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# Neural Network based Digit Recognition at Higher Frequency

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**Abstract:** *Digit recognition is the process by which a proposed system at higher order frequency recognises digits and converts them into a digital format that can be used by the modelled system at higher order frequency in terms of 60GHz. The present concept proposed here has gained the major focus by many research schoolers to analyze the pattern based application for the sake of different variety of applications including alphabets, numerical, handling of data at the higher order frequency. We discuss in full the being system for handwritten character recognition in this paper. The essential functional unit of ANN is to perform the basic multiplier operation, the use of ANN as an operation of multiplier for executable with the neuron exist in the network. The desired work is carried out in xlinix vivado platform by selecting the best possible weights and biases by considering the parameters such as the accuracy, recognition rate and time consumed for the proposed system in terms of milliseconds*

**Keywords:** Character recognition, English Preprocessing; Segmentation; neural network; Convolution neural network

## I. INTRODUCTION

As the ANN i.e., Artificial Neural Networks are usually based on the fact of parallel architecture of the neuron operation which is actually inspired by the operation of the human brain functionality. Technically these are the union of similar multicore computing system, comprised with the unique individual elements of processing called neuron. At the early stage of ANN development with its invention of network elements such as perceptron with the predefined learning rule by Frank Rosenblatt [1]. As an next level of development in the domain of the ANN is the with multi-layer perceptron network for the resultant of the back propagation algorithm [2].

To identify between identical equivalent features, the little distinctions between them must be connected.One of the mo st difficult aspects of achieving this with characters is that they do not appear in the same relative location of the letter owing to the varying proportions in which characters are written by different alphabetsin the English language. [3]

A given input character form must be identified by mapping it to a single character in a specified character set.This research article proposes a dynamic structure in terms of control structure to minimization of the various computations during the run time of the applications. Which has achieved by the modified serial booth multiplier, which skips over various operations all one or all one operations with the individual address locations. The multiplier considers all the simple bits under the operands in the primitive blocks which are implemented for the various GPU's, CPU's and DSP's. The first important step in any character recognition system is pre-processing followed by segmentation and point birth. Pre- processing includes the way that are demanded to shape the input image into a form suitable for segmentation (8). In the segmentation, the input image. is segmented into individual characters and also, each character is resized in to m x n pixels .towards the training network. The Selection of applicable point birth system is presumably the single most important factor in achieving high recognition performance. Several styles of point birth for character recognition are reported within the literature [4].

## II. ARTIFICAL NEURAL NETWORKS (ANN'S)

ANN is the unique technique which are the imitation development of the systemized methodology upon the working of the human brain neuron functionality in any problem solving approach. Basically ANN methods can be broadly

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classified into two basic types namely forward propagation and backward propagation. These two mentioned propagation techniques can perform again with the various neuron combination with the different layers such as multi layer based as well as commonly operated hidden layer neurons in the operation of the any methodology implemented. As shown in figure 1,single hidden layer ANN network three different stages of the neural network which are classified as input, output and hidden layer, the novelty of the neural network is the operation in which the every input nodes are interconnected with the all possible hidden nodes and the number of output nodes are also connected with all the possible hidden nodes to the output node. [5]

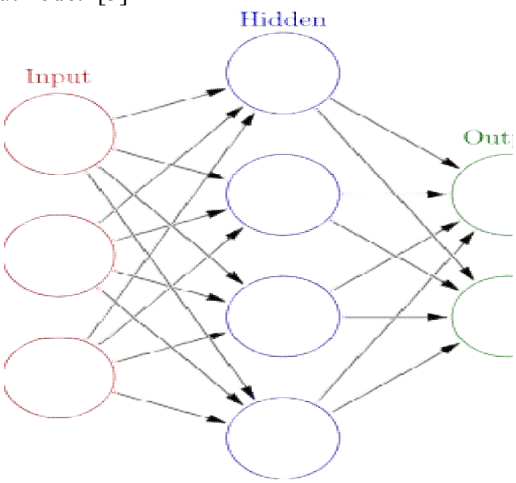


Figure1. Simple architecture of neural network.

