 filter applied 16 times.

This test uses 12 people. half all attempts for training
the other half of all attempts for testing.

#

Network: test99

Inputs' training epoch limit: 100

Outputs' training epoch limit: 100

Maximum number of new units: 500

Number of trials: 1

Training score threshold: 0.100000

Testing score threshold: 0.490000

SigOff 0.10, WtRng 1.00, WtMul 1.00

OMu 2.00, OEps 0.35, ODcy 0.00010, OPat 8, OChange 0.01

IMu 2.00, IEps 1.00, IDcy 0.00000, IPat 8, IChange 0.03

Utype: SIGMOID, Otype: SIGMOID, Pool 8

Epoch 100: Out Time-out 103 bits wrong, error 9.73.

Epoch 264: Out Time-out 22 bits wrong, error 1.00.

SigOff 0.10, WtRng 1.00, WtMul 1.00

OMu 2.00, OEps 0.35, ODcy 0.00010, OPat 8, OChange 0.01

IMu 2.00, IEps 1.00, IDcy 0.00000, IPat 8, IChange 0.03

Utype: SIGMOID, Otype: SIGMOID, Pool 8

Victory at 345 epochs, 67 units, 2 hidden, Error 0.11.

TRAINING LOOP STATS

SigOff 0.10, WtRng 1.00, WtMul 1.00

OMu 2.00, OEps 0.35, ODcy 0.00010, OPat 8, OChange 0.01

IMu 2.00, IEps 1.00, IDcy 0.00000, IPat 8, IChange 0.03

Utype: SIGMOID, Otype: SIGMOID, Pool 8

Victories: 1, Defeats: 0,
 Training Epochs - Min: 345, Avg: 345, Max: 345,
 Hidden Units - Min: 2, Avg: 2.0, Max: 2,

175 bits wrong, error 147.8338

71 cases missclassified.

3929.4 real 3584.4 user 21.2 sys

0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	0.97	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
0	0	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.97	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
1	1	0.00	0.97	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2	2	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.05	0.00
2	8	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.08	0.46	0.00
2	2	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.13	0.00	0.00
2	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.94	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00
3	3	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.27	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.97	0.00	0.03	0.00	0.00	0.01	0.00
3	3	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.05	0.00
4	4	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.30
4	4	0.00	0.00	0.00	0.00	0.82	0.02	0.00	0.00	0.00	0.16
5	5	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.05
5	5	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.50	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00	0.42	0.00
5	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
5	3	0.00	0.00	0.00	0.49	0.00	0.48	0.00	0.00	0.00	0.03
6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.03	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.04	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.07	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00

6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.02	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.37
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.34
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.51	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.99
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.99
9	9	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.99
0	0	0.90	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.51	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.80	0.00	0.20	0.00	0.00	0.00	0.00
3	5	0.00	0.00	0.00	0.14	0.00	0.78	0.00	0.08	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	9	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.57
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01
5	1	0.00	0.72	0.00	0.04	0.00	0.22	0.00	0.02	0.00	0.00
5	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.03	0.00	0.97	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.15	0.00	0.85	0.00	0.00	0.00	0.00

5	5	0.00	0.00	0.00	0.15	0.00	0.85	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.02	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.01	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	1	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
7	1	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
7	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	4	0.00	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.07
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.99
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
0	0	0.45	0.00	0.00	0.00	0.00	0.43	0.12	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.52	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	8	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.60	0.00
3	3	0.00	0.00	0.26	0.74	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.20	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00
4	5	0.00	0.01	0.00	0.00	0.37	0.62	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00

4	4	0.00	0.00	0.00	0.00	0.93	0.07	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.10	0.00	0.76	0.14	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.21	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00
6	6	0.02	0.00	0.05	0.00	0.00	0.00	0.93	0.00	0.00	0.00
6	2	0.00	0.00	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.81	0.00	0.18
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.01
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.03
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.05	0.12	0.00	0.00	0.00	0.00	0.68	0.16
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.98	0.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	4	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.28	0.02
9	9	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.08	0.00	0.53
9	4	0.34	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00
9	3	0.00	0.00	0.00	0.80	0.00	0.20	0.00	0.00	0.00	0.00
0	0	0.99	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
0	0	0.99	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
0	0	0.91	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.01	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.01	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.79	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.72	0.00	0.28	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.73	0.00	0.27	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.05	0.63	0.32	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.95	0.05	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.75	0.25	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.36	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.06	0.00	0.94	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.14	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.08	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.01	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.12
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	4	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.44
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.98
0	0	0.88	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.97	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00	0.00
2	1	0.20	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.15	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.49	0.51	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.02	0.98	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00
4	4	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.02	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.06
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.05	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	7	0.00	0.00	0.24	0.00	0.00	0.12	0.00	0.64	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.17	0.83	0.00	0.00	0.00	0.00
6	6	0.00	0.01	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.02
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.02
7	7	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.85	0.00	0.06
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.03
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	2	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.47	0.00
8	8	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.87	0.00
8	8	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.63	0.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.67
9	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.32
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.54
9	9	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.99
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
1	1	0.00	0.84	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.15
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.01
3	3	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.49
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.24	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.02
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
5	5	0.01	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.10	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.01	0.00
5	5	0.10	0.06	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.27
5	5	0.00	0.00	0.00	0.31	0.00	0.69	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	0	0.52	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.97	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.67	0.00	0.00
7	7	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.50	0.00	0.49
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
8	3	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.46	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.98
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.97
9	9	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.51
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

0	0	0.96	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.93	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.03	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.61	0.39	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.12	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.01	0.92	0.00	0.07	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.95	0.00	0.05	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0.00	0.08
4	9	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.57
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.02
5	5	0.00	0.00	0.03	0.01	0.00	0.95	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.41	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.37	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.17	0.00
6	6	0.00	0.13	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	1	0.00	0.95	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.21
9	9	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.64
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.31	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	1	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	7	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.85	0.00	0.07
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	5	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.48
4	5	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.06
4	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
4	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
5	5	0.00	0.00	0.01	0.00	0.00	0.49	0.00	0.00	0.00	0.49
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.38	0.62	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.01	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.97	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
7	7	0.00	0.00	0.00	0.03	0.00	0.02	0.00	0.95	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.99	0.00	0.00
8	3	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.32	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00

8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	3	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.22	0.21
9	8	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.02
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
0	3	0.08	0.00	0.06	0.86	0.00	0.00	0.00	0.00	0.00	0.00
0	2	0.12	0.00	0.86	0.00	0.00	0.01	0.00	0.00	0.00	0.00
0	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
0	3	0.47	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00
0	3	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.99	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
1	4	0.00	0.10	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.98	0.00	0.00	0.00	0.02	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.02	0.00	0.00
3	4	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00
3	3	0.00	0.00	0.13	0.87	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.49	0.51	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.06	0.00	0.00	0.59	0.34	0.00	0.00	0.00	0.00
4	4	0.00	0.03	0.47	0.00	0.50	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	0.64	0.36	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.08	0.00	0.00	0.92	0.00	0.00	0.00
6	6	0.28	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.07	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.70	0.00	0.08
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.97	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.38

7	7	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.01
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	2	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.04	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	9	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.68
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.22	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.39	0.42	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.97	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.01	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.14	0.00	0.00
2	7	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.37	0.00	0.34
2	7	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.94	0.03	0.00
2	2	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.04	0.00
3	3	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.36	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	0	0.99	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.78	0.22	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.01	0.00
5	5	0.02	0.02	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00
5	5	0.01	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
5	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00

6	6	0.00	0.00	0.03	0.03	0.00	0.01	0.92	0.00	0.01	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.97	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.64	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.03
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.05
8	6	0.00	0.00	0.05	0.00	0.00	0.00	0.86	0.00	0.08	0.00
8	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50
9	3	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.01	0.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.21
0	0	0.84	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
1	1	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
1	1	0.00	0.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
1	1	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.20	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	2	0.00	0.00	0.68	0.00	0.00	0.00	0.02	0.00	0.31	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	9	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.97
4	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
4	9	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.87
4	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
4	4	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.48
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.24	0.00	0.01	0.00	0.00	0.75	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.02	0.00	0.00
5	5	0.30	0.00	0.00	0.00	0.00	0.67	0.00	0.04	0.00	0.00

5	5	0.00	0.00	0.02	0.00	0.00	0.93	0.00	0.05	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.07	0.00	0.00	0.93	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50
7	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.93
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.11
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.99
9	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.03
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.98
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.99
9	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	3	0.00	0.00	0.00	0.92	0.08	0.00	0.00	0.00	0.00	0.00
0	0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.00	0.63	0.37	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.02	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9	0.01	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.85
2	2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	2	0.00	0.01	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
4	4	0.00	0.07	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00

4	4	0.00	0.01	0.00	0.00	0.75	0.00	0.00	0.24	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.04	0.96	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.17	0.52	0.00	0.00	0.00	0.31
5	5	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
5	5	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.04
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
6	6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.87	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
7	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	2	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.49	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
8	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
9	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.45
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.72
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
9	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Appendix D

Hidden Markov Model Results

This section is the actual output from the Hidden Markov Model. The sections are divided according to individual and attempt. The overall results are described at the end.

Testing for Bill, Attempt 1

Input from NN: 58142	Desired HMM Out: 59142	Actual HMM Out: 58142
Input from NN: 88272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 56378	Desired HMM Out: 56379	Actual HMM Out: 56378
Input from NN: 18672	Desired HMM Out: 19672	Actual HMM Out: 18672
Input from NN: 76308	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 83458	Desired HMM Out: 93458	Actual HMM Out: 63458
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 29099
Input from NN: 88558	Desired HMM Out: 99559	Actual HMM Out: 99558
Input from NN: 80886	Desired HMM Out: 90896	Actual HMM Out: 90996

Accumulative results for this person are:

Name: Bill Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 40
Number of words in error after HMM: 9
Error Rate before HMM: 40.00%
Error Rate after HMM: 9.00%

Testing for Bill, Attempt 2

Input from NN: 34572	Desired HMM Out: 34578	Actual HMM Out: 34572
Input from NN: 59148	Desired HMM Out: 59142	Actual HMM Out: 59145
Input from NN: 68724	Desired HMM Out: 62784	Actual HMM Out: 63784
Input from NN: 29878	Desired HMM Out: 89272	Actual HMM Out: 29272
Input from NN: 82022	Desired HMM Out: 28088	Actual HMM Out: 58088
Input from NN: 12887	Desired HMM Out: 18227	Actual HMM Out: 12227
Input from NN: 95881	Desired HMM Out: 95221	Actual HMM Out: 95581
Input from NN: 54618	Desired HMM Out: 54612	Actual HMM Out: 54618
Input from NN: 63687	Desired HMM Out: 63627	Actual HMM Out: 63637
Input from NN: 62127	Desired HMM Out: 68187	Actual HMM Out: 68127
Input from NN: 63127	Desired HMM Out: 63187	Actual HMM Out: 63127

Accumulative results for this person are:

Name: Bill Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 92
Number of words in error after HMM: 20
Error Rate before HMM: 46.00%
Error Rate after HMM: 10.00%

Testing for Bill, Attempt 3

Input from NN: 62784	Desired HMM Out: 62784	Actual HMM Out: 62754
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Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 59272
Input from NN: 17684	Desired HMM Out: 17684	Actual HMM Out: 18684
Input from NN: 91170	Desired HMM Out: 91170	Actual HMM Out: 91180
Input from NN: 93458	Desired HMM Out: 93458	Actual HMM Out: 93455
Input from NN: 58454	Desired HMM Out: 58454	Actual HMM Out: 55454
Input from NN: 95548	Desired HMM Out: 95548	Actual HMM Out: 95545
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 68727

Accumulative results for this person are:

Name: Bill Completed Attempt: 3
 Number of words processed: 300
 Number of words in error from NN: 92
 Number of words in error after HMM: 28
 Error Rate before HMM: 30.67%
 Error Rate after HMM: 9.33%

