CHAPTER 3

RESEARCH DESIGN

3.1 INTRODUCTION

The system architecture for recognition of multilingual handwritten numerals has been described in this chapter. The description about the methodological framework, including training and testing phase has been given in the following section.

3.2 RECOGNITION OF HANDWRITTEN NUMERALS

The processes involved in handwritten numeral recognition are in a sequential and pipelined fashion. Each phase in the pipeline depends on the success of the previous phase in order to produce optimal results. These are image acquisition, preprocessing, segmentation, representation, description, feature extraction and classification. At the lowest level, the numeral document reading problem consists of the document image which can be obtained from the image acquisition phase. At the highest level, the interpretation of the input image exists in the form of recognized numerals. The preprocessing, segmentation, representation, description and feature extraction modules lie between these two levels. The preprocessing and extraction of numerals have been explained in chapter 4 and the proposed representation scheme and proposed feature extraction algorithm have been explained in chapter 5. Figure 3.1 shows the phases of handwritten numeral recognition process.
Figure 3.1 Phases of Handwritten Numeral Recognition Process

3.3 METHODOLOGICAL FRAMEWORK

The proposed roundoff mean aspect ratio value based zoning representation scheme and first order partial derivatives based feature extraction method have been applied for both training and testing. In this proposed research work, machine learning model has been applied for numeral recognition. The two main sub divisions of machine learning are supervised learning and unsupervised learning. The usage of supervised learning in this proposed research work is to predict the input numeral accurately during testing and unsupervised learning has been applied to cluster the data during the training, so that the number of prototypes of a class could be reduced.
3.3.1 Training Phase

In order to recognize the numerals, the handwritten numerals should be trained properly and should have desirable characteristics as follows:

- Training must establish a mapping between the unknown numeral and the true numeral.
- Both training and testing data should be generated from the same underlying process.
- In case of touching the border of the square box allotted for writing numerals, the training algorithm should not ignore such numerals and attempt to do the best possible.
- The training algorithm must train adequate number of samples for a particular numeral.

This training phase consists of two sub-phases. In the first sub-phase, mean aspect ratio values of all the ten class images of all samples in the training data set of a language would be calculated and based on that roundoff mean aspect ratio value, number of zones along x and y axis would be determined using proposed representation scheme and the number of zones required would be stored in the global database. In the second sub-phase, morphological dilation process has been applied to connect the broken numeral of a sample data and using the number of zones along x and y axis for a particular language which is available in the global database, standard zone size has been assigned, for example, (16-by-16), and the image normalization could be performed for each numeral. The proposed feature extraction algorithm has been applied to a sample data and the generated features would be stored in the feature vector. This procedure would be applied for all the isolated handwritten numerals of a same class. These
feature vectors are grouped into clusters and their mean values are calculated. Along with the mean values of each cluster, Unicode value of the corresponding numeral of a language would be stored in the library as a prototype.

### 3.3.2 Testing Phase

The performance of the proposed roundoff mean aspect ratio based representation and first order partial derivatives based feature extraction algorithm could be verified in the testing phase. In order to recognize the input numerals, the test data should have the following characteristics:

- The test data should be generated from the same underlying process that generated the training data
- The test data set and the training data should be a disjoint data set.

The isolated handwritten numeral from the test set would be the input in the testing phase. Morphological dilation process has been applied to connect the broken numerals of a sample numeral, and using the number of zones along x and y axis for a particular language which is available in the global database, standard zone size has been defined, and size normalization could be performed for each numeral. After representation, the proposed first order partial derivatives based feature extraction algorithm should be invoked to generate the input feature vector of a given numeral image. To classify the numeral, the Euclidean distance between the generated input feature vector of the given sample and the mean feature vector from the library is determined. The numeral class assigned to the input numeral is one which results in the nearest Euclidean distance. Figure 3.2 shows the system architecture of the proposed research work.
Figure 3.2 Overall Research Design for Recognition of multilingual handwritten numerals
In general, four measures in terms of percentage, namely, recognition rate, rejection rate, substitution rate and reliability rate can be used to assess the performance of the proposed representation scheme and feature extraction algorithm. The recognition rate (or success rate) is the percentage of input samples recognized correctly. Rejection rate is the percentage of input samples rejected as being not recognizable. Substitution rate (or misrecognition rate) is the percentage of input samples recognized incorrectly and reliability rate is the percentage of the input samples correctly recognized after excluding the rejected samples. The proposed research work uses only one measure namely recognition rate for the purpose of assessing the performance of the representation scheme and feature extraction algorithm.

3.4 CONCLUDING REMARKS

The overall research design for recognition of multilingual handwritten numerals has been designed. It includes two phases, namely, training phase and testing phase. In the training phase, supervised learning has been utilized to train the samples, and unsupervised learning has been used to reduce the number of prototypes. In the testing phase, the input numeral is classified using the proposed method namely roundoff mean aspect ratio value based zoning representation scheme and the first order partial derivatives based feature extraction algorithm.