Spatio Partitioning of Character Image for Automatic Recognition of Digits

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Abstract: In the running word, there is growing demand for the software systems to recognize characters in computer system when information is scanned through paper documents as we have number of newspapers and books which are in printed format related to different subjects the current capacity to translate paper documents quickly and accurately into machine readable form using optical character recognition technology augments the opportunities in document searching and storing as well as automated documents processing. A fast response in translating large collections of image-based electronic documents into structured electronics documents is still a problem.

As an enhancement to the optical character recognition [1] (OCR) technology, I would like to propose a framework that recognize a printed digits in the character image using "spatio partitioning method". The proposed system is efficiently recognize the digits from 0 to 9 different font size based on the new concept of feature extraction and which is classified under decision tree classifier, efficiency and time complexity of the proposed system also described. Partitioning is based on the pixel distribution of the character image; the pixel distribution describes the patter of the characters that is by spatially distributed foreground pixel.

Keywords: Image processing, optical character recognition, pixel distribution, spatio partitioning.

I. INTRODUCTION

Machine replication of human functions, like reading, is an ancient dream. However, over the last five decades, machine reading has grown from a dream to reality. Optical character recognition has become one of the most successful applications of technology in the field of pattern recognition and artificial intelligence. Thus our need is to develop character recognition software system to recognize the characters. The conversion of paper documents into electronic format is an on-going task in many of the organization particularly in research and development (R & D) area, in large business enterprises, in government institutions, so on.

Document image processing
An image is a two dimensional function f(x,y),where x and y are special coordinates consisting discrete quantities of intensity values.

Digital image is composed of finite number of elements called pixels. Each pixel represents particular location. Digital image processing refers to processing of image using digital computers. OCR is a field of research in pattern recognition, artificial intelligence and computer vision.

In mathematics, space partitioning is the process of dividing a space into two or more disjoint subsets. In other words space partitioning divides a space into non-overlapping regions. Efficiently locate objects by storing them in a data structure organized by their positions.

Purpose
The primary objective is to speed up the process of Digits recognition in character image. Our character recognition is based on a spatio partitioning; it aims to recognize digits 0 to 9 and which size invariant and rotation invariant.

II. RELATED WORK

The Optical Character recognition has been a subject of research. Pattern recognition has three main steps: observation, pattern segmentation, and pattern classification. Optical Character Recognition (OCR) [1] systems is transforming large amount of documents, either printed alphabet or handwritten into machine encoded text without any transformation, noise, resolution variations and other factors.

A number of researches have been proposed over the years for character recognition. A noble idea was conceptualized way back in 1999 by (Sural and Das). The ability of a software or application like this one needs the ability to apply pattern recognition, pattern interpretation and learning.

The few approaches that use hand written character recognition for text recognition have been summarized here:
Handwritten Character Recognition
 1. Handwritten Character Recognition using Neural Network [2]: Objective of this paper is to recognize the characters in a given scanned documents and study the effects of changing the Models of ANN.

 2. Handwritten Character Recognition Using Gradient Features [3]: Feature extraction is an integral part of any recognition system. The aim of feature extraction is to describe the pattern by means of minimum number of features that are effective in discriminating pattern classes. The gradient measures the magnitude and direction of the greatest change in intensity in a small neighborhood of each pixel Gradients are computed by means of the Sobel operator.

 3. Character Recognition Using Mat lab's Neural Network Toolbox [4]: Recognition of Handwritten text has been one of the active and challenging areas of research in the field of image processing and pattern recognition. It has numerous applications which include, reading aid for blind, bank cheques and conversion of any hand written document into structural text form.

4. Neural based handwritten character recognition [5]: This paper explores the existing ring based method (W.I.Reber, 1987), the new sector based method and the combination of these, termed the Fusion method for the recognition of handwritten English capital letters.

III. PROPOSED METHODOLOGY

Our proposed system is "Recognition of printed digits using spatio partitioning" which takes character image as input character, process the character, and train the algorithm, to recognize the pattern.

This project is aimed at developing system which will be helpful in recognizing digits from 0 to 9 of different font size and times new roman font style and character can be rotation invariant.