Testing for Bill, Attempt 4

Input from NN: 18731	Desired HMM Out: 12751	Actual HMM Out: 18751
Input from NN: 87033	Desired HMM Out: 27053	Actual HMM Out: 27033
Input from NN: 34378	Desired HMM Out: 34578	Actual HMM Out: 54572
Input from NN: 39148	Desired HMM Out: 59142	Actual HMM Out: 54148
Input from NN: 68784	Desired HMM Out: 62784	Actual HMM Out: 68784
Input from NN: 78793	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89878	Desired HMM Out: 89272	Actual HMM Out: 27272
Input from NN: 08789	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 33937	Desired HMM Out: 53957	Actual HMM Out: 55457
Input from NN: 78896	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 36379	Desired HMM Out: 56379	Actual HMM Out: 36379
Input from NN: 67818	Desired HMM Out: 67218	Actual HMM Out: 67818
Input from NN: 19678	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36345
Input from NN: 93438	Desired HMM Out: 93458	Actual HMM Out: 95458
Input from NN: 88088	Desired HMM Out: 28088	Actual HMM Out: 88088
Input from NN: 30906	Desired HMM Out: 30906	Actual HMM Out: 50906
Input from NN: 18887	Desired HMM Out: 18227	Actual HMM Out: 12227
Input from NN: 67787	Desired HMM Out: 67727	Actual HMM Out: 67227
Input from NN: 93881	Desired HMM Out: 95221	Actual HMM Out: 95881
Input from NN: 34618	Desired HMM Out: 54612	Actual HMM Out: 54618
Input from NN: 63436	Desired HMM Out: 63456	Actual HMM Out: 63436
Input from NN: 31463	Desired HMM Out: 51463	Actual HMM Out: 31463
Input from NN: 61888	Desired HMM Out: 61222	Actual HMM Out: 61888
Input from NN: 63687	Desired HMM Out: 63627	Actual HMM Out: 63687
Input from NN: 99339	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 18743	Desired HMM Out: 12745	Actual HMM Out: 18745
Input from NN: 18403	Desired HMM Out: 18405	Actual HMM Out: 18403
Input from NN: 18113	Desired HMM Out: 18115	Actual HMM Out: 18113
Input from NN: 63633	Desired HMM Out: 63635	Actual HMM Out: 63633
Input from NN: 90330	Desired HMM Out: 90550	Actual HMM Out: 90330
Input from NN: 68188	Desired HMM Out: 68122	Actual HMM Out: 68188

Accumulative results for this person are:

Name: Bill Completed Attempt: 4
 Number of words processed: 400
 Number of words in error from NN: 142

Number of words in error after HMM: 60
Error Rate before HMM: 35.50%
Error Rate after HMM: 15.00%

Testing for Bill, Attempt 5

Input from NN: 27033	Desired HMM Out: 27053	Actual HMM Out: 27033
Input from NN: 34378	Desired HMM Out: 34578	Actual HMM Out: 54578
Input from NN: 39142	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 08729	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 33937	Desired HMM Out: 53957	Actual HMM Out: 55457
Input from NN: 72296	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 36379	Desired HMM Out: 56379	Actual HMM Out: 36379
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36345
Input from NN: 93438	Desired HMM Out: 93458	Actual HMM Out: 95458
Input from NN: 30906	Desired HMM Out: 30906	Actual HMM Out: 50906
Input from NN: 63436	Desired HMM Out: 63456	Actual HMM Out: 63436
Input from NN: 31463	Desired HMM Out: 51463	Actual HMM Out: 31463
Input from NN: 18403	Desired HMM Out: 18405	Actual HMM Out: 18403
Input from NN: 18113	Desired HMM Out: 18115	Actual HMM Out: 18113
Input from NN: 63633	Desired HMM Out: 63635	Actual HMM Out: 63633
Input from NN: 90330	Desired HMM Out: 90550	Actual HMM Out: 90330

Accumulative results for this person are:

Name: Bill Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 171
Number of words in error after HMM: 77
Error Rate before HMM: 34.20%
Error Rate after HMM: 15.40%

Testing for Bob, Attempt 1

Input from NN: 12711	Desired HMM Out: 12751	Actual HMM Out: 12755
Input from NN: 14142	Desired HMM Out: 59142	Actual HMM Out: 14542
Input from NN: 72741	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 84272	Desired HMM Out: 89272	Actual HMM Out: 84272
Input from NN: 13417	Desired HMM Out: 53957	Actual HMM Out: 13457
Input from NN: 68144	Desired HMM Out: 68544	Actual HMM Out: 68144
Input from NN: 16374	Desired HMM Out: 56379	Actual HMM Out: 16374
Input from NN: 41170	Desired HMM Out: 91170	Actual HMM Out: 95570
Input from NN: 03344	Desired HMM Out: 03399	Actual HMM Out: 03344
Input from NN: 14672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 11404	Desired HMM Out: 55404	Actual HMM Out: 11409
Input from NN: 63411	Desired HMM Out: 63411	Actual HMM Out: 63455
Input from NN: 43418	Desired HMM Out: 93458	Actual HMM Out: 93418
Input from NN: 17271	Desired HMM Out: 57275	Actual HMM Out: 17275
Input from NN: 18414	Desired HMM Out: 58454	Actual HMM Out: 18454
Input from NN: 10314	Desired HMM Out: 50354	Actual HMM Out: 10354
Input from NN: 41221	Desired HMM Out: 95221	Actual HMM Out: 91221
Input from NN: 14612	Desired HMM Out: 54612	Actual HMM Out: 14612
Input from NN: 44041	Desired HMM Out: 99041	Actual HMM Out: 99045
Input from NN: 11463	Desired HMM Out: 51463	Actual HMM Out: 11463
Input from NN: 46314	Desired HMM Out: 96314	Actual HMM Out: 96354
Input from NN: 14141	Desired HMM Out: 54545	Actual HMM Out: 14545

Input from NN: 63634	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 44114	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 40441	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 14163	Desired HMM Out: 14163	Actual HMM Out: 14563
Input from NN: 40846	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 18111	Desired HMM Out: 18115	Actual HMM Out: 18111
Input from NN: 63631	Desired HMM Out: 63635	Actual HMM Out: 63631

Accumulative results for this person are:

Name: Bob Completed Attempt: 1
 Number of words processed: 100
 Number of words in error from NN: 58
 Number of words in error after HMM: 29
 Error Rate before HMM: 58.00%
 Error Rate after HMM: 29.00%

Testing for Bob, Attempt 2

Input from NN: 12131	Desired HMM Out: 12751	Actual HMM Out: 12757
Input from NN: 21033	Desired HMM Out: 27053	Actual HMM Out: 27033
Input from NN: 34318	Desired HMM Out: 34578	Actual HMM Out: 54518
Input from NN: 12193	Desired HMM Out: 72795	Actual HMM Out: 12795
Input from NN: 33931	Desired HMM Out: 53957	Actual HMM Out: 55957
Input from NN: 68344	Desired HMM Out: 68544	Actual HMM Out: 68144
Input from NN: 12296	Desired HMM Out: 72296	Actual HMM Out: 12296
Input from NN: 36319	Desired HMM Out: 56379	Actual HMM Out: 36379
Input from NN: 61218	Desired HMM Out: 67218	Actual HMM Out: 67278
Input from NN: 14300	Desired HMM Out: 74500	Actual HMM Out: 14500
Input from NN: 91110	Desired HMM Out: 91170	Actual HMM Out: 91110
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36345
Input from NN: 16308	Desired HMM Out: 76308	Actual HMM Out: 16308
Input from NN: 93438	Desired HMM Out: 93458	Actual HMM Out: 95418
Input from NN: 30906	Desired HMM Out: 30906	Actual HMM Out: 50906
Input from NN: 38434	Desired HMM Out: 58454	Actual HMM Out: 18454
Input from NN: 93221	Desired HMM Out: 95221	Actual HMM Out: 91227
Input from NN: 34612	Desired HMM Out: 54612	Actual HMM Out: 54672
Input from NN: 63436	Desired HMM Out: 63456	Actual HMM Out: 63436
Input from NN: 31463	Desired HMM Out: 51463	Actual HMM Out: 11463
Input from NN: 61222	Desired HMM Out: 61222	Actual HMM Out: 67222
Input from NN: 63031	Desired HMM Out: 63037	Actual HMM Out: 63031
Input from NN: 63134	Desired HMM Out: 63134	Actual HMM Out: 63754
Input from NN: 18403	Desired HMM Out: 18405	Actual HMM Out: 18403
Input from NN: 68181	Desired HMM Out: 68187	Actual HMM Out: 68181
Input from NN: 18113	Desired HMM Out: 18115	Actual HMM Out: 18111
Input from NN: 63633	Desired HMM Out: 63635	Actual HMM Out: 63633
Input from NN: 90330	Desired HMM Out: 90550	Actual HMM Out: 90330
Input from NN: 68122	Desired HMM Out: 68122	Actual HMM Out: 68722
Input from NN: 63181	Desired HMM Out: 63187	Actual HMM Out: 63181

Accumulative results for this person are:

Name: Bob Completed Attempt: 2
 Number of words processed: 200
 Number of words in error from NN: 114
 Number of words in error after HMM: 59
 Error Rate before HMM: 57.00%

Error Rate after HMM: 29.50%

Testing for Bob, Attempt 3

Input from NN: 39518	Desired HMM Out: 34578	Actual HMM Out: 34518
Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 62189	Desired HMM Out: 62784	Actual HMM Out: 62184
Input from NN: 12195	Desired HMM Out: 72795	Actual HMM Out: 12745
Input from NN: 89212	Desired HMM Out: 89272	Actual HMM Out: 84272
Input from NN: 08129	Desired HMM Out: 08729	Actual HMM Out: 08129
Input from NN: 22219	Desired HMM Out: 22274	Actual HMM Out: 22279
Input from NN: 53951	Desired HMM Out: 53957	Actual HMM Out: 53451
Input from NN: 68599	Desired HMM Out: 68544	Actual HMM Out: 68599
Input from NN: 12296	Desired HMM Out: 72296	Actual HMM Out: 12296
Input from NN: 11689	Desired HMM Out: 17684	Actual HMM Out: 11684
Input from NN: 36890	Desired HMM Out: 36840	Actual HMM Out: 36890
Input from NN: 56319	Desired HMM Out: 56379	Actual HMM Out: 56314
Input from NN: 19500	Desired HMM Out: 74500	Actual HMM Out: 14500
Input from NN: 91110	Desired HMM Out: 91170	Actual HMM Out: 91110
Input from NN: 19612	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 16308	Desired HMM Out: 76308	Actual HMM Out: 16308
Input from NN: 95221	Desired HMM Out: 95221	Actual HMM Out: 95227
Input from NN: 59612	Desired HMM Out: 54612	Actual HMM Out: 54672
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 51963	Desired HMM Out: 51463	Actual HMM Out: 57963
Input from NN: 61222	Desired HMM Out: 61222	Actual HMM Out: 67222
Input from NN: 63031	Desired HMM Out: 63037	Actual HMM Out: 63031
Input from NN: 63639	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18905
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 68181	Desired HMM Out: 68187	Actual HMM Out: 68181
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 63181	Desired HMM Out: 63187	Actual HMM Out: 63181
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90969

Accumulative results for this person are:

Name: Bob Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 176
Number of words in error after HMM: 91
Error Rate before HMM: 58.67%
Error Rate after HMM: 30.33%

Testing for Bob, Attempt 4

Input from NN: 27055	Desired HMM Out: 27053	Actual HMM Out: 27055
Input from NN: 54578	Desired HMM Out: 34578	Actual HMM Out: 54578
Input from NN: 92705	Desired HMM Out: 92703	Actual HMM Out: 92705
Input from NN: 55957	Desired HMM Out: 53957	Actual HMM Out: 55957
Input from NN: 56579	Desired HMM Out: 56379	Actual HMM Out: 36379
Input from NN: 05599	Desired HMM Out: 03399	Actual HMM Out: 05599
Input from NN: 56545	Desired HMM Out: 36343	Actual HMM Out: 36345
Input from NN: 95458	Desired HMM Out: 93458	Actual HMM Out: 95458
Input from NN: 50906	Desired HMM Out: 30906	Actual HMM Out: 50906