The major advantage of the neural network is its accuracy, fast in processing and reduced delay for the data processing, hence in this research article it is proposed to focus on the application of an arithmetic operator such as multiplier for the betterment when compared with the other six existing techniques such as Array based, Modified Booth, Wallace tree, modified booth Wallace tree and twin pipe serial parallel with possible eight various parameters as listed in table 1. As described, the single hidden layer can also be increased to multiple layer for the betterment of the performance of any kind of the operations and the pictorial representation of the Multi Layer Perceptron(MLP) ANN network is as shown in figure 2. [6]

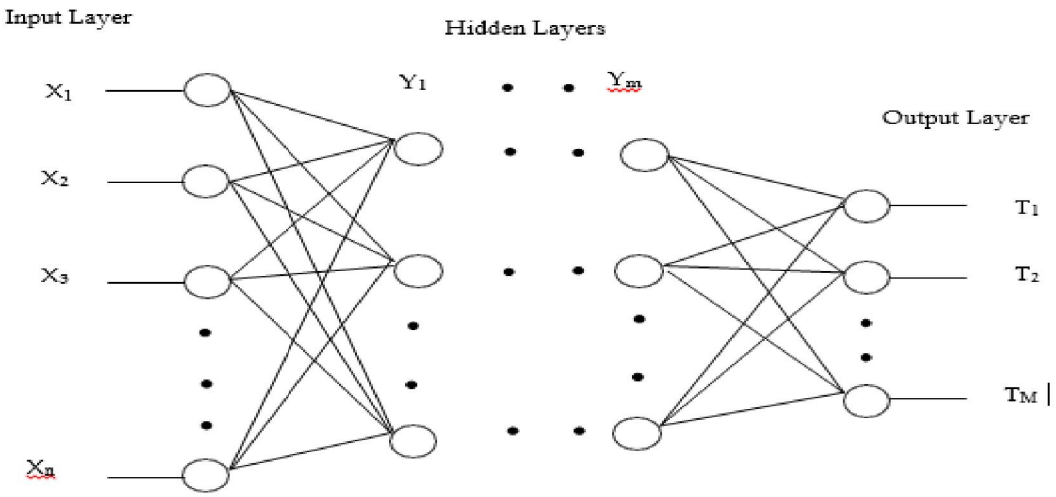


Figure 2: Multilayer perceptron Neural network

MLP networks consists of multiple layers of computational units, interconnected in a feed-forward way. Each neuron in one layer has directed connections to the neurons of the subsequent layer. Learning occurs in the perceptron by changing connection weights after each data is processed, based on the error in the output compared to the expected result. The weights of MLP are generally trained on a labeled sample set to minimize the squared error. This learning

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algorithm is called back propagation (BP). The samples are fed iteratively and the weights are adjusted on each input pattern. The general architecture of an MLP is shown in Figure. 2. The network is designed with *n* input neurons, *m* hidden layers and M output neuron, where M is the number of classes.[7]

The incorporated MLP based ANN technique has dominated its usage due to its several advantages, which can be briefed as follows:

- No connections within a layer
- No direct connections between input and output layers
- Fully connected between layers
- More than 3 layers
- Number of output units need not be equal to number of input units
- Number of hidden units per layer can be more or less than input or output units

Artificial neural network is a computational model that is having functional capabilities of biological neural networks. It consists of a interconnected group of artificial neurons which processes the given information. ANNs are composed of artificial neurons which are conceptually derived from biological neurons. Each artificial neuron has inputs and produce a single output which can be sent to multiple other neurons. The inputs can be the feature values of a sample of external data, such as images or documents, or they can be the outputs of other neurons. The outputs of the final output neurons of the neural net accomplish the task The manner of interconnection differentiates the network models into feed forward networks, recurrent networks, self-organizing networks, and so on. In neural networks, a neuron has a set of connecting weights (corresponding to synapses in biological neurons), a summing unit, and an activation function as shown in figure 3. [8]