In our problem we propose a new method called spatio partitioning, which is based on pixel distribution of character image, an image is represented with set of pixel values that is 0 or 1, if the pixel value is 1 then the pixel is on and if the pixel value is 0 then pixel is off, in general pixel distribution tells the pattern of the image, that is by spatially distributed foreground pixel of the image.

Basically an image is defined as light intensity function $f(x, y)$ where x and y are the spatio coordinates .we perform the spatio partitioning on the image to recognize the character.

Spatio partitioning is a special type of segmentation, where in which an image is, partitioned such that there will be equal number of pixel in both partitions.

We can have four types of Partitioning
- Horizontal Partitioning
- Vertical Partitioning
- Principle Diagonal Partitioning
- Off Diagonal Partitioning

Before partitioning the image we first find out the total number of on pixels in the image by scanning the image matrix.

Different combinations of the partition can be performed on different level to recognize the image and based on the decision tree classifier the digit is recognized and complexity of recognizing the digit is based on the depth of the decision tree where exactly the digit is available in the decision tree for the recognition. The proposed system would recognize the digits in a character image on the printed document with a different font size.

Architecture of the Proposed System

The proposed system is divided into two modules
1. Training or learning
2. Recognition
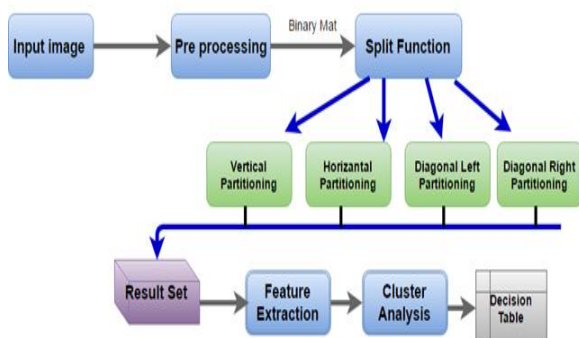
Training or learning module:

Figure 3.1: Architecture of Training Module

First module that is training or learning where we train the system with different sample of datasets to build the decision table, architecture of training module is shown in figure 3.1.

Second module is recognition where we recognize the given image based on the decision tree classification and figure 3.2 shows the architecture of the recognition module.
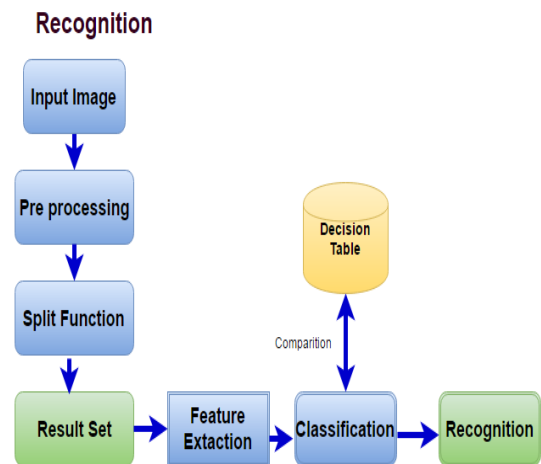

Figure 3.2: Architecture of Recognition Module

IV. DATA GENERATION

Proposed system recognition system is trained with different samples of each digit. Spatio partitioning is special type of segmentation where each character image is partitioned such that equal number of pixels in each partitioned segments.

Before partitioning the image we first find out the total number of on pixels in the image by scanning the image matrix.

In each level of partitions we can have 4 set of features and patterns are observed, then system try to discriminate between the digits from 0 to 9, the features are stored in the feature vector and decision tree will be created.

The four set of features are horizontal partition position, vertical partition position, left diagonal partition position and right diagonal partition position.

Automatic Data Set Generation

The training system of the proposed method are trained with 250 image samples of each digit that is for digit 0 there are 250 sample with different font size of the times new roman font style ,totally 10 * 250 = 2500 images are taken as input for the training system.

For the above data set generation is done automatically, by the program and will generate the images effectively by the machine.

Pre-Processing of input image

Main objective of this process is to making the document image easier to process in order to increase the overall efficiency of the recognition system.