Input from NN: 50554	Desired HMM Out: 50354	Actual HMM Out: 50554
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 63727
Input from NN: 15722	Desired HMM Out: 13722	Actual HMM Out: 15722
Input from NN: 96555	Desired HMM Out: 96333	Actual HMM Out: 96355
Input from NN: 65057	Desired HMM Out: 63037	Actual HMM Out: 63057
Input from NN: 65154	Desired HMM Out: 63134	Actual HMM Out: 63154
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18113

Accumulative results for this person are:

Name: Bob Completed Attempt: 4
 Number of words processed: 400
 Number of words in error from NN: 216
 Number of words in error after HMM: 107
 Error Rate before HMM: 54.00%
 Error Rate after HMM: 26.75%

Testing for Bob, Attempt 5

Input from NN: 12151	Desired HMM Out: 12751	Actual HMM Out: 12757
Input from NN: 34518	Desired HMM Out: 34578	Actual HMM Out: 14518
Input from NN: 12195	Desired HMM Out: 72795	Actual HMM Out: 12795
Input from NN: 12296	Desired HMM Out: 72296	Actual HMM Out: 12296
Input from NN: 61218	Desired HMM Out: 67218	Actual HMM Out: 67278
Input from NN: 14500	Desired HMM Out: 74500	Actual HMM Out: 14500
Input from NN: 91110	Desired HMM Out: 91170	Actual HMM Out: 91110
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36345
Input from NN: 16308	Desired HMM Out: 76308	Actual HMM Out: 16308
Input from NN: 93458	Desired HMM Out: 93458	Actual HMM Out: 95458
Input from NN: 30906	Desired HMM Out: 30906	Actual HMM Out: 10906
Input from NN: 95221	Desired HMM Out: 95221	Actual HMM Out: 95227
Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54672
Input from NN: 51463	Desired HMM Out: 51463	Actual HMM Out: 57463
Input from NN: 61222	Desired HMM Out: 61222	Actual HMM Out: 67222
Input from NN: 63031	Desired HMM Out: 63037	Actual HMM Out: 63031
Input from NN: 63134	Desired HMM Out: 63134	Actual HMM Out: 63114
Input from NN: 68181	Desired HMM Out: 68187	Actual HMM Out: 68181
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18175
Input from NN: 68122	Desired HMM Out: 68122	Actual HMM Out: 68722
Input from NN: 63181	Desired HMM Out: 63187	Actual HMM Out: 63181

Accumulative results for this person are:

Name: Bob Completed Attempt: 5
 Number of words processed: 500
 Number of words in error from NN: 252
 Number of words in error after HMM: 128
 Error Rate before HMM: 50.40%
 Error Rate after HMM: 25.60%

Testing for Donnie, Attempt 1

Input from NN: 27058	Desired HMM Out: 27053	Actual HMM Out: 27008
Input from NN: 59132	Desired HMM Out: 59142	Actual HMM Out: 09142
Input from NN: 72795	Desired HMM Out: 72795	Actual HMM Out: 72790
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 39272
Input from NN: 92708	Desired HMM Out: 92703	Actual HMM Out: 92708
Input from NN: 58957	Desired HMM Out: 53957	Actual HMM Out: 58907

Input from NN: 68533	Desired HMM Out: 68544	Actual HMM Out: 63544
Input from NN: 17683	Desired HMM Out: 17684	Actual HMM Out: 17634
Input from NN: 86830	Desired HMM Out: 36840	Actual HMM Out: 36340
Input from NN: 08899	Desired HMM Out: 03399	Actual HMM Out: 08899
Input from NN: 86838	Desired HMM Out: 36343	Actual HMM Out: 36348
Input from NN: 55303	Desired HMM Out: 55404	Actual HMM Out: 55403
Input from NN: 95538	Desired HMM Out: 95548	Actual HMM Out: 90548
Input from NN: 51368	Desired HMM Out: 51463	Actual HMM Out: 51363
Input from NN: 96813	Desired HMM Out: 96314	Actual HMM Out: 96814
Input from NN: 18722	Desired HMM Out: 13722	Actual HMM Out: 18722
Input from NN: 96888	Desired HMM Out: 96333	Actual HMM Out: 96888
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 90909
Input from NN: 68087	Desired HMM Out: 63037	Actual HMM Out: 63087
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99009
Input from NN: 68183	Desired HMM Out: 63134	Actual HMM Out: 68184
Input from NN: 90768	Desired HMM Out: 90768	Actual HMM Out: 90763
Input from NN: 68681	Desired HMM Out: 63631	Actual HMM Out: 63681
Input from NN: 90335	Desired HMM Out: 90445	Actual HMM Out: 90345
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18110
Input from NN: 68187	Desired HMM Out: 63187	Actual HMM Out: 68187
Input from NN: 90963	Desired HMM Out: 90964	Actual HMM Out: 90963

Accumulative results for this person are:

Name: Donnie Completed Attempt: 1

Number of words processed: 100

Number of words in error from NN: 59

Number of words in error after HMM: 27

Error Rate before HMM: 59.00%

Error Rate after HMM: 27.00%

Testing for Donnie, Attempt 2

Input from NN: 12751	Desired HMM Out: 12751	Actual HMM Out: 12754
Input from NN: 54142	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72745	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 84272	Desired HMM Out: 89272	Actual HMM Out: 14272
Input from NN: 53457	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 56374	Desired HMM Out: 56379	Actual HMM Out: 56374
Input from NN: 03344	Desired HMM Out: 03399	Actual HMM Out: 03344
Input from NN: 14672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55404	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 21081
Input from NN: 45548	Desired HMM Out: 95548	Actual HMM Out: 95541
Input from NN: 18881	Desired HMM Out: 18881	Actual HMM Out: 18181
Input from NN: 44041	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 51463	Desired HMM Out: 51463	Actual HMM Out: 54463
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 18722
Input from NN: 63634	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 44554	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 63134	Desired HMM Out: 63134	Actual HMM Out: 63184
Input from NN: 40445	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 40846	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18145

Accumulative results for this person are:

Name: Donnie Completed Attempt: 2
 Number of words processed: 200
 Number of words in error from NN: 99
 Number of words in error after HMM: 48
 Error Rate before HMM: 49.50%
 Error Rate after HMM: 24.00%

Testing for Donnie, Attempt 3

Input from NN: 12751	Desired HMM Out: 12751	Actual HMM Out: 12741
Input from NN: 35578	Desired HMM Out: 34578	Actual HMM Out: 95578
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 92703	Desired HMM Out: 92703	Actual HMM Out: 92709
Input from NN: 08729	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 22275	Desired HMM Out: 22274	Actual HMM Out: 22275
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 59957
Input from NN: 68555	Desired HMM Out: 68544	Actual HMM Out: 68454
Input from NN: 72296	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 03399	Desired HMM Out: 03399	Actual HMM Out: 09999
Input from NN: 36353	Desired HMM Out: 36343	Actual HMM Out: 36353
Input from NN: 55505	Desired HMM Out: 55404	Actual HMM Out: 54505
Input from NN: 93558	Desired HMM Out: 93458	Actual HMM Out: 99558
Input from NN: 30906	Desired HMM Out: 30906	Actual HMM Out: 90906
Input from NN: 95555	Desired HMM Out: 95455	Actual HMM Out: 95454
Input from NN: 95558	Desired HMM Out: 95548	Actual HMM Out: 95458
Input from NN: 50355	Desired HMM Out: 50354	Actual HMM Out: 50345
Input from NN: 63555	Desired HMM Out: 63545	Actual HMM Out: 63454
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 63722
Input from NN: 63135	Desired HMM Out: 63134	Actual HMM Out: 63634
Input from NN: 63631	Desired HMM Out: 63631	Actual HMM Out: 63636
Input from NN: 90555	Desired HMM Out: 90445	Actual HMM Out: 90545
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18114
Input from NN: 63635	Desired HMM Out: 63635	Actual HMM Out: 63634
Input from NN: 90550	Desired HMM Out: 90550	Actual HMM Out: 90540

Accumulative results for this person are:

Name: Donnie Completed Attempt: 3
 Number of words processed: 300
 Number of words in error from NN: 131
 Number of words in error after HMM: 73
 Error Rate before HMM: 43.67%
 Error Rate after HMM: 24.33%

Testing for Donnie, Attempt 4

Input from NN: 54142	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72745	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 84272	Desired HMM Out: 89272	Actual HMM Out: 84272
Input from NN: 53457	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 56374	Desired HMM Out: 56379	Actual HMM Out: 56374
Input from NN: 03344	Desired HMM Out: 03399	Actual HMM Out: 03344
Input from NN: 14672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55404	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 68088
Input from NN: 63634	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 44554	Desired HMM Out: 99559	Actual HMM Out: 99554

Input from NN: 40445 Desired HMM Out: 90445 Actual HMM Out: 90995
Input from NN: 40846 Desired HMM Out: 90896 Actual HMM Out: 90846

Accumulative results for this person are:

Name: Donnie Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 171
Number of words in error after HMM: 86
Error Rate before HMM: 42.75%
Error Rate after HMM: 21.50%

Testing for Donnie, Attempt 5

Input from NN: 00327 Desired HMM Out: 00367 Actual HMM Out: 00927
Input from NN: 53142 Desired HMM Out: 59142 Actual HMM Out: 53146
Input from NN: 22784 Desired HMM Out: 62784 Actual HMM Out: 22784
Input from NN: 83272 Desired HMM Out: 89272 Actual HMM Out: 83672
Input from NN: 32703 Desired HMM Out: 92703 Actual HMM Out: 92709
Input from NN: 08723 Desired HMM Out: 08729 Actual HMM Out: 08763
Input from NN: 12727 Desired HMM Out: 16727 Actual HMM Out: 12727
Input from NN: 53357 Desired HMM Out: 53957 Actual HMM Out: 59957
Input from NN: 17284 Desired HMM Out: 17684 Actual HMM Out: 17284
Input from NN: 27218 Desired HMM Out: 67218 Actual HMM Out: 27218
Input from NN: 03333 Desired HMM Out: 03399 Actual HMM Out: 09999
Input from NN: 13272 Desired HMM Out: 19672 Actual HMM Out: 13672
Input from NN: 72308 Desired HMM Out: 76308 Actual HMM Out: 72908
Input from NN: 33458 Desired HMM Out: 93458 Actual HMM Out: 33458
Input from NN: 28088 Desired HMM Out: 28088 Actual HMM Out: 68088
Input from NN: 30302 Desired HMM Out: 30906 Actual HMM Out: 90906
Input from NN: 27272 Desired HMM Out: 67276 Actual HMM Out: 27272
Input from NN: 50354 Desired HMM Out: 50354 Actual HMM Out: 90954
Input from NN: 27727 Desired HMM Out: 67727 Actual HMM Out: 27727
Input from NN: 54212 Desired HMM Out: 54612 Actual HMM Out: 54212
Input from NN: 23452 Desired HMM Out: 63456 Actual HMM Out: 63452
Input from NN: 32314 Desired HMM Out: 96314 Actual HMM Out: 36314
Input from NN: 32333 Desired HMM Out: 96333 Actual HMM Out: 36399
Input from NN: 32303 Desired HMM Out: 96909 Actual HMM Out: 36309
Input from NN: 23233 Desired HMM Out: 63639 Actual HMM Out: 63633
Input from NN: 33553 Desired HMM Out: 99559 Actual HMM Out: 99553
Input from NN: 30728 Desired HMM Out: 90768 Actual HMM Out: 90728
Input from NN: 30832 Desired HMM Out: 90896 Actual HMM Out: 90836
Input from NN: 30324 Desired HMM Out: 90964 Actual HMM Out: 90364

Accumulative results for this person are:

Name: Donnie Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 247
Number of words in error after HMM: 115
Error Rate before HMM: 49.40%
Error Rate after HMM: 23.00%

Testing for Greg, Attempt 1

Input from NN: 28088 Desired HMM Out: 28088 Actual HMM Out: 27088
Input from NN: 63456 Desired HMM Out: 63456 Actual HMM Out: 63454

Accumulative results for this person are:

Name: Greg Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 0
Number of words in error after HMM: 2
Error Rate before HMM: 0.00%
Error Rate after HMM: 2.00%

