HANDWRITTEN DIGIT RECOGNITION BY PROXIMAL SUPPORT VECTOR MACHINE

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Abstract-- Handwritten Digit Recognition System involves reception and interpretation of handwritten digits by a machine. Due to variation in shape and orientation of handwritten digits, it is difficult for a machine to interpret handwritten digits. Handwritten digit Recognition has a wide area of research due to its vast applications like automatic bank cheques processing, billing and automatic postal service. In this thesis, an Offline Handwritten Digit Recognition System is presented. The recognition system is broadly divided into 2 parts, first part is feature extraction from handwritten images and the second one is classification of feature vector into digits. We propose descriptors for handwritten digit recognition based on Histogram of Oriented Gradient (HOG) feature .It is one of the widely used feature vector for object detection in computer vision. For classification of features, linear Proximal Support Vector Machine (PSVM) Classifier is proposed. This is a binary class classifier which is further converted to a 10 class classifier by means of One against all algorithm. Due to small training time, PSVM classifier is preferable over standard Support Vector Machine (SVM) Classifier. The handwritten images both for training and testing are taken from MNIST database. The performance of the system is measured in terms of Sensitivity, Accuracy, Positive Predictivity and Specificity. The performance of PSVM classifier is better compared to Artificial Neural Network (ANN).

Index terms- Histogram of Oriented Gradient (HOG) feature, proximal Support Vector Machine (PSVM) Classifier, neural network

I. INTRODUCTION (HEADING 1)

Handwritten Digit Recognition System involves reception and interpretation of handwritten digits by a machine. Handwritten Recognition System can be divided into Offline and Online Recognition System. In case of Offline Recognition System the image of the handwritten text is scanned off- line from document by optical scanning known as optical character recognition (O.C.R.) .Where as in case of Online Recognition the text as it is written on a special digitizer or Personal Digital Assistant.

Writing styles differs in shape and orientation from person to person that makes handwriting digit recognition a challenging task. For the development of reliable handwritten digit recognition, two steps are important. The first step is extraction of discriminating feature from handwritten images and the second method is the classification of new digit images. The dimension of feature should be small. The feature to be extracted should have minimum variance within a class and maximum variance between classes. The Classifier to be used should able to classify digit with high accuracy and should take less training time during classification.

This thesis focuses on Offline Recognition System. The handwritten images are taken from MNIST (Mixed National Institute of Standards and Technology) database. The handwritten digits from 0 to 9 are trained and then tested using supervised machine learning model. Histogram of Oriented Gradient (HOG) based features are extracted from handwritten digits. Proximal Support Vector Machine (PSVM) classifier is used .The performance of classification is measured in terms four parameters derived from confusion matrix and training delay. The performance of Proximal Support Vector Machine (PSVM) Classifier is compared with Artificial Neural Network (ANN).

II. LITERATURE REVIEW

Handwritten digit Recognition has a wide area of research due to its vast applications. Recognition system can be divided into two major steps. First step is feature extraction from handwritten images and the second one is classification.

Researchers suggested different methodologies for feature extraction [4-7]. The Histograms of Oriented Gradient Features is used for object detection like Human Detection [8-9], Pedestrian Detection [10], Large Scale Sign Detection [11] [13], Real-Time Detection and Recognition of Road Traffic Signs [12] . The popularity of HOG feature is due to invariance to local geometric and photometric transformations within local spatial or orientation bin size. In order to implement such property, it is used as a feature descriptor for handwritten digits.

For classification of features of handwritten digits, classifiers like ANN [16-18], k-nearest neighbors (k-NN) [19] and Support Vector Machine (SVM) [20-21] [28-29] are used. Out of these classifiers SVM is widely applicable. The main advantage of SVM classifier is high accuracy, but the classifier takes long training time. The computational time taken by Proximal SVM (PSVM) classifier is very less as compared to SVM [32]. Considering reduced training delay during classification, PSVM classifier is used in this wok.