Following are the stages involved in the proposed system pre-processing
- Image is converted in gray scale
- Thresholding
- Creating Bounding rectangle
- Normalization
- Resize the image

- Image is converted into Binary Matrix

Pre-processing step involves RGB to gray scale image conversion, thresholding, noise removal etc. In RGB to gray scale image conversion, RGB image is converted to gray image. Thresholding converts gray image to black and white image. After this process will create bounding rectangle through which we eliminate unwanted regions present in the input image and we can process only the character in the image.

Then the Input image is resized to that standard size because we are recognizing the digits with different size and the size of the image varying with different size. After resizing the image, the image goes into normalization process to eliminate the noise present in the image; the normalization is done by defining the specific histogram equalization points in the image. Finally the gray scale image is converted binary matrix.

Color Image   gray scale   Noise induced image Binary Image

Figure: Input image to pre-processed bounded image

V. PARTITIONING OR SPLIT FUNCTION

After the image preprocessing the main functionality will be split function. Basically in split function we partition the image, before that we count the total number of on pixels in the image it is done by scanning the image matrix and we partition the image such that equal number of pixels in each partitions

We have different types of partitions in the proposed system
1. Horizontal Partition
2. Vertical Partition
3. Principle Diagonal Partition
4. Off Diagonal Partition

Horizontal Partition: image is scanned horizontally and we partition the image such that equal number of on pixel in both the horizontal parts by preserving the basic idea of equal pixel distribution. Horizontal partition of the image is shown in Figure 5.1
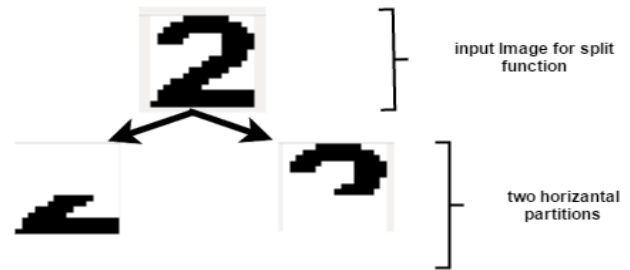

Figure 5.1: Horizontal Partition of the image

Vertical Partition: image is scanned vertically and we partition the image such that equal number of on pixel in both the vertical parts by preserving the basic idea of equal pixel distribution. Vertical partition of the image is shown in Figure 5.2

Figure 5.2: vertical partition of the image

Principle Diagonal Partition: image is scanned diagonally from top left corner and we partition the image such that equal number of on pixel in both the diagonal parts by preserving the basic idea of equal pixel distribution, diagonal left partition of the image is shown in Figure 5.3.
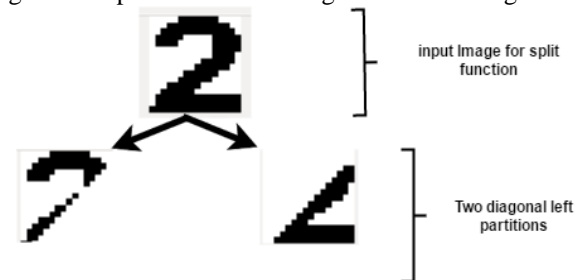

Figure 5.3: principle diagonal partition of the image

Off Diagonal Partition: image is scanned diagonally from top right corner and we partition the image such that equal number of on pixel in both the diagonal parts by preserving the basic idea of equal pixel distribution, Off Diagonal partition of the image is shown in Figure 5.4.
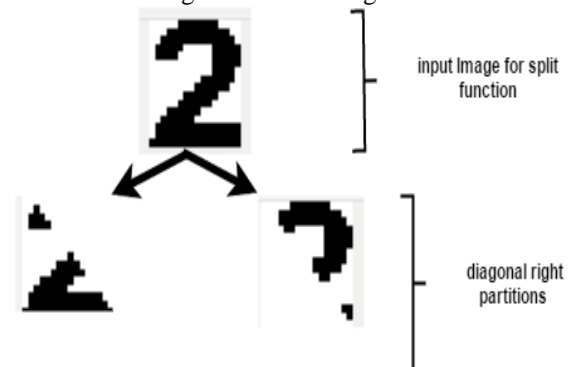