Testing for Greg, Attempt 2

Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36363
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 27088
Input from NN: 63456	Desired HMM Out: 63456	Actual HMM Out: 63454

Accumulative results for this person are:

Name: Greg Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 0
Number of words in error after HMM: 5
Error Rate before HMM: 0.00%
Error Rate after HMM: 2.50%

Testing for Greg, Attempt 3

Input from NN: 00767	Desired HMM Out: 00367	Actual HMM Out: 00363
Input from NN: 27057	Desired HMM Out: 27053	Actual HMM Out: 27057
Input from NN: 92707	Desired HMM Out: 92703	Actual HMM Out: 92707
Input from NN: 57957	Desired HMM Out: 53957	Actual HMM Out: 57957
Input from NN: 17684	Desired HMM Out: 17684	Actual HMM Out: 13684
Input from NN: 74500	Desired HMM Out: 74500	Actual HMM Out: 34500
Input from NN: 07799	Desired HMM Out: 03399	Actual HMM Out: 03799
Input from NN: 76708	Desired HMM Out: 76308	Actual HMM Out: 36308
Input from NN: 70906	Desired HMM Out: 30906	Actual HMM Out: 70906
Input from NN: 50754	Desired HMM Out: 50354	Actual HMM Out: 50754
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 63727
Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54512
Input from NN: 96777	Desired HMM Out: 96333	Actual HMM Out: 96337
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 90909
Input from NN: 67174	Desired HMM Out: 63134	Actual HMM Out: 63174
Input from NN: 90768	Desired HMM Out: 90768	Actual HMM Out: 90368
Input from NN: 18767	Desired HMM Out: 18363	Actual HMM Out: 18763
Input from NN: 90964	Desired HMM Out: 90964	Actual HMM Out: 90954

Accumulative results for this person are:

Name: Greg Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 40
Number of words in error after HMM: 23
Error Rate before HMM: 13.33%
Error Rate after HMM: 7.67%

Testing for Greg, Attempt 4

Input from NN: 12751	Desired HMM Out: 12751	Actual HMM Out: 12741
Input from NN: 54142	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72745	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 84272	Desired HMM Out: 89272	Actual HMM Out: 54272

Input from NN: 53457	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 56374	Desired HMM Out: 56379	Actual HMM Out: 56374
Input from NN: 03344	Desired HMM Out: 03399	Actual HMM Out: 03344
Input from NN: 14672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55404	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 45455	Desired HMM Out: 95455	Actual HMM Out: 95454
Input from NN: 58454	Desired HMM Out: 58454	Actual HMM Out: 55454
Input from NN: 45548	Desired HMM Out: 95548	Actual HMM Out: 95545
Input from NN: 44041	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 63634	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 44554	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 40445	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 40846	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18114
Input from NN: 63635	Desired HMM Out: 63635	Actual HMM Out: 63634
Input from NN: 40550	Desired HMM Out: 90550	Actual HMM Out: 90540

Accumulative results for this person are:

Name: Greg Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 80
Number of words in error after HMM: 43
Error Rate before HMM: 20.00%
Error Rate after HMM: 10.75%

Testing for Greg, Attempt 5

Input from NN: 59142	Desired HMM Out: 59142	Actual HMM Out: 58142
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 99272

Accumulative results for this person are:

Name: Greg Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 80
Number of words in error after HMM: 45
Error Rate before HMM: 16.00%
Error Rate after HMM: 9.00%

Testing for HPG, Attempt 1

Input from NN: 62784	Desired HMM Out: 62784	Actual HMM Out: 63784
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 29088
Input from NN: 63627	Desired HMM Out: 63627	Actual HMM Out: 63637
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 90909
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 90964	Desired HMM Out: 90964	Actual HMM Out: 90904

Accumulative results for this person are:

Name: HPG Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 0
Number of words in error after HMM: 7
Error Rate before HMM: 0.00%
Error Rate after HMM: 7.00%

Testing for HPG, Attempt 2

Input from NN: 58141	Desired HMM Out: 59142	Actual HMM Out: 58141
Input from NN: 88171	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 11174	Desired HMM Out: 22274	Actual HMM Out: 12274
Input from NN: 17684	Desired HMM Out: 17684	Actual HMM Out: 27684
Input from NN: 11171	Desired HMM Out: 22272	Actual HMM Out: 12272
Input from NN: 56378	Desired HMM Out: 56379	Actual HMM Out: 56378
Input from NN: 81170	Desired HMM Out: 91170	Actual HMM Out: 92270
Input from NN: 18671	Desired HMM Out: 19672	Actual HMM Out: 18672
Input from NN: 76308	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 18088	Desired HMM Out: 28088	Actual HMM Out: 18099
Input from NN: 18117	Desired HMM Out: 18227	Actual HMM Out: 18127
Input from NN: 85111	Desired HMM Out: 95221	Actual HMM Out: 95111
Input from NN: 54611	Desired HMM Out: 54612	Actual HMM Out: 54611
Input from NN: 61111	Desired HMM Out: 61222	Actual HMM Out: 62222
Input from NN: 88558	Desired HMM Out: 99559	Actual HMM Out: 99558
Input from NN: 80886	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 68111	Desired HMM Out: 68122	Actual HMM Out: 68111

Accumulative results for this person are:

Name: HPG Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 60
Number of words in error after HMM: 24
Error Rate before HMM: 30.00%
Error Rate after HMM: 12.00%

Testing for HPG, Attempt 3

Input from NN: 34572	Desired HMM Out: 34578	Actual HMM Out: 34572
Input from NN: 29272	Desired HMM Out: 89272	Actual HMM Out: 27272
Input from NN: 67212	Desired HMM Out: 67218	Actual HMM Out: 67222
Input from NN: 91170	Desired HMM Out: 91170	Actual HMM Out: 91270
Input from NN: 22022	Desired HMM Out: 28088	Actual HMM Out: 27088
Input from NN: 12227	Desired HMM Out: 18227	Actual HMM Out: 12227
Input from NN: 95542	Desired HMM Out: 95548	Actual HMM Out: 95542
Input from NN: 95221	Desired HMM Out: 95221	Actual HMM Out: 95881
Input from NN: 12221	Desired HMM Out: 18881	Actual HMM Out: 12221
Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54618
Input from NN: 62127	Desired HMM Out: 68187	Actual HMM Out: 68127
Input from NN: 63127	Desired HMM Out: 63187	Actual HMM Out: 63127

Accumulative results for this person are:

Name: HPG Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 90
Number of words in error after HMM: 36
Error Rate before HMM: 30.00%
Error Rate after HMM: 12.00%

Testing for HPG, Attempt 4

Input from NN: 68744	Desired HMM Out: 68544	Actual HMM Out: 68744
Input from NN: 76379	Desired HMM Out: 56379	Actual HMM Out: 76379
Input from NN: 74700	Desired HMM Out: 74500	Actual HMM Out: 54500

Input from NN: 97477	Desired HMM Out: 95455	Actual HMM Out: 95457
Input from NN: 99779	Desired HMM Out: 99559	Actual HMM Out: 99579
Input from NN: 18407	Desired HMM Out: 18405	Actual HMM Out: 18407
Input from NN: 18117	Desired HMM Out: 18115	Actual HMM Out: 18117
Input from NN: 63637	Desired HMM Out: 63635	Actual HMM Out: 63637
Input from NN: 90770	Desired HMM Out: 90550	Actual HMM Out: 90570

Accumulative results for this person are:

Name: HPG Completed Attempt: 4
 Number of words processed: 400
 Number of words in error from NN: 119
 Number of words in error after HMM: 45
 Error Rate before HMM: 29.75%
 Error Rate after HMM: 11.25%

Testing for HPG, Attempt 5

Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54618
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Accumulative results for this person are:

Name: HPG Completed Attempt: 5
 Number of words processed: 500
 Number of words in error from NN: 119
 Number of words in error after HMM: 46
 Error Rate before HMM: 23.80%
 Error Rate after HMM: 9.20%

Testing for Isa, Attempt 1

Input from NN: 39272	Desired HMM Out: 89272	Actual HMM Out: 39272
Input from NN: 03729	Desired HMM Out: 08729	Actual HMM Out: 03729
Input from NN: 63544	Desired HMM Out: 68544	Actual HMM Out: 63544
Input from NN: 17634	Desired HMM Out: 17684	Actual HMM Out: 17634
Input from NN: 36340	Desired HMM Out: 36840	Actual HMM Out: 36340
Input from NN: 76303	Desired HMM Out: 76308	Actual HMM Out: 76303
Input from NN: 93453	Desired HMM Out: 93458	Actual HMM Out: 93453
Input from NN: 23033	Desired HMM Out: 28088	Actual HMM Out: 27033
Input from NN: 53454	Desired HMM Out: 58454	Actual HMM Out: 53454
Input from NN: 95543	Desired HMM Out: 95548	Actual HMM Out: 95543
Input from NN: 13631	Desired HMM Out: 18681	Actual HMM Out: 13631
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 18722
Input from NN: 63134	Desired HMM Out: 63134	Actual HMM Out: 63184
Input from NN: 90763	Desired HMM Out: 90768	Actual HMM Out: 90763
Input from NN: 63137	Desired HMM Out: 68187	Actual HMM Out: 63187
Input from NN: 90396	Desired HMM Out: 90896	Actual HMM Out: 90396
Input from NN: 63122	Desired HMM Out: 68122	Actual HMM Out: 63122
Input from NN: 90346	Desired HMM Out: 90846	Actual HMM Out: 90346

Accumulative results for this person are:

Name: Isa Completed Attempt: 1
 Number of words processed: 100
 Number of words in error from NN: 30
 Number of words in error after HMM: 18
 Error Rate before HMM: 30.00%
 Error Rate after HMM: 18.00%

Testing for Isa, Attempt 2

Input from NN: 59142	Desired HMM Out: 59142	Actual HMM Out: 53142
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 81272
Input from NN: 19672	Desired HMM Out: 19672	Actual HMM Out: 13672
Input from NN: 95548	Desired HMM Out: 95548	Actual HMM Out: 95545
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 96309

Accumulative results for this person are:

Name: Isa Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 30
Number of words in error after HMM: 23
Error Rate before HMM: 15.00%
Error Rate after HMM: 11.50%

Testing for Isa, Attempt 3

Accumulative results for this person are:

Name: Isa Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 30
Number of words in error after HMM: 23
Error Rate before HMM: 10.00%
Error Rate after HMM: 7.67%

Testing for Isa, Attempt 4

Input from NN: 59142	Desired HMM Out: 59142	Actual HMM Out: 55142
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 08729	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 72296	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 55404	Desired HMM Out: 55404	Actual HMM Out: 55454

Accumulative results for this person are:

Name: Isa Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 30
Number of words in error after HMM: 28
Error Rate before HMM: 7.50%
Error Rate after HMM: 7.00%

Testing for Isa, Attempt 5

Input from NN: 00307	Desired HMM Out: 00367	Actual HMM Out: 06367
Input from NN: 34578	Desired HMM Out: 34578	Actual HMM Out: 54578
Input from NN: 92703	Desired HMM Out: 92703	Actual HMM Out: 92763
Input from NN: 08729	Desired HMM Out: 08729	Actual HMM Out: 68729
Input from NN: 10727	Desired HMM Out: 16727	Actual HMM Out: 10727
Input from NN: 72290	Desired HMM Out: 72296	Actual HMM Out: 72290
Input from NN: 99903	Desired HMM Out: 99963	Actual HMM Out: 99903
Input from NN: 17084	Desired HMM Out: 17684	Actual HMM Out: 19084
Input from NN: 50379	Desired HMM Out: 56379	Actual HMM Out: 56399
Input from NN: 91170	Desired HMM Out: 91170	Actual HMM Out: 91190
Input from NN: 03399	Desired HMM Out: 03399	Actual HMM Out: 63399
Input from NN: 19072	Desired HMM Out: 19672	Actual HMM Out: 19072
Input from NN: 30343	Desired HMM Out: 36343	Actual HMM Out: 36345