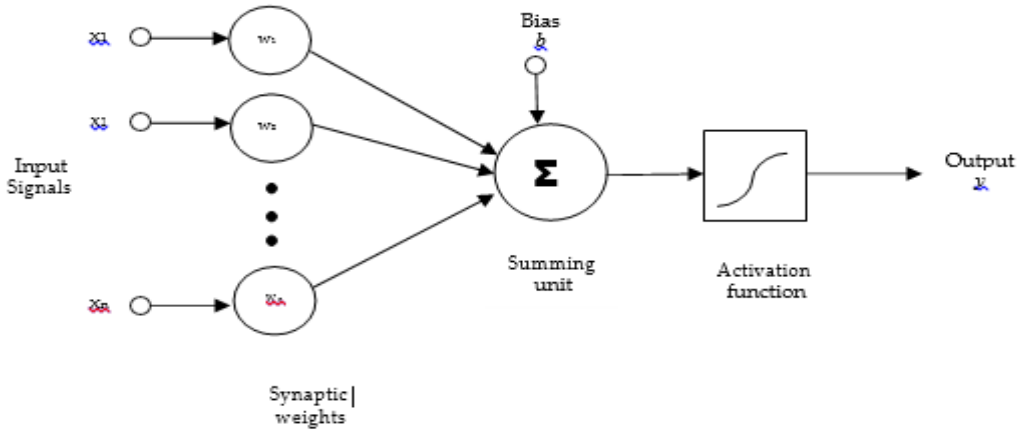


Figure 3. Single neuron architecture

To find the output of the neuron, first we take the weighted sum of all the inputs, weighted by the weights of the connections from the inputs to the neuron. We add a bias term to this sum. This weighted sum is sometimes called the activation. This weighted sum is then passed through a (usually nonlinear) activation function to produce the output. The network consists of connections, each connection providing the output of one neuron as an input to another neuron. Each connection is assigned a weight that represents its relative importance A given neuron can have multiple input and output connections. The propagation function computes the input to a neuron from the outputs of its predecessor neurons and their connections as a weighted sum.[9] A bias term can be added to the result of the propagation.

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## III. SYSTEM DESIGN

The overview of the system implementation is as shown below:

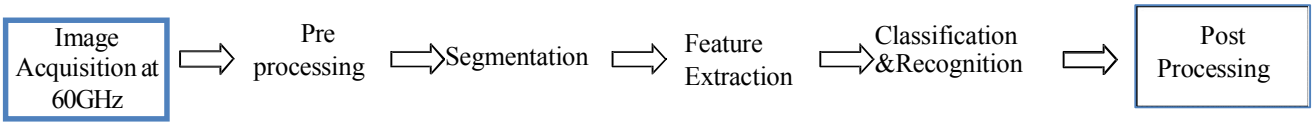


Fig.4: General Block Diagram for English Alphabet recognition.

Step 1: START
Step 2: Collect dataset i.e. digits(0-9) for training.
Step 3: Collect test patterns for testing.
Step 4: Apply preprocessing and extract features from collected samples.
Step 5: Define methods for training & testing using xlinix vivado and other toolboxes.
Step 6: Training the network using defined algorithm.
Step 7: Repeat Step 5 if wants reducing the errors.
Step 8: Testing the pattern.
Step 9: Check recognized character.
Step 10: STOP

### 3.1 Image Pre-processing

Image pre-processing is a method where documents are processed to clean and bring them into desired format for further processing. It is series of operations. Pre-processing aims at improving data in given image by reducing or eliminating undesired distortions and enhancing important features in image.[10]
Pre-processing is not a single step. It includes number of operations as mentioned below:

- **Gray Scale Conversion:** The process, in which RGB image is converted toblack &white, is called grayscale conversion. For binarization gray scaling is important because after doing these only gray shades remain in image and binarization of such images is efficient. Rgb2gray function is used to perform this operation. It eliminates hue and saturation and retains luminance.
- **Binarization:** In binarization, gray image is converted into an image having pure black & pure white pixel values. In this process, pixels having intensities lower than half of full intensity are converted to black and remaining intensity values are converted to white pixels.
- **Inversion:** In inversion, present image is just an inverse of previous one. That means, each pixel of image has colour or intensity value which is exact inverse of that of previous image. This is important because any character of image must only be extracted efficiently from its background. It is only required in case where objects of interest are of darker intensity on lighter background.
- **Noise Removal:** Noise can occur at the time of capturing theimage or image transmission. Noise is nothing but the unwanted data in input image that shows different intensities than true ones. This noise can be removed by using either of the following filtering: By Mean Filtering, By Median Filtering, By Average Filtering, By Adaptive Filtering, etc
- **Edge Detection:** Most of the information is enclosed in edges so edges are detected and by using filters these are enhanced. For this some masks such as prewitt, sobel, laplacain, etc are used which detect the horizontal, vertical edges, etc.
- **Morphological Operations:** The reason behind morphological operations is filtering document by replacing convolution by logical operation. Dilation, erosion, filling, opening, closing, etc come under morphological operations. These operations smoothens contours, decay joined strokes, connect broken strokes, perform thinning, etc. hence morphological operations help in removing noise from images. These techniques use a structuring element. It is placed at all probable locations in image & it is compared with the neighborhood of pixels. In dilation pixels are added to the object's boundary and image grows or thickens the object. Erosion

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removes pixels from object boundaries. Also, opening where erosion is followed by dilation & closing where dilation is followed by erosion are the typical morphological operations.