Figure 5.4: diagonal right partitions

Automatic Data Generation

After the partition of image we generate the data automatically as result set for all the training data set that is for 2500 images the values are generated as follows

Level 0 horizontal data for all the digits i.e. from 0 to 9 is showed in the below table 1

digit 0	digit 1	digit 2	digit 3	digit 4	digit 5	digit 6	digit 7	digit 8	digit 9
255	255	255	255	255	281	302	185	255	209
255	255	255	255	255	281	302	185	255	209
255	255	344	176	255	235	340	115	255	238
335	255	278	421	290	265	300	160	348	267
255	255	173	255	312	397	286	114	232	137
255	307	390	256	283	281	255	119	283	256
255	307	390	256	283	281	255	119	255	256
255	301	395	269	308	296	289	104	243	252
255	296	352	263	325	247	292	106	255	232
255	296	358	263	325	213	292	75	255	232
255	292	321	267	302	183	288	86	290	215
255	292	339	267	302	192	288	73	290	221
255	260	354	251	316	177	265	78	255	244
255	260	230	251	324	177	272	78	255	233
255	280	319	263	296	197	289	59	254	217
255	280	343	256	296	205	289	62	253	217
255	279	251	274	297	188	286	57	284	227
255	277	213	265	301	191	286	54	255	222
255	276	233	250	294	209	281	55	247	230
255	276	249	245	294	202	281	54	245	230
260	274	241	245	290	188	275	53	249	232
255	273	207	234	291	196	299	48	249	213
255	256	222	258	291	200	278	65	260	231
239	255	205	245	298	218	273	48	255	230
255	256	252	258	326	208	278	118	254	231
255	256	229	261	331	206	278	107	251	231
255	255	344	176	255	235	340	115	255	238
335	255	278	421	290	265	300	160	348	267
255	255	173	255	312	397	286	114	232	137
255	307	390	256	283	281	255	119	283	256
255	307	390	256	283	281	255	119	255	256
255	301	395	269	308	296	289	104	243	252
255	296	352	263	325	247	292	106	255	232
255	296	358	263	325	213	292	75	255	232
255	292	321	267	302	183	288	86	290	215
255	292	339	267	302	192	288	73	290	221
255	260	354	251	316	177	265	78	255	244

Table 5.1: showed above the horizontal partition data that are generated for some samples of digits 0 to 9 of different size like this we can generate the 4 set of data of each digit in an each level

these data are analyzed while understanding the patterns in order to discriminate between the digits.

We can take these data in a matrix and we can run some clustering algorithm for better understanding the result set or the data generated. We can also go for multidimensional feature vector by the combination of the generated result set.

VI. NEW CONCEPT OF FEATURE EXTRACTION

Feature extraction is the heart of any character recognition system. Feature extraction can be considered as finding a set of parameters (features) that define the shape of the underlying character as precisely and uniquely as possible. The term feature selection refers to algorithm that selects the best subset of the input feature set.

Feature extracted for the proposed methodology are

- Horizontal partition line , area and number of pixels on both the partitions,
- Vertical partition line , area and number of pixels on both the partitions
- Diagonal left partition line ,area and number of pixels on both the partitions
- Diagonal right partition line ,area and number of pixels on both the partitions

Partition line, area and number of pixels on partitioned image are directly proportional to each other so we take either of these features in our method.

Illustration

Prosed system has two level of partition that is level 0 and level 1.

Level 0 partitions is also called first level of partition of the image in this level we can extract four features that is horizontal data, vertical data, principle diagonal data (dleft) and Off diagonal data (d right).

Level 1 partition is also called second level of partition of the image, in this level horizontal parts of level 0 and vertical parts of level 0 will participate in level 1 partition and features are extracted in each half of the particular parts.