Input from NN: 70308	Desired HMM Out: 76308	Actual HMM Out: 90368
Input from NN: 93458	Desired HMM Out: 93458	Actual HMM Out: 95458
Input from NN: 30900	Desired HMM Out: 30906	Actual HMM Out: 30900
Input from NN: 07270	Desired HMM Out: 67276	Actual HMM Out: 67270
Input from NN: 18081	Desired HMM Out: 18681	Actual HMM Out: 18081
Input from NN: 50354	Desired HMM Out: 50354	Actual HMM Out: 56354
Input from NN: 03450	Desired HMM Out: 63456	Actual HMM Out: 63450
Input from NN: 90314	Desired HMM Out: 96314	Actual HMM Out: 90314
Input from NN: 90333	Desired HMM Out: 96333	Actual HMM Out: 90333
Input from NN: 90909	Desired HMM Out: 96909	Actual HMM Out: 90909
Input from NN: 03037	Desired HMM Out: 63037	Actual HMM Out: 63637
Input from NN: 18107	Desired HMM Out: 18107	Actual HMM Out: 18109
Input from NN: 03030	Desired HMM Out: 63630	Actual HMM Out: 63636
Input from NN: 90708	Desired HMM Out: 90768	Actual HMM Out: 90908
Input from NN: 90890	Desired HMM Out: 90896	Actual HMM Out: 90890
Input from NN: 90840	Desired HMM Out: 90846	Actual HMM Out: 90840
Input from NN: 90904	Desired HMM Out: 90964	Actual HMM Out: 90904

Accumulative results for this person are:

Name: Isa Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 81
Number of words in error after HMM: 58
Error Rate before HMM: 16.20%
Error Rate after HMM: 11.60%

Testing for Larry, Attempt 1

Input from NN: 58142	Desired HMM Out: 59142	Actual HMM Out: 58142
Input from NN: 88272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 56378	Desired HMM Out: 56379	Actual HMM Out: 56378
Input from NN: 18672	Desired HMM Out: 19672	Actual HMM Out: 18672
Input from NN: 76308	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 29099
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 63727
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 63722
Input from NN: 88558	Desired HMM Out: 99559	Actual HMM Out: 99558
Input from NN: 63134	Desired HMM Out: 63134	Actual HMM Out: 63634
Input from NN: 80886	Desired HMM Out: 90896	Actual HMM Out: 90996

Accumulative results for this person are:

Name: Larry Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 40
Number of words in error after HMM: 11
Error Rate before HMM: 40.00%
Error Rate after HMM: 11.00%

Testing for Larry, Attempt 2

Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72795	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 54272
Input from NN: 92703	Desired HMM Out: 92703	Actual HMM Out: 92709
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 36890	Desired HMM Out: 36840	Actual HMM Out: 36890

Input from NN: 56379	Desired HMM Out: 56379	Actual HMM Out: 56374
Input from NN: 03399	Desired HMM Out: 03399	Actual HMM Out: 09999
Input from NN: 19672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 93958	Desired HMM Out: 93458	Actual HMM Out: 99955
Input from NN: 30906	Desired HMM Out: 30906	Actual HMM Out: 90906
Input from NN: 58959	Desired HMM Out: 58454	Actual HMM Out: 55454
Input from NN: 95598	Desired HMM Out: 95548	Actual HMM Out: 95545
Input from NN: 50359	Desired HMM Out: 50354	Actual HMM Out: 50954
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 63639	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18905
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90969

Accumulative results for this person are:

Name: Larry Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 72
Number of words in error after HMM: 33
Error Rate before HMM: 36.00%
Error Rate after HMM: 16.50%

Testing for Larry, Attempt 3

Input from NN: 34518	Desired HMM Out: 34578	Actual HMM Out: 34518
Input from NN: 62184	Desired HMM Out: 62784	Actual HMM Out: 62184
Input from NN: 12195	Desired HMM Out: 72795	Actual HMM Out: 12795
Input from NN: 08129	Desired HMM Out: 08729	Actual HMM Out: 08129
Input from NN: 53951	Desired HMM Out: 53957	Actual HMM Out: 53951
Input from NN: 12296	Desired HMM Out: 72296	Actual HMM Out: 12296
Input from NN: 11684	Desired HMM Out: 17684	Actual HMM Out: 11684
Input from NN: 14500	Desired HMM Out: 74500	Actual HMM Out: 14500
Input from NN: 91110	Desired HMM Out: 91170	Actual HMM Out: 91110
Input from NN: 16308	Desired HMM Out: 76308	Actual HMM Out: 16308
Input from NN: 95221	Desired HMM Out: 95221	Actual HMM Out: 95227
Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54672
Input from NN: 61222	Desired HMM Out: 61222	Actual HMM Out: 67222
Input from NN: 63031	Desired HMM Out: 63037	Actual HMM Out: 63031
Input from NN: 68181	Desired HMM Out: 68187	Actual HMM Out: 68181
Input from NN: 63181	Desired HMM Out: 63187	Actual HMM Out: 63181

Accumulative results for this person are:

Name: Larry Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 108
Number of words in error after HMM: 49
Error Rate before HMM: 36.00%
Error Rate after HMM: 16.33%

Testing for Larry, Attempt 4

Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 59272
Input from NN: 58454	Desired HMM Out: 58454	Actual HMM Out: 55454

Input from NN: 95548	Desired HMM Out: 95548	Actual HMM Out: 95545
Input from NN: 18681	Desired HMM Out: 18681	Actual HMM Out: 18181
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 12722

Accumulative results for this person are:

Name: Larry Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 108
Number of words in error after HMM: 54
Error Rate before HMM: 27.00%
Error Rate after HMM: 13.50%

Testing for Larry, Attempt 5

Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 59272
Input from NN: 95548	Desired HMM Out: 95548	Actual HMM Out: 95545
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 90909

Accumulative results for this person are:

Name: Larry Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 108
Number of words in error after HMM: 57
Error Rate before HMM: 21.60%
Error Rate after HMM: 11.40%

Testing for Rich, Attempt 1

Input from NN: 34573	Desired HMM Out: 34578	Actual HMM Out: 34579
Input from NN: 53142	Desired HMM Out: 59142	Actual HMM Out: 58142
Input from NN: 33272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 32703	Desired HMM Out: 92703	Actual HMM Out: 92709
Input from NN: 03723	Desired HMM Out: 08729	Actual HMM Out: 03729
Input from NN: 53357	Desired HMM Out: 53957	Actual HMM Out: 59957
Input from NN: 63544	Desired HMM Out: 68544	Actual HMM Out: 63544
Input from NN: 17634	Desired HMM Out: 17684	Actual HMM Out: 17634
Input from NN: 36340	Desired HMM Out: 36840	Actual HMM Out: 36340
Input from NN: 03333	Desired HMM Out: 03399	Actual HMM Out: 09999
Input from NN: 13672	Desired HMM Out: 19672	Actual HMM Out: 13672
Input from NN: 76303	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 33453	Desired HMM Out: 93458	Actual HMM Out: 33453
Input from NN: 23033	Desired HMM Out: 28088	Actual HMM Out: 29099
Input from NN: 30306	Desired HMM Out: 30906	Actual HMM Out: 90906
Input from NN: 53454	Desired HMM Out: 58454	Actual HMM Out: 53454
Input from NN: 35543	Desired HMM Out: 95548	Actual HMM Out: 95543
Input from NN: 13631	Desired HMM Out: 18681	Actual HMM Out: 13631
Input from NN: 50354	Desired HMM Out: 50354	Actual HMM Out: 50954
Input from NN: 36314	Desired HMM Out: 96314	Actual HMM Out: 36314
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 18722
Input from NN: 36333	Desired HMM Out: 96333	Actual HMM Out: 36399
Input from NN: 36303	Desired HMM Out: 96909	Actual HMM Out: 36309
Input from NN: 63633	Desired HMM Out: 63639	Actual HMM Out: 63633
Input from NN: 33553	Desired HMM Out: 99559	Actual HMM Out: 99553
Input from NN: 63134	Desired HMM Out: 63134	Actual HMM Out: 63184
Input from NN: 30763	Desired HMM Out: 90768	Actual HMM Out: 90763
Input from NN: 63137	Desired HMM Out: 68187	Actual HMM Out: 63187

Input from NN: 30336	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 63122	Desired HMM Out: 68122	Actual HMM Out: 63122
Input from NN: 30346	Desired HMM Out: 90846	Actual HMM Out: 90346
Input from NN: 30364	Desired HMM Out: 90964	Actual HMM Out: 90364

Accumulative results for this person are:

Name: Rich Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 63
Number of words in error after HMM: 32
Error Rate before HMM: 63.00%
Error Rate after HMM: 32.00%

Testing for Rich, Attempt 2

Input from NN: 12751	Desired HMM Out: 12751	Actual HMM Out: 12741
Input from NN: 58152	Desired HMM Out: 59142	Actual HMM Out: 58142
Input from NN: 72785	Desired HMM Out: 72795	Actual HMM Out: 72784
Input from NN: 88272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 22275	Desired HMM Out: 22274	Actual HMM Out: 22275
Input from NN: 68555	Desired HMM Out: 68544	Actual HMM Out: 68454
Input from NN: 56378	Desired HMM Out: 56379	Actual HMM Out: 56378
Input from NN: 81170	Desired HMM Out: 91170	Actual HMM Out: 91270
Input from NN: 18672	Desired HMM Out: 19672	Actual HMM Out: 18672
Input from NN: 36353	Desired HMM Out: 36343	Actual HMM Out: 36353
Input from NN: 55505	Desired HMM Out: 55404	Actual HMM Out: 54505
Input from NN: 76308	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 29099
Input from NN: 85555	Desired HMM Out: 95455	Actual HMM Out: 95454
Input from NN: 85558	Desired HMM Out: 95548	Actual HMM Out: 95458
Input from NN: 50355	Desired HMM Out: 50354	Actual HMM Out: 50345
Input from NN: 85221	Desired HMM Out: 95221	Actual HMM Out: 95222
Input from NN: 88051	Desired HMM Out: 99041	Actual HMM Out: 99051
Input from NN: 63555	Desired HMM Out: 63545	Actual HMM Out: 63454
Input from NN: 88558	Desired HMM Out: 99559	Actual HMM Out: 99558
Input from NN: 80555	Desired HMM Out: 90445	Actual HMM Out: 90545
Input from NN: 80886	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18114
Input from NN: 63635	Desired HMM Out: 63635	Actual HMM Out: 63634
Input from NN: 80550	Desired HMM Out: 90550	Actual HMM Out: 90540

Accumulative results for this person are:

Name: Rich Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 125
Number of words in error after HMM: 57
Error Rate before HMM: 62.50%
Error Rate after HMM: 28.50%

Testing for Rich, Attempt 3

Input from NN: 11751	Desired HMM Out: 12751	Actual HMM Out: 12741
Input from NN: 59151	Desired HMM Out: 59142	Actual HMM Out: 59141
Input from NN: 11175	Desired HMM Out: 22274	Actual HMM Out: 12274
Input from NN: 68555	Desired HMM Out: 68544	Actual HMM Out: 68454
Input from NN: 17685	Desired HMM Out: 17684	Actual HMM Out: 27684

Input from NN: 11171	Desired HMM Out: 22272	Actual HMM Out: 12272
Input from NN: 91170	Desired HMM Out: 91170	Actual HMM Out: 92270
Input from NN: 55505	Desired HMM Out: 55404	Actual HMM Out: 54505
Input from NN: 18088	Desired HMM Out: 28088	Actual HMM Out: 18088
Input from NN: 57175	Desired HMM Out: 57275	Actual HMM Out: 57274
Input from NN: 95555	Desired HMM Out: 95455	Actual HMM Out: 95454
Input from NN: 18117	Desired HMM Out: 18227	Actual HMM Out: 18127
Input from NN: 95558	Desired HMM Out: 95548	Actual HMM Out: 95458
Input from NN: 50355	Desired HMM Out: 50354	Actual HMM Out: 50345
Input from NN: 95111	Desired HMM Out: 95221	Actual HMM Out: 95111
Input from NN: 55611	Desired HMM Out: 54612	Actual HMM Out: 54611
Input from NN: 63555	Desired HMM Out: 63545	Actual HMM Out: 63454
Input from NN: 61111	Desired HMM Out: 61222	Actual HMM Out: 62222
Input from NN: 90555	Desired HMM Out: 90445	Actual HMM Out: 90545
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18114
Input from NN: 63635	Desired HMM Out: 63635	Actual HMM Out: 63634
Input from NN: 90550	Desired HMM Out: 90550	Actual HMM Out: 90540
Input from NN: 68111	Desired HMM Out: 68122	Actual HMM Out: 68111