### 3.2 Feature Extraction

Feature extraction is the process where relevant information about different shapes present in the pattern is detected and put in a vector to use further for classification. Depending on the feature vectors system classifies the inputs with significant accuracy. So, the features extracted should be highly discriminative with reduced dimensions in order to reduce the computation requirements in classification. Feature extraction is done properly, and then it can also reduce the errors such as mean square error or inter-distance differences, etc. Each character has some features, which play an important role in pattern recognition. Indian Marathi language characters have many particular features. Feature extraction describes the relevant shape information contained in characters so that the task of classifying the character is made easy by a formal procedure. Feature extraction stage in Marathi language characters Character system analyses these Marathi language characters Character segment and selects a set of features that can be used to uniquely identify. Mainly, this stage is main part of system because output depends on these features.[11]

## IV. DATABASE AND RECOGNITION

The bracket stage is the decision making part of a recognition system and it uses the features uprooted in the former stage. A feed forward back propagation neural network having two retired layers with armature of 54-100-100-38 is used to perform the bracket. The retired layers use log sigmoid activation function, and the affair subcase is a competitive subcase, as one of the characters is to be linked. The point vector is denoted as X where X = (f1, f2, …, fd) where f denotes features and d is the number of zones into which each character is divided. The number of input neurons is determined by the length of the point vectored. The total number of characters n determines the number of neurons in the affair subcase. The number of neurons in the retired layers is attained by trial and error. The most compact network is chosen and presented.[12]

The spread of the English dialect in India has been driven to get adjusted to suit the nearby phonemes. Nonetheless, the substantial decent variety in Indian dialects and societies caused the occurrence of situations where a similar English word can mean diverse things to various individuals in various parts of India. With all points considered, Indian English has fewer characteristics in vowel sounds than in the consonants, particularly, the vowel phoneme framework seen having a few likenesses with that of English. Seeing the utterances in dialects from local speakers using the dialects and among the error free highlights of the vowel-sounds utilized by some Indian English speakers.[13]

## V. RESULTS AND DISCUSSION

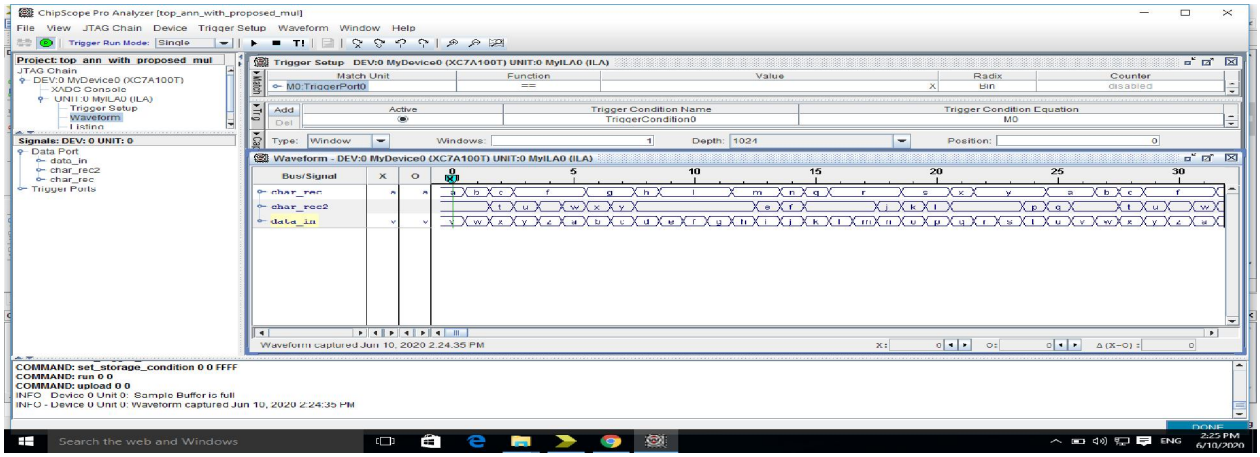


Figure 5. When rst=1

Figure 5 and 6 clearly shows the simulation results of vivdo for the demonstration of the proposed system for the higher order frequency for the operation and recognition of the English alphabets.