Feature extracted in level 1 are as follows:

Horizontal first half: horizontal partition line
Vertical partition line
Principle Diagonal partition line
Off Diagonal partition line
Horizontal second half: horizontal partition line
Vertical partition line
Principle Diagonal partition line
Off Diagonal partition line
Vertical first half: horizontal partition line
Vertical partition line
Principle Diagonal partition line
Off Diagonal partition line
Vertical second half: horizontal partition line
Vertical partition line
Principle Diagonal partition line
Off Diagonal partition line

The digits are classified under the above feature set
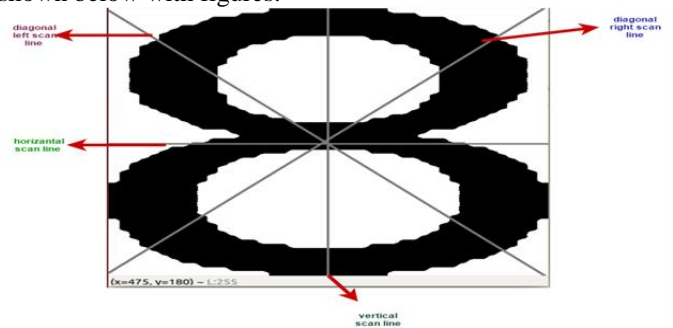Intelligent discrimination between different features is shown below with figures.

Figure 6.1: level 0 partition of the image 8

Level 0 partition of digit 8 feature set (259,255,506,516) that is horizontal scan line, vertical scan line, principal diagonal scan line (diagonal left) and Off diagonal partition line (diagonal right). The figure 6.1 is partitioned in level 1 and the figures are showed below.
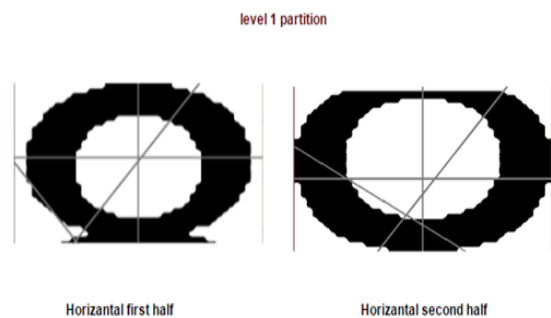

Figure 6.2: horizontal level 1 partition

In Level1 partition we have two set of partitions that is horizontal and vertical partition in each partition, there will be first half and second half partitions and features are extracted for all these partitions. Figure 6.2 shows horizontal partitions and feature sets are for 8_horizantal_first_half (120,255,381,641) and for 8_horizantal_second_half (396,255,675,346).
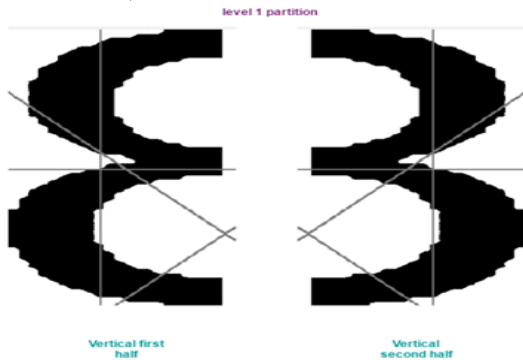

Figure 6.3 vertical partitions of digit 8

Figure 6.3 shows vertical partitions and feature sets are for 8_vertical_first_half (260,109,383,393) and for 8_vertical_second_half (259,401,628,639).

We cannot discriminate each digit in the first level of partition itself for this reason partition has done up to second level, in each level we have taken the feature set that is horizontal feature, vertical feature, diagonal left feature and diagonal right feature, by analyzing the each feature and will draw the graph, and will take the minimum value and maximum value from this feature then will created the range for each digit by cluster analysis.
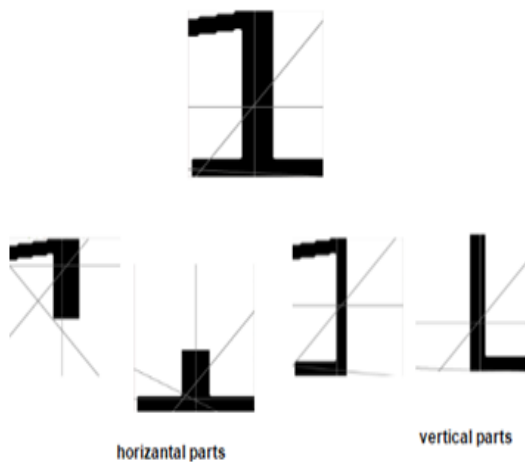