Accumulative results for this person are:

Name: Rich Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 181
Number of words in error after HMM: 80
Error Rate before HMM: 60.33%
Error Rate after HMM: 26.67%

Testing for Rich, Attempt 4

Input from NN: 00767	Desired HMM Out: 00367	Actual HMM Out: 00363
Input from NN: 27057	Desired HMM Out: 27053	Actual HMM Out: 27057
Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72795	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 84272
Input from NN: 92707	Desired HMM Out: 92703	Actual HMM Out: 92707
Input from NN: 22279	Desired HMM Out: 22274	Actual HMM Out: 22279
Input from NN: 57957	Desired HMM Out: 53957	Actual HMM Out: 57457
Input from NN: 68599	Desired HMM Out: 68544	Actual HMM Out: 68599
Input from NN: 17689	Desired HMM Out: 17684	Actual HMM Out: 13684
Input from NN: 76890	Desired HMM Out: 36840	Actual HMM Out: 36890
Input from NN: 79500	Desired HMM Out: 74500	Actual HMM Out: 34500
Input from NN: 07799	Desired HMM Out: 03399	Actual HMM Out: 03799
Input from NN: 19672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55909
Input from NN: 76708	Desired HMM Out: 76308	Actual HMM Out: 36308
Input from NN: 70906	Desired HMM Out: 30906	Actual HMM Out: 70906
Input from NN: 50759	Desired HMM Out: 50354	Actual HMM Out: 50754
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 63727
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 96777	Desired HMM Out: 96333	Actual HMM Out: 96337
Input from NN: 19090	Desired HMM Out: 14090	Actual HMM Out: 19090
Input from NN: 67679	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 67179	Desired HMM Out: 63134	Actual HMM Out: 63179
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18905

Input from NN: 90768	Desired HMM Out: 90768	Actual HMM Out: 90368
Input from NN: 18767	Desired HMM Out: 18363	Actual HMM Out: 18763
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90969

Accumulative results for this person are:

Name: Rich Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 240
Number of words in error after HMM: 111
Error Rate before HMM: 60.00%
Error Rate after HMM: 27.75%

Testing for Rich, Attempt 5

Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72795	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 84272
Input from NN: 22279	Desired HMM Out: 22274	Actual HMM Out: 22279
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 68599	Desired HMM Out: 68544	Actual HMM Out: 68599
Input from NN: 36890	Desired HMM Out: 36840	Actual HMM Out: 36890
Input from NN: 19672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55909
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 19090	Desired HMM Out: 14090	Actual HMM Out: 19090
Input from NN: 63639	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18905
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90969

Accumulative results for this person are:

Name: Rich Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 272
Number of words in error after HMM: 128
Error Rate before HMM: 54.40%
Error Rate after HMM: 25.60%

Testing for Sarah, Attempt 1

Input from NN: 33367	Desired HMM Out: 00367	Actual HMM Out: 90367
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 50957
Input from NN: 39999	Desired HMM Out: 09999	Actual HMM Out: 99999
Input from NN: 74533	Desired HMM Out: 74500	Actual HMM Out: 74503
Input from NN: 33399	Desired HMM Out: 03399	Actual HMM Out: 90099
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36340
Input from NN: 93458	Desired HMM Out: 93458	Actual HMM Out: 90458
Input from NN: 39339	Desired HMM Out: 09009	Actual HMM Out: 99009
Input from NN: 33936	Desired HMM Out: 30906	Actual HMM Out: 90906
Input from NN: 53354	Desired HMM Out: 50354	Actual HMM Out: 50954
Input from NN: 96333	Desired HMM Out: 96333	Actual HMM Out: 96303

Input from NN: 63337	Desired HMM Out: 63037	Actual HMM Out: 63907
Input from NN: 18137	Desired HMM Out: 18107	Actual HMM Out: 18137
Input from NN: 93372	Desired HMM Out: 90072	Actual HMM Out: 90372
Input from NN: 63633	Desired HMM Out: 63630	Actual HMM Out: 63633
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18114
Input from NN: 93553	Desired HMM Out: 90550	Actual HMM Out: 90553

Accumulative results for this person are:

Name: Sarah Completed Attempt: 1
 Number of words processed: 100
 Number of words in error from NN: 36
 Number of words in error after HMM: 18
 Error Rate before HMM: 36.00%
 Error Rate after HMM: 18.00%

Testing for Sarah, Attempt 2

Input from NN: 42754	Desired HMM Out: 12751	Actual HMM Out: 12754
Input from NN: 27254	Desired HMM Out: 27053	Actual HMM Out: 27454
Input from NN: 44578	Desired HMM Out: 34578	Actual HMM Out: 14578
Input from NN: 59442	Desired HMM Out: 59142	Actual HMM Out: 59112
Input from NN: 62784	Desired HMM Out: 62784	Actual HMM Out: 62781
Input from NN: 92724	Desired HMM Out: 92703	Actual HMM Out: 92721
Input from NN: 46727	Desired HMM Out: 16727	Actual HMM Out: 36727
Input from NN: 68544	Desired HMM Out: 68544	Actual HMM Out: 68541
Input from NN: 47684	Desired HMM Out: 17684	Actual HMM Out: 17681
Input from NN: 46842	Desired HMM Out: 36840	Actual HMM Out: 36812
Input from NN: 74522	Desired HMM Out: 74500	Actual HMM Out: 74540
Input from NN: 94472	Desired HMM Out: 91170	Actual HMM Out: 91172
Input from NN: 46444	Desired HMM Out: 36343	Actual HMM Out: 36341
Input from NN: 55424	Desired HMM Out: 55404	Actual HMM Out: 55403
Input from NN: 94458	Desired HMM Out: 93458	Actual HMM Out: 91458
Input from NN: 28288	Desired HMM Out: 28088	Actual HMM Out: 08488
Input from NN: 42926	Desired HMM Out: 30906	Actual HMM Out: 10906
Input from NN: 95548	Desired HMM Out: 95548	Actual HMM Out: 95518
Input from NN: 52454	Desired HMM Out: 50354	Actual HMM Out: 54454
Input from NN: 95224	Desired HMM Out: 95221	Actual HMM Out: 95403
Input from NN: 54642	Desired HMM Out: 54612	Actual HMM Out: 54634
Input from NN: 99244	Desired HMM Out: 99041	Actual HMM Out: 99034
Input from NN: 54464	Desired HMM Out: 51463	Actual HMM Out: 54363
Input from NN: 96444	Desired HMM Out: 96314	Actual HMM Out: 96341
Input from NN: 44722	Desired HMM Out: 13722	Actual HMM Out: 11722
Input from NN: 64222	Desired HMM Out: 61222	Actual HMM Out: 63422
Input from NN: 96444	Desired HMM Out: 96333	Actual HMM Out: 96341
Input from NN: 64247	Desired HMM Out: 63037	Actual HMM Out: 63417
Input from NN: 48427	Desired HMM Out: 18107	Actual HMM Out: 18127
Input from NN: 92272	Desired HMM Out: 90072	Actual HMM Out: 92272
Input from NN: 64444	Desired HMM Out: 63134	Actual HMM Out: 63411
Input from NN: 48425	Desired HMM Out: 18405	Actual HMM Out: 18145
Input from NN: 64642	Desired HMM Out: 63630	Actual HMM Out: 63634
Input from NN: 92768	Desired HMM Out: 90768	Actual HMM Out: 92768
Input from NN: 64644	Desired HMM Out: 63631	Actual HMM Out: 63634
Input from NN: 48464	Desired HMM Out: 18363	Actual HMM Out: 18463
Input from NN: 92445	Desired HMM Out: 90445	Actual HMM Out: 90345
Input from NN: 44464	Desired HMM Out: 14163	Actual HMM Out: 11363

Input from NN: 48445	Desired HMM Out: 18115	Actual HMM Out: 18145
Input from NN: 92552	Desired HMM Out: 90550	Actual HMM Out: 90554
Input from NN: 92964	Desired HMM Out: 90964	Actual HMM Out: 90963

Accumulative results for this person are:

Name: Sarah Completed Attempt: 2
 Number of words processed: 200
 Number of words in error from NN: 120
 Number of words in error after HMM: 59
 Error Rate before HMM: 60.00%
 Error Rate after HMM: 29.50%

Testing for Sarah, Attempt 3

Input from NN: 12751	Desired HMM Out: 12751	Actual HMM Out: 12741
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 09272
Input from NN: 74588	Desired HMM Out: 74500	Actual HMM Out: 74588
Input from NN: 91178	Desired HMM Out: 91170	Actual HMM Out: 91178
Input from NN: 83399	Desired HMM Out: 03399	Actual HMM Out: 63399
Input from NN: 55484	Desired HMM Out: 55404	Actual HMM Out: 55484
Input from NN: 18998	Desired HMM Out: 10990	Actual HMM Out: 18990
Input from NN: 28888	Desired HMM Out: 28088	Actual HMM Out: 28888
Input from NN: 95548	Desired HMM Out: 95548	Actual HMM Out: 95540
Input from NN: 63837	Desired HMM Out: 63037	Actual HMM Out: 63637
Input from NN: 18187	Desired HMM Out: 18107	Actual HMM Out: 18187
Input from NN: 98872	Desired HMM Out: 90072	Actual HMM Out: 90872
Input from NN: 98896	Desired HMM Out: 90896	Actual HMM Out: 90096
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18114
Input from NN: 98558	Desired HMM Out: 90550	Actual HMM Out: 90558

Accumulative results for this person are:

Name: Sarah Completed Attempt: 3
 Number of words processed: 300
 Number of words in error from NN: 156
 Number of words in error after HMM: 74
 Error Rate before HMM: 52.00%
 Error Rate after HMM: 24.67%

Testing for Sarah, Attempt 4

Input from NN: 33367	Desired HMM Out: 00367	Actual HMM Out: 30367
Input from NN: 34572	Desired HMM Out: 34578	Actual HMM Out: 34572
Input from NN: 29272	Desired HMM Out: 89272	Actual HMM Out: 27272
Input from NN: 32729	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 50957
Input from NN: 62544	Desired HMM Out: 68544	Actual HMM Out: 63544
Input from NN: 72296	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 74533	Desired HMM Out: 74500	Actual HMM Out: 74503
Input from NN: 33399	Desired HMM Out: 03399	Actual HMM Out: 30099
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36340
Input from NN: 93452	Desired HMM Out: 93458	Actual HMM Out: 90458
Input from NN: 12227	Desired HMM Out: 18227	Actual HMM Out: 12227
Input from NN: 95542	Desired HMM Out: 95548	Actual HMM Out: 95542
Input from NN: 95221	Desired HMM Out: 95221	Actual HMM Out: 95881
Input from NN: 12221	Desired HMM Out: 18881	Actual HMM Out: 12221

Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54618
Input from NN: 96333	Desired HMM Out: 96333	Actual HMM Out: 96303
Input from NN: 12137	Desired HMM Out: 18107	Actual HMM Out: 18137
Input from NN: 93372	Desired HMM Out: 90072	Actual HMM Out: 90372
Input from NN: 63633	Desired HMM Out: 63630	Actual HMM Out: 63633
Input from NN: 93762	Desired HMM Out: 90768	Actual HMM Out: 90763
Input from NN: 62127	Desired HMM Out: 68187	Actual HMM Out: 68127
Input from NN: 93553	Desired HMM Out: 90550	Actual HMM Out: 90553
Input from NN: 63127	Desired HMM Out: 63187	Actual HMM Out: 63127

Accumulative results for this person are:

Name: Sarah Completed Attempt: 4
 Number of words processed: 400
 Number of words in error from NN: 213
 Number of words in error after HMM: 98
 Error Rate before HMM: 53.25%
 Error Rate after HMM: 24.50%