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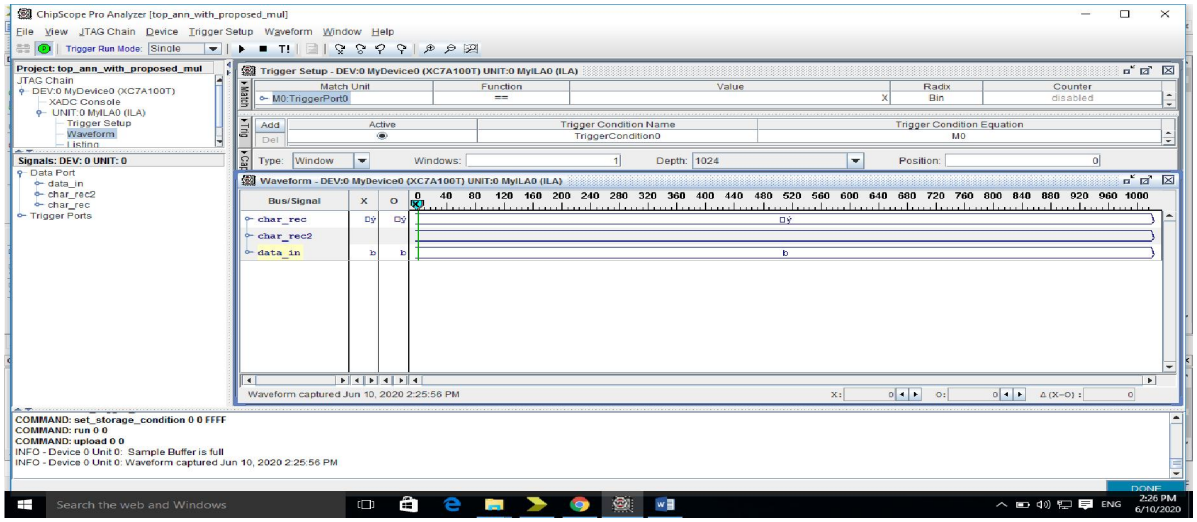


Figure 6. When rst=0

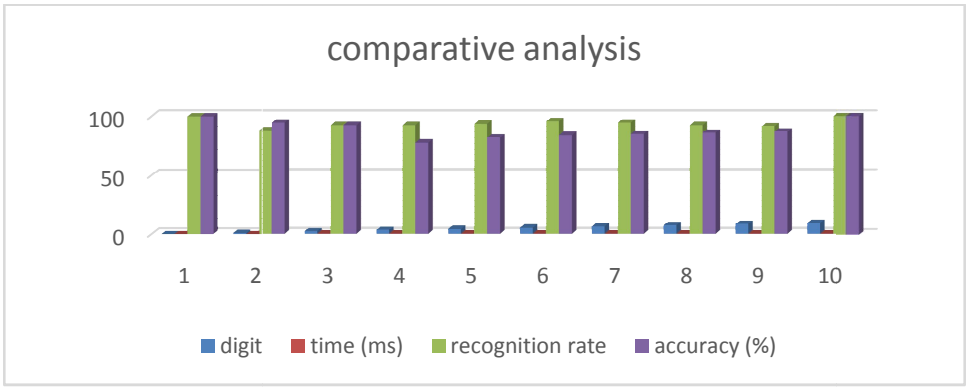


Figure 7 comparative analysis

The figure 7 shows the summary of the datasets considered for the digits, all the 10 digits are considered for analysis with the parameters such as accuracy in terms of percentage, recognition rate for the 100 samples of each alphabet under consideration and total time consumed for the recognition and accuracy at the higher order frequency of 60GHz. Figure 8 and 9 represents the dataset representation of the accuracy and recognition rate with time taken in terms of milliseconds respectively.