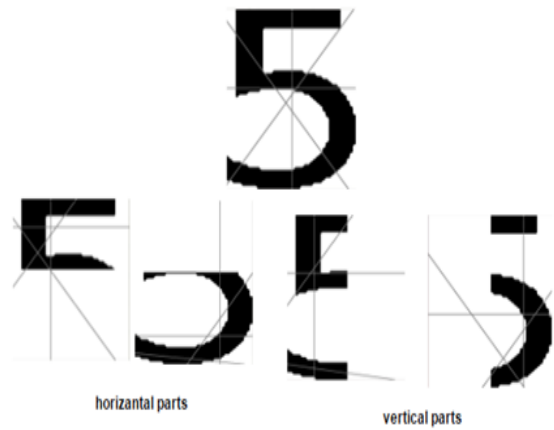**Figure 6.4: illustration of digit 1 samples**

Figure 6.5: illustration of digit 5 sample

VII. DECISION TREE CLASSIFIER

Classification stage in an OCR process assigns labels to character images based on the features extracted and the relationships among the features [Kasturi et al, 2002].

Proposed system uses the decision tree classifier for the recognition of printed digits. Decision Tree Classifier is a simple and widely used classification technique. It applies a straightforward idea to solve the classification problem.

Observing the Domain

Extracted features should be analyzed to understand the domain of the data set, once after the partition the feature of different digits are stored in some file.

The data set are numbers 0,1,2,3,4,5,6,7,8 and 9 and exact symmetric digits are 0 and 8 , partition of these digits in the first level 0 and will be overlapped because of symmetric in nature.

Digits 7 will appear differently compared to all digits in the data set so 7 can be recognized in the first level of partition but still there will be some disturbance still some small font size so 7 also recognized in the second level of partition.

While partitioning the image, level of partition, type of split, which half and which feature of the partition are the main attribute for classification.

Understanding the pattern

After having the domain knowledge, it is required to understand the patterns of each digit by drawing graph for each level of partition values.

Graph representation of the feature extracted is useful for understanding the pattern of each data set and by using this graph we can cluster the data.

Cluster analysis

Based on the result set that are taken after partition in different level, we are trying do the cluster analysis , as the input dataset is the digits from 0 to 9 we should get the discrimination between this digits and should understand how this digits will cluster based on the feature that are extracted.

Because our objective is to recognize the digits with high accuracy we are going with the level 2 partitions of each character image, based on this sptio partitioning the digits are clustered accordingly and it is showed in below graphs and different graph will describe the feature values for different partition with different level.
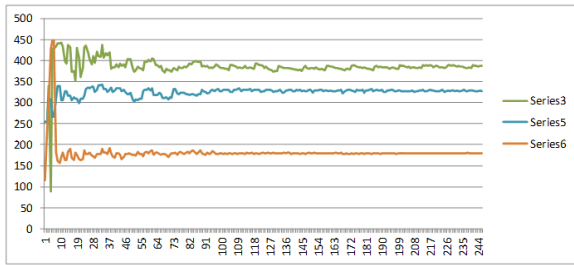
Retrieval Number: C6650098319/19©BEIESP
DOI:10.35940/ijrte.C6650.098319
Journal Website: www.ijrte.org

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Figure 6.6: Horizontal level one partition and first half with horizontal data graph, discriminable lines are 2, 4 and 5 respectively

Design of decision tree

Decision tree is build based on the statistical analysis of the trained data and by understanding the patterns before that there some attribute for classification

Level number

Level 0
Level 1

Type of split

Horizontal split: 1
Vertical split: 0

Which half

First half: 1
Second half: 2

Which feature

Horizontal data: 0
Vertical data: 1
Diagonal left data: 2
Diagonal right data: 3

Range

Lower bound
Upper bound

Based on the above attribute the decision table 6.1 is build and it is showed in table 2, after generation of decision table the first module that is training module is done and next will be recognition.

