DEVELOPMENT OF A NIGERIAN VEHICLE PLATE CHARACTER RECOGNITION SYSTEM USING TEMPLATE MATCHING

BY

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CERTIFICATION

This project with the title

DEVELOPMENT OF A NIGERIAN VEHICLE PLATE CHARACTER RECOGNITION SYSTEM USING TEMPLATE MATCHING

Submitted by

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Has satisfied the regulations governing the award of degree of

BACHELOR OF ENGINEERING (B.Eng)

Federal University Oye-Ekiti, Ekiti

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12-03-2018

Date

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DECLARATION

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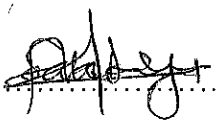
Sign: 

Date: 12/03/2018

DEDICATION

This research work is dedicated to God Almighty, the Alpha and Omega of my life, who has been there right from the beginning to this very point, for Special support and compassion towards me during the course of my university academics. To God is the glory.

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First and foremost, I appreciate God, the all-knowing, the Creator of the heavens and earth, the One that has always led me through the path of the unknown. He has been faithful in the journey of my life. His understanding is more than what human understanding can fathom, there is no way I can honor Him enough for all He has done for me.

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ABSTRACT

Tracking of vehicles, manage on-site car parking spaces, and warehouse traffic are problem that need real-time solution and can be solve by using character recognition in vehicle plate which can be obtain by using different classifier e.g. artificial neural network, fuzzy logic, Neural-fuzzy hybridization, and generic algorithm, template matching which can solve regression and binary classification problems.

This project aims is to develop a system that will detect and recognize plate number images of Nigerian vehicle using template matching.

The proposed system will use the following phase to achieve the result image acquisition by using digital camera, image preprocessing by greyscale, remove noise, image enhancement and thresholding, then image segmentation by multiple thresholding, dilation, enrode and dissection. Recognition by template matching for the classification and the system will be evaluated.

The result of test carried out on the system been developed shows that the prototype have 18% segmentation error, RGB color recognition model have is 88.8% accuracy and 77.7% accuracy of the template matching character recognition.

The system at the end of the test shows the usefulness and effectiveness of template matching in character recognition and the system have several advantages in transportation sector.

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CHAPTER ONE

INTRODUCTION

1.1. PREAMBLE

Mobility is crucial to functionality of cities as it affects their socio-economic activities. It is also a fact that the economic development of a nation is closely linked to its transport system, as a result of the ever increasing development, human activities dependence on road transportation that intrinsic worth increase in the number of vehicles of different categories on the road, the difficulty in movements on inter-city roads and other major corridors is due to large obstructions such as traffic crashes, broken down vehicles (Kayode, 2015), The same factor that draw inhabitants to congregate in large urban areas also lead to sometimes intolerable levels of traffic congestion on urban streets and thoroughfares (Ukpata, 2012).

Traffic regulations and vehicle rule have been put in place to help in control of the road security, traffic control, and road management, vehicle accident control which is by assigning a particular identification to each vehicle using plate, such plate number are formatted in different color with combination of alphabet and number. The color of the plate the indicate the categories of the vehicle in private, commercial and government, the number and alphabet combination is the identification of vehicle which can been use to trace the vehicle for any security issue.

The development of traffic control systems for urban streets has paralleled the development and use of the automobile in aspect of monitoring and control vehicle traffic is getting difficult day by day, overcoming this problem, the use of computerized machine is needed, to monitor vehicle digital image processing will give an additional advantage is that it is fast process with negligible errors (Deshmukh, 2016).

Images are converted into arrays of numbers which is called "pixels", which could then be processed by computer programs (Nilsson, 2012), this field came to be known as "optical character recognition." Most of the recognition methods at that time depended on matching a character (Nilsson, 2012).

Character recognition is an art of detecting segmenting and identifying characters from image. More precisely, character recognition is a process of detecting and recognizing characters from input image and converts it into American Standard Code for Information Interchange (ASCII) or other equivalent machine editable form Early efforts at the perception of visual images concentrated on recognizing alphanumeric characters on documents. (Venkata & Sastry, 2016)

The main objective of the project is use character recognition to develop a system that will recognize the characters in a Nigerian vehicle license plate and classify them as private, commercial, government, or diplomatic among others using template matching which can be applicable in traffic control, road management, traffic crashes, broken down vehicle, road security etc.