III. MOTIVATION OF THESIS

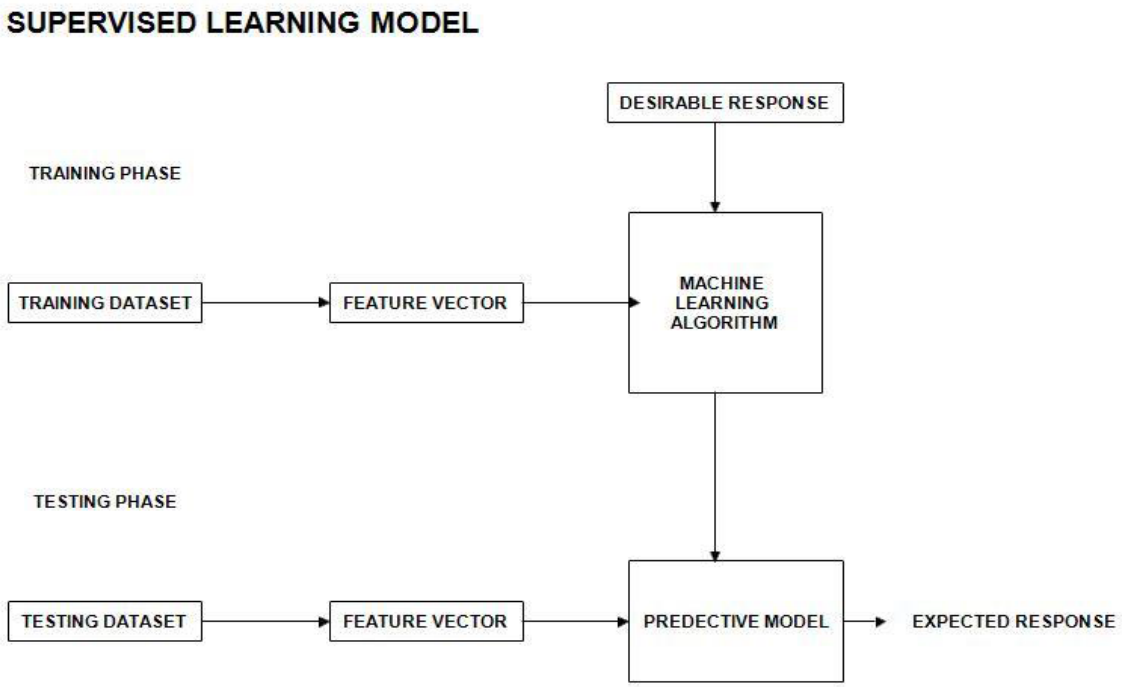
The importance of handwritten digit recognition is due to its vast practical applications .We need a highly reliable recognition system. Higher recognition rate on handwritten digits increases the recognition accuracy for handwritten data, existing in strings. Designing a handwritten digit recognition system with 100% accuracy is practically impossible. A higher reliability system reduces financial loss due to misclassification error. For example in reading the amounts on cheques and billing [28]. Another application of handwritten digit recognition is automatic postal service. Other application involves digit recognition not necessarily handwritten. The techniques that are applicable for handwritten digits recognition can also be applied for printed digit recognition. Automatic License plate recognition is one among most widely used applications.

IV. BRIEF INTRODUCTION TO SUPERVISED MACHINE LEARNING

Machine learning deals with the study and the construction of machine or system that can learn from data. It can also be defined as learning from experience .For example, a machine learning system can able to distinguish between spam and non-spam messages by learning on email messages. After training, it can differentiate new email messages into spam and non-spam folders. The need of machine learning is to make system automated. System automation reduces operation time and manual labor..

In supervised learning model along with input data, desirable response are also provided to the system [14]. The process is divided into two phases, first the training phase and second the testing phase. During the training phase the weights of the network are updated on the basis of training input and desirable response. Weight updating is done on the basis of specific optimization algorithm. On completion of training phase the weight of the network is considered to be optimum. This model is called as predictive model .The supervised learning model is shown in figure 1.1. A test dataset is applied to the network for validation after then the model is made generalized. Generalization refers to the ability to produce reasonable outputs for inputs not encountered during the training.

V. SUPERVISED LEARNING MODEL



Supervised learning can be divided into two broad categories

Classification- Classification deals with the identification of a new observation's class or category, on the basis of a training dataset containing class membership information. The mathematical function which implements classification is known as classifier.

Regression- The estimation of the relationships among variables is called as regression analysis. Forecasting and prediction are some applications of regression analysis