Digit Name	level of split	type of split	which half	Range (LB-UB)	which feature
7	1	1	2	50 – 125	0
2	1	1	1	350-450	0
4	1	1	1	260-350	0
5	1	1	1	150 – 210	0
1	1	1	2	270 – 350	1
3	1	1	1	160 -275	1
9	1	1	2	190 – 300	0
6	1	0	2	155 – 220	0
8	1	1	1	350 – 440	3
0	1	1	1	293 – 320	3

Table 6.1: decision table for automatic recognition of digits in the character image

As a part of recognition any input image is first goes in to preprocessing then it is follows the brute force approach for recognition.

Algorithm for recognition:

Given image will first check whether digit is 7 with the attribute as shown, if the value input image is matches with

the value of digit 7 then the image is 7 else it check with next digit in the decision table if not the given image is the digit 7.
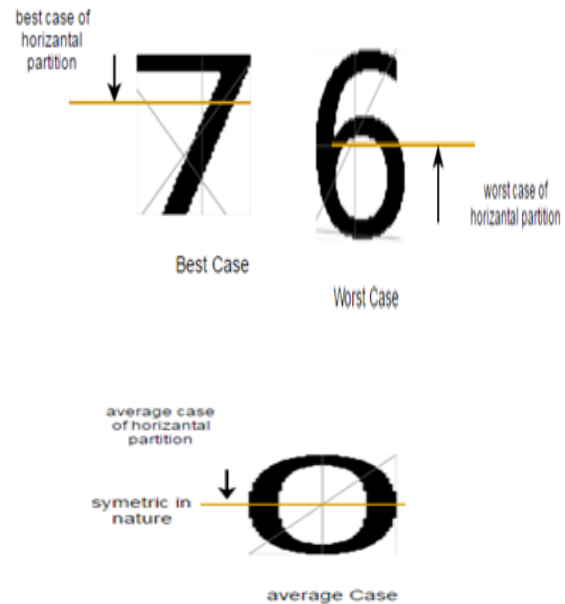
VIII. EXPERIMENTAL ANALYSIS

OCR Accuracy

The proposed algorithm has been implemented in OPENCV C++ application and operating system as Ubuntu. For the experiments we consider scanned images as well as 2500 images are generated automatically with 100% accuracy, different types images also considered here. For each digit from 0 to 9 varied with font size and the system is able to recognize them very efficiently using spatio partitioning method.

Partitioning Accuracy

Partitioning is taken as special type of segmentation, partitioning of the image by preserving the criteria of equal pixel distribution is very important stage in our project.

Time complexity of partitioning algorithm will be constant time and detailed description as follows: best case of horizontal partition is digit 7 and worst case complexity digit 6 and average case is considered as digit 0 and 8, partitioning the image work gives more than 95% accuracy in our project.

Feature Extraction Accuracy

Feature extraction phase is prominent phase that highly affects the recognition efficiency. So feature extraction should be done carefully and suitably. Recognition of the digits using spatio partitioning has new concept of feature extraction, feature extraction work gives 100% accuracy and mainly depends on the input image and preprocessing method that is involved in the system.

Recognition Accuracy

Automatic recognition of digits using spatio partitioning method uses the decision tree classifier for recognition ,

complexity taken as depth of the decision tree in classification and time complexity in recognizing the digits is taken as constant time because total number of digits in the data sets are 10 that is 0 to 9 and given image first look into decision table and check whether it digit 7 then so on as per the decision table values, if the given image is 7 then in first scan we recognize the digit, if the given digit is not a digit from 0 to 9 then that will be the worst case. The proposed system recognizes the digits of different font size but the accuracy of recognition is taken 99 % for the digits font size is greater than 10 with times new roman font style.

IX. CONCLUSION

Our proposed model **"spatio partitioning of character image for automatic recognition of digits"** which is expected to be efficient, reduces human effort and ease for recognition digits when compared to the existing system of recognition of digits. The proposed system has designed such that it is easily implemented to the different font style, we can carry forward it to various applications such as - Reading of handwritten characters, reading traffic signal and many more.

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