Testing for Sarah, Attempt 5

Input from NN: 27353	Desired HMM Out: 27053	Actual HMM Out: 27050
Input from NN: 62784	Desired HMM Out: 62784	Actual HMM Out: 63784
Input from NN: 92733	Desired HMM Out: 92703	Actual HMM Out: 92700
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 50957
Input from NN: 33399	Desired HMM Out: 03399	Actual HMM Out: 00099
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36340
Input from NN: 93458	Desired HMM Out: 93458	Actual HMM Out: 90458
Input from NN: 33936	Desired HMM Out: 30906	Actual HMM Out: 00906
Input from NN: 53354	Desired HMM Out: 50354	Actual HMM Out: 50054
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 10722
Input from NN: 96333	Desired HMM Out: 96333	Actual HMM Out: 96300
Input from NN: 63627	Desired HMM Out: 63627	Actual HMM Out: 63637
Input from NN: 63337	Desired HMM Out: 63037	Actual HMM Out: 63007

Accumulative results for this person are:

Name: Sarah Completed Attempt: 5
 Number of words processed: 500
 Number of words in error from NN: 249
 Number of words in error after HMM: 111
 Error Rate before HMM: 49.80%
 Error Rate after HMM: 22.20%

Testing for Stuart, Attempt 1

Input from NN: 53142	Desired HMM Out: 59142	Actual HMM Out: 53142
Input from NN: 32703	Desired HMM Out: 92703	Actual HMM Out: 92709
Input from NN: 53357	Desired HMM Out: 53957	Actual HMM Out: 59957
Input from NN: 03333	Desired HMM Out: 03399	Actual HMM Out: 09999
Input from NN: 13672	Desired HMM Out: 19672	Actual HMM Out: 13672
Input from NN: 33458	Desired HMM Out: 93458	Actual HMM Out: 33458
Input from NN: 30306	Desired HMM Out: 30906	Actual HMM Out: 90906
Input from NN: 50354	Desired HMM Out: 50354	Actual HMM Out: 50954
Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54512
Input from NN: 36314	Desired HMM Out: 96314	Actual HMM Out: 36314
Input from NN: 36333	Desired HMM Out: 96333	Actual HMM Out: 36399
Input from NN: 36303	Desired HMM Out: 96909	Actual HMM Out: 36309

Input from NN: 63633	Desired HMM Out: 63639	Actual HMM Out: 63633
Input from NN: 33553	Desired HMM Out: 99559	Actual HMM Out: 99553
Input from NN: 30836	Desired HMM Out: 90896	Actual HMM Out: 90836
Input from NN: 30364	Desired HMM Out: 90964	Actual HMM Out: 90954

Accumulative results for this person are:

Name: Stuart Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 40
Number of words in error after HMM: 16
Error Rate before HMM: 40.00%
Error Rate after HMM: 16.00%

Testing for Stuart, Attempt 2

Input from NN: 00367	Desired HMM Out: 00367	Actual HMM Out: 00363
Input from NN: 27053	Desired HMM Out: 27053	Actual HMM Out: 27453
Input from NN: 59102	Desired HMM Out: 59142	Actual HMM Out: 59112
Input from NN: 08729	Desired HMM Out: 08729	Actual HMM Out: 18729
Input from NN: 22270	Desired HMM Out: 22274	Actual HMM Out: 22270
Input from NN: 68500	Desired HMM Out: 68544	Actual HMM Out: 68540
Input from NN: 17680	Desired HMM Out: 17684	Actual HMM Out: 13684
Input from NN: 70500	Desired HMM Out: 74500	Actual HMM Out: 74540
Input from NN: 36303	Desired HMM Out: 36343	Actual HMM Out: 36303
Input from NN: 55000	Desired HMM Out: 55404	Actual HMM Out: 55400
Input from NN: 76308	Desired HMM Out: 76308	Actual HMM Out: 36308
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 28188
Input from NN: 95508	Desired HMM Out: 95548	Actual HMM Out: 95508
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 63727
Input from NN: 50612	Desired HMM Out: 54612	Actual HMM Out: 54512
Input from NN: 63056	Desired HMM Out: 63456	Actual HMM Out: 63455
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 95909
Input from NN: 63630	Desired HMM Out: 63634	Actual HMM Out: 63630
Input from NN: 63130	Desired HMM Out: 63134	Actual HMM Out: 63130
Input from NN: 18005	Desired HMM Out: 18405	Actual HMM Out: 18145
Input from NN: 90768	Desired HMM Out: 90768	Actual HMM Out: 90368
Input from NN: 90005	Desired HMM Out: 90445	Actual HMM Out: 90045
Input from NN: 90550	Desired HMM Out: 90550	Actual HMM Out: 90554
Input from NN: 90806	Desired HMM Out: 90846	Actual HMM Out: 90845
Input from NN: 90960	Desired HMM Out: 90964	Actual HMM Out: 90954

Accumulative results for this person are:

Name: Stuart Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 72
Number of words in error after HMM: 41
Error Rate before HMM: 36.00%
Error Rate after HMM: 20.50%

Testing for Stuart, Attempt 3

Input from NN: 34576	Desired HMM Out: 34578	Actual HMM Out: 34576
Input from NN: 67764	Desired HMM Out: 62784	Actual HMM Out: 67284
Input from NN: 77795	Desired HMM Out: 72795	Actual HMM Out: 27295
Input from NN: 69777	Desired HMM Out: 89272	Actual HMM Out: 69272
Input from NN: 06779	Desired HMM Out: 08729	Actual HMM Out: 18729

Input from NN: 16777	Desired HMM Out: 16727	Actual HMM Out: 18727
Input from NN: 77774	Desired HMM Out: 22274	Actual HMM Out: 27274
Input from NN: 77796	Desired HMM Out: 72296	Actual HMM Out: 27296
Input from NN: 77777	Desired HMM Out: 22272	Actual HMM Out: 27272
Input from NN: 77777	Desired HMM Out: 27227	Actual HMM Out: 27272
Input from NN: 76306	Desired HMM Out: 76308	Actual HMM Out: 76318
Input from NN: 93456	Desired HMM Out: 93458	Actual HMM Out: 93456
Input from NN: 76066	Desired HMM Out: 28088	Actual HMM Out: 78188
Input from NN: 57775	Desired HMM Out: 57275	Actual HMM Out: 72727
Input from NN: 16777	Desired HMM Out: 18227	Actual HMM Out: 18727
Input from NN: 95546	Desired HMM Out: 95548	Actual HMM Out: 95546
Input from NN: 16661	Desired HMM Out: 18681	Actual HMM Out: 18881
Input from NN: 67777	Desired HMM Out: 67727	Actual HMM Out: 67272
Input from NN: 95771	Desired HMM Out: 95221	Actual HMM Out: 95721
Input from NN: 54617	Desired HMM Out: 54612	Actual HMM Out: 54812
Input from NN: 13777	Desired HMM Out: 13722	Actual HMM Out: 13727
Input from NN: 61777	Desired HMM Out: 61222	Actual HMM Out: 61272
Input from NN: 63677	Desired HMM Out: 63627	Actual HMM Out: 63672
Input from NN: 16107	Desired HMM Out: 18107	Actual HMM Out: 18112
Input from NN: 16363	Desired HMM Out: 18363	Actual HMM Out: 16363
Input from NN: 66177	Desired HMM Out: 68122	Actual HMM Out: 68127

Accumulative results for this person are:

Name: Stuart Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 124
Number of words in error after HMM: 67
Error Rate before HMM: 41.33%
Error Rate after HMM: 22.33%

Testing for Stuart, Attempt 4

Input from NN: 34572	Desired HMM Out: 34578	Actual HMM Out: 34572
Input from NN: 67724	Desired HMM Out: 62784	Actual HMM Out: 67284
Input from NN: 29777	Desired HMM Out: 89272	Actual HMM Out: 29272
Input from NN: 77774	Desired HMM Out: 22274	Actual HMM Out: 27274
Input from NN: 77796	Desired HMM Out: 72296	Actual HMM Out: 72796
Input from NN: 77777	Desired HMM Out: 22272	Actual HMM Out: 72727
Input from NN: 77777	Desired HMM Out: 27227	Actual HMM Out: 72727
Input from NN: 72022	Desired HMM Out: 28088	Actual HMM Out: 78088
Input from NN: 12777	Desired HMM Out: 18227	Actual HMM Out: 12727
Input from NN: 67777	Desired HMM Out: 67727	Actual HMM Out: 67272
Input from NN: 95771	Desired HMM Out: 95221	Actual HMM Out: 95721
Input from NN: 13777	Desired HMM Out: 13722	Actual HMM Out: 13727
Input from NN: 61777	Desired HMM Out: 61222	Actual HMM Out: 61272
Input from NN: 63677	Desired HMM Out: 63627	Actual HMM Out: 63672
Input from NN: 62127	Desired HMM Out: 68187	Actual HMM Out: 68127
Input from NN: 62177	Desired HMM Out: 68122	Actual HMM Out: 68127
Input from NN: 63127	Desired HMM Out: 63187	Actual HMM Out: 63127

Accumulative results for this person are:

Name: Stuart Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 176
Number of words in error after HMM: 84

Error Rate before HMM: 44.00%
Error Rate after HMM: 21.00%

Testing for Stuart, Attempt 5

Input from NN: 12721	Desired HMM Out: 12751	Actual HMM Out: 12721
Input from NN: 28142	Desired HMM Out: 59142	Actual HMM Out: 58145
Input from NN: 98272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 23827	Desired HMM Out: 53957	Actual HMM Out: 63927
Input from NN: 18672	Desired HMM Out: 19672	Actual HMM Out: 18672
Input from NN: 76309	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 29099	Desired HMM Out: 28088	Actual HMM Out: 59099
Input from NN: 27272	Desired HMM Out: 57275	Actual HMM Out: 27272
Input from NN: 82221	Desired HMM Out: 95221	Actual HMM Out: 92221
Input from NN: 86333	Desired HMM Out: 96333	Actual HMM Out: 96363
Input from NN: 80986	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 19112	Desired HMM Out: 18115	Actual HMM Out: 18112

Accumulative results for this person are:

Name: Stuart Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 252
Number of words in error after HMM: 96
Error Rate before HMM: 50.40%
Error Rate after HMM: 19.20%

Testing for Tony, Attempt 1

Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54172
Input from NN: 72795	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 08729	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 22279	Desired HMM Out: 22274	Actual HMM Out: 22279
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 68599	Desired HMM Out: 68544	Actual HMM Out: 68599
Input from NN: 72296	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 36890	Desired HMM Out: 36840	Actual HMM Out: 36890
Input from NN: 19672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55909
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 90909
Input from NN: 19090	Desired HMM Out: 14090	Actual HMM Out: 19090
Input from NN: 63639	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18905
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90909

Accumulative results for this person are:

Name: Tony Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 32
Number of words in error after HMM: 20
Error Rate before HMM: 32.00%
Error Rate after HMM: 20.00%

Testing for Tony, Attempt 2

Input from NN: 58192	Desired HMM Out: 59142	Actual HMM Out: 58172
Input from NN: 62789	Desired HMM Out: 62784	Actual HMM Out: 63784
Input from NN: 88272	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 56278	Desired HMM Out: 56379	Actual HMM Out: 56378
Input from NN: 02288	Desired HMM Out: 03399	Actual HMM Out: 52288
Input from NN: 18672	Desired HMM Out: 19672	Actual HMM Out: 18672
Input from NN: 26292	Desired HMM Out: 36343	Actual HMM Out: 36372
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 76208	Desired HMM Out: 76308	Actual HMM Out: 76309
Input from NN: 82958	Desired HMM Out: 93458	Actual HMM Out: 92758
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 29099
Input from NN: 88091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 12722	Desired HMM Out: 13722	Actual HMM Out: 12722
Input from NN: 86222	Desired HMM Out: 96333	Actual HMM Out: 96222
Input from NN: 62627	Desired HMM Out: 63627	Actual HMM Out: 63637
Input from NN: 88558	Desired HMM Out: 99559	Actual HMM Out: 99558
Input from NN: 62129	Desired HMM Out: 63134	Actual HMM Out: 63127
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18455
Input from NN: 80995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 80886	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 80896	Desired HMM Out: 90846	Actual HMM Out: 90996
Input from NN: 80869	Desired HMM Out: 90964	Actual HMM Out: 90967