VI. SYSTEM OVERVIEW FOR HANDWRITTEN DIGIT RECOGNITION

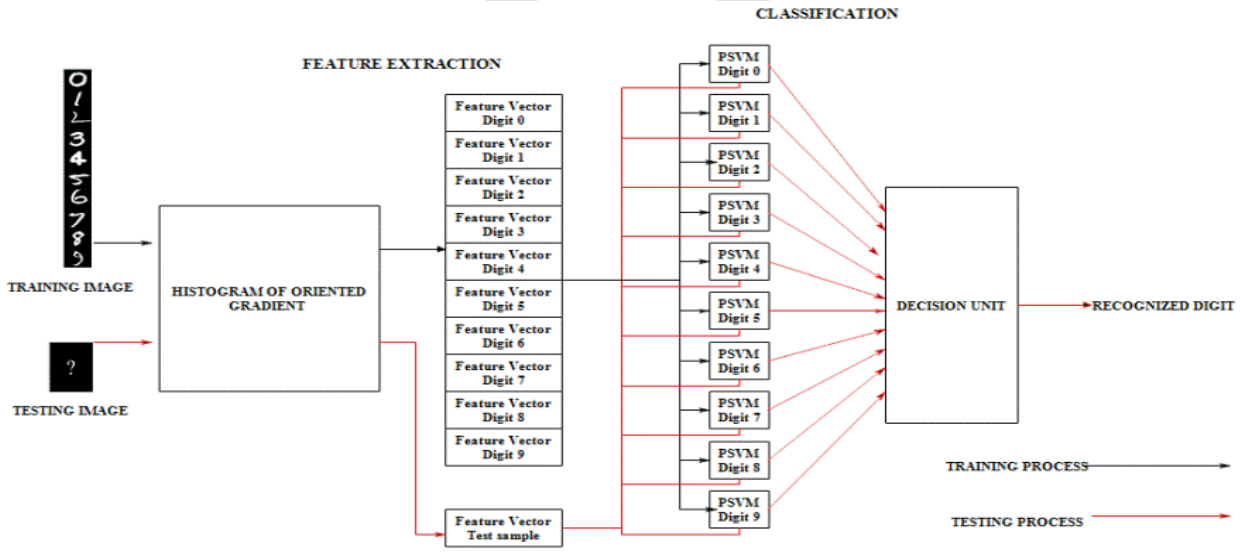


Figure 1.2: Handwritten Digit Recognition System

The learning model implemented for handwritten digit recognition is supervised. As discussed earlier, supervised machine learning has two phases- training and testing. First, from images of handwritten digits(i.e. training set images), features are extracted using HOG feature extraction .These feature vectors along with desirable response are given to PSVM networks so that the weights of the network get optimized and fixed. This completes the training phase. The entire training process is represented by black arrow as shown in figure 1.2.During testing phase; the features of unknown handwritten digits are extracted using the same feature extraction method. After then the feature vector for the test image is given to the weighted PSVM network and then the response is noted and then given to the decision unit. The decision units make decision and recognize the handwritten digit. In the above figure, the testing process is represented by red arrow.

VII. DATASET DESCRIPTION

We consider the recognition system to be offline. The images of handwritten digits are taken from MNIST database and the algorithms are implemented in MATLAB codes. The training and the testing handwritten images are shown in figure 1.3

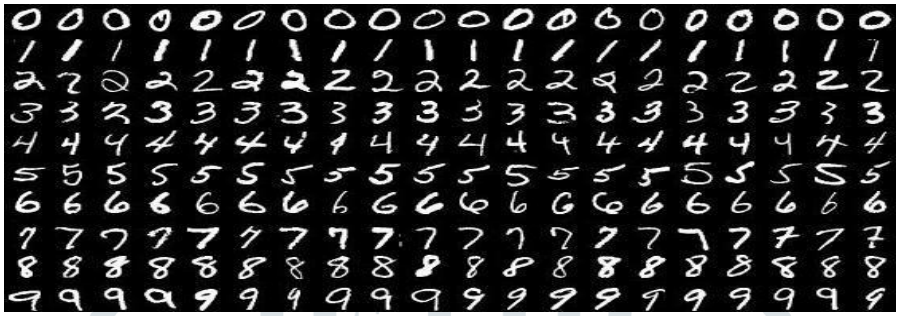


Figure 1.3: MNIST dataset

The MNIST database contains 60000 training set and 10000 testing set handwritten digits ranging from 0 to 9 [34].Each digit is normalized and centered in a gray-level image with size 28 X28. Table no 1.1 shows the distribution of training and testing dataset for handwritten digit 0-9 that are used in this experiment. A total of 10000 samples are taken both for training and testing set respectively.

Table 1.1: Dataset Distribution

DIGIT	***TRAINING SET***	***TESTING SET***
0	1000	980
1	1000	1135
2	1000	1032
3	1000	1010
4	1000	982
5	1000	892
6	1000	958
7	1000	1028
8	1000	974
9	1000	1009
TOTAL	**10000**	**10000**

VIII. CONCLUSIONS

In this thesis HOG-PSVM handwritten digit recognition system is presented. The images of handwritten digits are described in terms of 81 dimensions HOG feature descriptor. The HOG feature vector holds invariance to geometric and photometric transformations that are smaller than the local region of size 7X7 or orientation bin size 40 degrees. For recognition of HOG patterns of handwritten digits, a 10-class linear PSVM classifier is used. The overall accuracy of PSVM classifier is 98.65% with a training time of 59 milliseconds. PSVM classifier in less training time shows better performance as compared to ANN. Along with achieving a good recognition rate of 98.65 %, the system has also maintained small dimension for feature vector (i.e. 81dimension HOG feature) without using an additional dimension reduction technique and small training time required by PSVM classifier

IX. FUTURE WORK

The proposed recognition system is implemented on handwritten digits taken from MNIST database. Handwritten digit recognition system can be extended to a recognition system that can also able to recognize handwritten character and handwritten symbols. Future studies might consider on hardware implementation of recognition system.

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