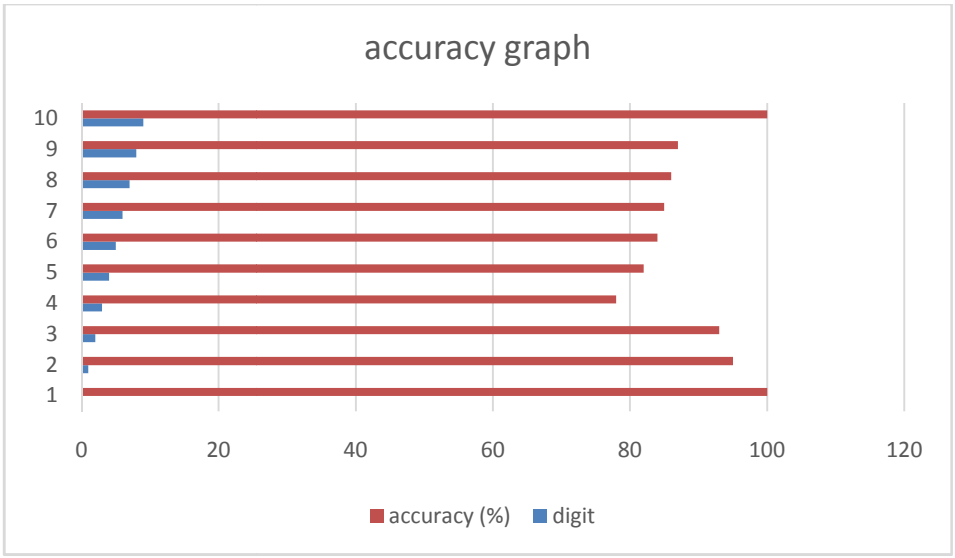


Figure 8 accuracy of digits recognized by the designed system.

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Table 1. recognition of English alphabets with accuracy, time and recognition rate.

| alphabet | time (ms) | recognition rate | accuracy (%) |
|---|---|---|---|
| 0 | 0.04 | 100 | 100 |
| 1 | 0.047 | 88 | 95 |
| 2 | 0.045 | 93 | 93 |
| 3 | 0.046 | 93 | 78 |
| 4 | 0.047 | 94 | 82 |
| 5 | 0.048 | 96 | 84 |
| 6 | 0.045 | 95 | 85 |
| 7 | 0.044 | 93 | 86 |
| 8 | 0.046 | 92 | 87 |
| 9 | 0.039 | 100 | 100 |

The table 1 shows the exact values of all the alphabets under consideration for the analysis at the higher order frequency of about 60GHz.

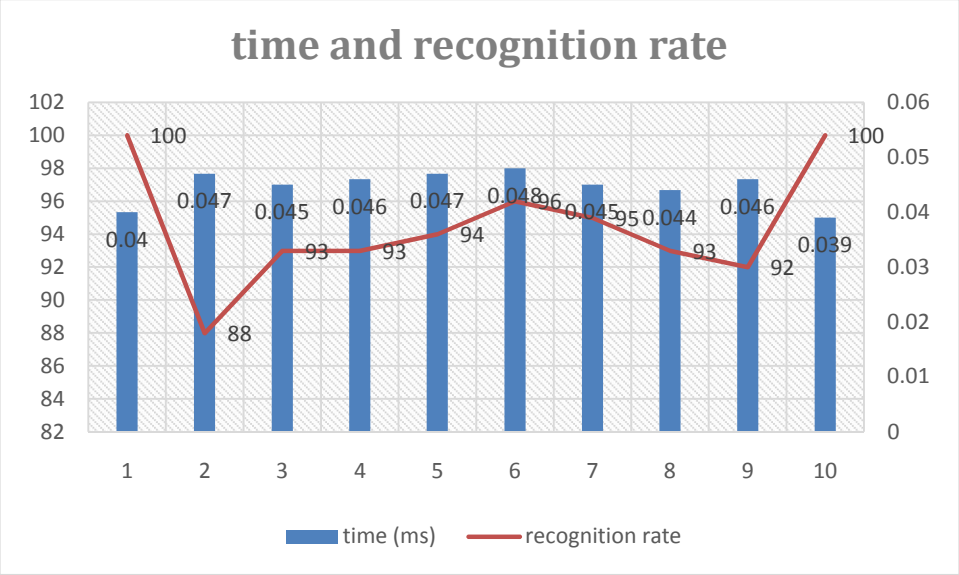


Figure 9. recognition rate and time for recognition.

## VI. CONCLUSION

This project is intended to build a system that recognizes the digit (0-9) at higher order fequency. This method produces good results for database used as text images which are considered in different database styles. Neural networks are commonly used for character recognition because of their property to tolerate high noise. Extracting features is one of the most essential steps in the character recognition domain. A strongly chosen feature set provides a good recognition rate. Without effective pre- processing, the extracted features of images are of low quality. The gradient feature extraction technique is highly accurate than the geometric feature extraction technique. Gradient feature extraction technique is faster to process high-end data. It can be observed that the all the five vowels has achieved the better accuracy and recognition when compared with other alphabets under consideration. It can also be clearly conclude that the time taken for the recognition of the English vowels were also comparatively less and advantageous..

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