Accumulative results for this person are:

Name: Tony Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 111
Number of words in error after HMM: 42
Error Rate before HMM: 55.50%
Error Rate after HMM: 21.00%

Testing for Tony, Attempt 3

Input from NN: 39598	Desired HMM Out: 34578	Actual HMM Out: 34548
Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54172
Input from NN: 92995	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89292	Desired HMM Out: 89272	Actual HMM Out: 99272
Input from NN: 92903	Desired HMM Out: 92703	Actual HMM Out: 72703
Input from NN: 08929	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 53959	Desired HMM Out: 53957	Actual HMM Out: 53454
Input from NN: 92296	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 19689	Desired HMM Out: 17684	Actual HMM Out: 14684
Input from NN: 56399	Desired HMM Out: 56379	Actual HMM Out: 56399
Input from NN: 99500	Desired HMM Out: 74500	Actual HMM Out: 99500
Input from NN: 91190	Desired HMM Out: 91170	Actual HMM Out: 91140
Input from NN: 19692	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 96308	Desired HMM Out: 76308	Actual HMM Out: 96309
Input from NN: 28088	Desired HMM Out: 28088	Actual HMM Out: 29088
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 96333	Desired HMM Out: 96333	Actual HMM Out: 96363
Input from NN: 96909	Desired HMM Out: 96909	Actual HMM Out: 96709
Input from NN: 63039	Desired HMM Out: 63037	Actual HMM Out: 63034

Input from NN: 18109	Desired HMM Out: 18107	Actual HMM Out: 18109
Input from NN: 63639	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 90968	Desired HMM Out: 90768	Actual HMM Out: 90968
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 68189	Desired HMM Out: 68187	Actual HMM Out: 68184
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90996
Input from NN: 90896	Desired HMM Out: 90846	Actual HMM Out: 90996
Input from NN: 63189	Desired HMM Out: 63187	Actual HMM Out: 63184
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90967

Accumulative results for this person are:

Name: Tony Completed Attempt: 3
 Number of words processed: 300
 Number of words in error from NN: 173
 Number of words in error after HMM: 72
 Error Rate before HMM: 57.67%
 Error Rate after HMM: 24.00%

Testing for Tony, Attempt 4

Input from NN: 59192	Desired HMM Out: 59142	Actual HMM Out: 54142
Input from NN: 72795	Desired HMM Out: 72795	Actual HMM Out: 72745
Input from NN: 89272	Desired HMM Out: 89272	Actual HMM Out: 84272
Input from NN: 22279	Desired HMM Out: 22274	Actual HMM Out: 22279
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 53457
Input from NN: 68599	Desired HMM Out: 68544	Actual HMM Out: 68599
Input from NN: 36890	Desired HMM Out: 36840	Actual HMM Out: 36890
Input from NN: 19672	Desired HMM Out: 19672	Actual HMM Out: 14672
Input from NN: 55909	Desired HMM Out: 55404	Actual HMM Out: 55909
Input from NN: 99091	Desired HMM Out: 99041	Actual HMM Out: 99091
Input from NN: 19090	Desired HMM Out: 14090	Actual HMM Out: 19090
Input from NN: 63639	Desired HMM Out: 63639	Actual HMM Out: 63634
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99554
Input from NN: 18905	Desired HMM Out: 18405	Actual HMM Out: 18455
Input from NN: 90995	Desired HMM Out: 90445	Actual HMM Out: 90995
Input from NN: 19163	Desired HMM Out: 14163	Actual HMM Out: 18163
Input from NN: 90896	Desired HMM Out: 90896	Actual HMM Out: 90846
Input from NN: 90969	Desired HMM Out: 90964	Actual HMM Out: 90969

Accumulative results for this person are:

Name: Tony Completed Attempt: 4
 Number of words processed: 400
 Number of words in error from NN: 205
 Number of words in error after HMM: 90
 Error Rate before HMM: 51.25%
 Error Rate after HMM: 22.50%

Testing for Tony, Attempt 5

Input from NN: 33367	Desired HMM Out: 00367	Actual HMM Out: 30367
Input from NN: 72775	Desired HMM Out: 72795	Actual HMM Out: 72275
Input from NN: 87272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 72733	Desired HMM Out: 92703	Actual HMM Out: 72703
Input from NN: 38727	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 53757	Desired HMM Out: 53957	Actual HMM Out: 50957

Input from NN: 72276	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 37777	Desired HMM Out: 09999	Actual HMM Out: 37272
Input from NN: 56377	Desired HMM Out: 56379	Actual HMM Out: 56372
Input from NN: 74533	Desired HMM Out: 74500	Actual HMM Out: 74503
Input from NN: 71173	Desired HMM Out: 91170	Actual HMM Out: 91190
Input from NN: 33377	Desired HMM Out: 03399	Actual HMM Out: 30099
Input from NN: 17672	Desired HMM Out: 19672	Actual HMM Out: 17672
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36340
Input from NN: 76338	Desired HMM Out: 76308	Actual HMM Out: 96308
Input from NN: 73458	Desired HMM Out: 93458	Actual HMM Out: 90458
Input from NN: 67727	Desired HMM Out: 67727	Actual HMM Out: 67227
Input from NN: 76333	Desired HMM Out: 96333	Actual HMM Out: 96303
Input from NN: 76737	Desired HMM Out: 96909	Actual HMM Out: 96709
Input from NN: 63337	Desired HMM Out: 63037	Actual HMM Out: 63009
Input from NN: 18137	Desired HMM Out: 18107	Actual HMM Out: 18109
Input from NN: 73372	Desired HMM Out: 90072	Actual HMM Out: 90372
Input from NN: 63637	Desired HMM Out: 63639	Actual HMM Out: 63637
Input from NN: 77557	Desired HMM Out: 99559	Actual HMM Out: 99557
Input from NN: 63633	Desired HMM Out: 63630	Actual HMM Out: 63633
Input from NN: 73768	Desired HMM Out: 90768	Actual HMM Out: 90968
Input from NN: 73876	Desired HMM Out: 90896	Actual HMM Out: 90876
Input from NN: 73553	Desired HMM Out: 90550	Actual HMM Out: 90553

Accumulative results for this person are:

Name: Tony Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 257
Number of words in error after HMM: 118
Error Rate before HMM: 51.40%
Error Rate after HMM: 23.60%

Testing for Wayne, Attempt 1

Input from NN: 87272	Desired HMM Out: 89272	Actual HMM Out: 87272
Input from NN: 72703	Desired HMM Out: 92703	Actual HMM Out: 72703
Input from NN: 08727	Desired HMM Out: 08729	Actual HMM Out: 08727
Input from NN: 53757	Desired HMM Out: 53957	Actual HMM Out: 52757
Input from NN: 72276	Desired HMM Out: 72296	Actual HMM Out: 72276
Input from NN: 56377	Desired HMM Out: 56379	Actual HMM Out: 56399
Input from NN: 71170	Desired HMM Out: 91170	Actual HMM Out: 91190
Input from NN: 17672	Desired HMM Out: 19672	Actual HMM Out: 17672
Input from NN: 76308	Desired HMM Out: 76308	Actual HMM Out: 96308
Input from NN: 13722	Desired HMM Out: 13722	Actual HMM Out: 12722
Input from NN: 76707	Desired HMM Out: 96909	Actual HMM Out: 96709
Input from NN: 18107	Desired HMM Out: 18107	Actual HMM Out: 18109
Input from NN: 63637	Desired HMM Out: 63639	Actual HMM Out: 63637
Input from NN: 77557	Desired HMM Out: 99559	Actual HMM Out: 99557
Input from NN: 70768	Desired HMM Out: 90768	Actual HMM Out: 90968
Input from NN: 70876	Desired HMM Out: 90896	Actual HMM Out: 90876

Accumulative results for this person are:

Name: Wayne Completed Attempt: 1
Number of words processed: 100
Number of words in error from NN: 40
Number of words in error after HMM: 16

Error Rate before HMM: 40.00%
Error Rate after HMM: 16.00%

Testing for Wayne, Attempt 2

Input from NN: 34572	Desired HMM Out: 34578	Actual HMM Out: 34572
Input from NN: 29272	Desired HMM Out: 89272	Actual HMM Out: 29272
Input from NN: 22022	Desired HMM Out: 28088	Actual HMM Out: 22222
Input from NN: 12227	Desired HMM Out: 18227	Actual HMM Out: 12227
Input from NN: 95542	Desired HMM Out: 95548	Actual HMM Out: 95542
Input from NN: 95221	Desired HMM Out: 95221	Actual HMM Out: 95881
Input from NN: 12221	Desired HMM Out: 18881	Actual HMM Out: 12221
Input from NN: 54612	Desired HMM Out: 54612	Actual HMM Out: 54618
Input from NN: 62127	Desired HMM Out: 68187	Actual HMM Out: 68127
Input from NN: 63127	Desired HMM Out: 63187	Actual HMM Out: 63127

Accumulative results for this person are:

Name: Wayne Completed Attempt: 2
Number of words processed: 200
Number of words in error from NN: 70
Number of words in error after HMM: 26
Error Rate before HMM: 35.00%
Error Rate after HMM: 13.00%

Testing for Wayne, Attempt 3

Input from NN: 59149	Desired HMM Out: 59142	Actual HMM Out: 55145
Input from NN: 89979	Desired HMM Out: 89272	Actual HMM Out: 82272
Input from NN: 99703	Desired HMM Out: 92703	Actual HMM Out: 22703
Input from NN: 08799	Desired HMM Out: 08729	Actual HMM Out: 08722
Input from NN: 56379	Desired HMM Out: 56379	Actual HMM Out: 56372
Input from NN: 55404	Desired HMM Out: 55404	Actual HMM Out: 55409
Input from NN: 98088	Desired HMM Out: 28088	Actual HMM Out: 58088
Input from NN: 95991	Desired HMM Out: 95221	Actual HMM Out: 95991
Input from NN: 99559	Desired HMM Out: 99559	Actual HMM Out: 99555

Accumulative results for this person are:

Name: Wayne Completed Attempt: 3
Number of words processed: 300
Number of words in error from NN: 99
Number of words in error after HMM: 35
Error Rate before HMM: 33.00%
Error Rate after HMM: 11.67%

Testing for Wayne, Attempt 4

Input from NN: 33367	Desired HMM Out: 00367	Actual HMM Out: 30367
Input from NN: 53957	Desired HMM Out: 53957	Actual HMM Out: 50957
Input from NN: 74533	Desired HMM Out: 74500	Actual HMM Out: 74503
Input from NN: 33399	Desired HMM Out: 03399	Actual HMM Out: 30099
Input from NN: 36343	Desired HMM Out: 36343	Actual HMM Out: 36340
Input from NN: 93458	Desired HMM Out: 93458	Actual HMM Out: 90458
Input from NN: 96333	Desired HMM Out: 96333	Actual HMM Out: 96303
Input from NN: 18137	Desired HMM Out: 18107	Actual HMM Out: 18137
Input from NN: 93372	Desired HMM Out: 90072	Actual HMM Out: 90372
Input from NN: 63633	Desired HMM Out: 63630	Actual HMM Out: 63633
Input from NN: 18115	Desired HMM Out: 18115	Actual HMM Out: 18145

Input from NN: 93553 Desired HMM Out: 90550 Actual HMM Out: 90553

Accumulative results for this person are:

Name: Wayne Completed Attempt: 4
Number of words processed: 400
Number of words in error from NN: 135
Number of words in error after HMM: 47
Error Rate before HMM: 33.75%
Error Rate after HMM: 11.75%

Testing for Wayne, Attempt 5

Accumulative results for this person are:

Name: Wayne Completed Attempt: 5
Number of words processed: 500
Number of words in error from NN: 135
Number of words in error after HMM: 47
Error Rate before HMM: 27.00%
Error Rate after HMM: 9.40%

Results for entire test run are:

Total number of words processed: 6000
Total number of words in error from NN = 2223
Total number of words in error after HMM = 1026
The number of HMM corrections = 1197
Error Rate before HMM: 37.05%
Error Rate after HMM: 17.10%