1.2. STATEMENT OF PROBLEM

Character recognition is the art of detecting, segmenting and identifying characters from an image. More precisely, it is the process of detecting and analyzing textual characters from an input image and converting the identified characters into computer editable form (Venkata & Sastry, 2016). Detecting text in natural images, as opposed to scans of printed pages, faxes and business cards, is an important step for a number of computer vision applications, such as computerized aid for visually impaired, automatic geo-coding of businesses, and robotic navigation in urban environments (Epshtein, 2005); (Deshmukh, 2016).

Many cities and districts have developed traffic control systems to help monitor the movement and flow of vehicles around the road network. This had typically involved looking at historical data, estimates, observations and statistics, such as: Car park usage, Pedestrian crossing usage, Number of vehicles along a road, Areas of low and high congestion, Frequency, location and cause of road works.

Monitoring, controlling and managing traffic or vehicle fleets is critical to a successful transportation operation, for both public and commercial enterprises. Organization may be responsible for law enforcement and must track public and government-issued vehicles as part of crime reduction efforts. The need license plate recognition solution to track vehicles, manage on-site car parking spaces, and warehouse traffic in real-time, to solve specific transportation and traffic challenges (axxonsoft, 2003).

There are various classifier that can be used in character recognition and plate recognition which are artificial neural network, fuzzy logic, Neural-fuzzy hybridization, and generic algorithm but they cannot be used for solving regression and binary classification problems, Template matching is the process of finding the location of a sub image called a template inside an image. Once a number of corresponding templates is found their centers are used as corresponding points to determine the registration parameters. Template matching or matrix matching is one of the most common classification methods that can be used for character recognition in which individual image pixels are used as features. Classification is performed by comparing an input, and Template matching is a trainable process as Template characters can be changed, fast and easy to compute (Nadira, Nik, Nik, Siti, & Zain, 2014).

However, this project aims to develop a system that will detect and recognize plate number images of Nigerian vehicle using template matching subsequently be used as part

of a locally made speed camera to enforce traffic speed by booking registered owners of such vehicles that violate traffic rules. The system should also be able to classify plate numbers into private, commercial, government or diplomatic among other types.

1.3. AIM AND OBJECTIVES

The aim of this project is to develop a system that will recognize the characters in a Nigerian vehicle license plate and classify them as private, commercial, government, or diplomatic among others using template matching and RGB color model separation technique. The specific objectives are

1. To design a system prototype that is capable of recognizing the characters in a Nigeria vehicle license plate.
2. To implement the designed system using template matching as Classifier
3. To evaluate the effectiveness of the system.

1.4. METHOD OF STUDY

The method of study to be applied in this project for success is state below

1. A streamlined process to be used in achieving the aim and objective of the project is by consulting relevant books, journals, web page and interaction.
2. Consulting the federal road safety commission officer for detail about the traffic regulation and the Nigerian license plate number format.
3. The RGB colour model separation technique and template matching technique will be used to develop the system in such a way that will be able to differential the colour of the plate number categories and retrieve it in a text format.
4. The collects of 26 license plate number will be captured
5. The capture image will be preprocessed appropriately.
6. Segmentation would be done on the preprocessed license plate number images.

7. Implementation of the system using extracted features.
8. Evaluation of the implemented Nigerian vehicle license plate number recognition system for recognition error, colour recognition error and other.

1.5. SCOPE OF STUDY

This project seek to develop a system using that will recognize the characters and color in a Nigerian vehicle license plate. The propose system will only work on a static image where in the image is be captured already earlier before use, therefore , image captured from a moving vehicle or motorcycle will not be considered for this work, also the proposed system might not work with for foreign vehicle license plate number as it focus on only Nigerian vehicle plate number, template matching will be used as the classifier although there are other equivalents such as artificial neural network(ANN), Genetic algorithm (GA) or Fuzzy logic (FL) Etc. lastly the system will only recognize character in the vehicle plate, as we have no intention to retrieve about the ownership of the vehicle whose plate has been recognized. However, the system can be extended to include such functionalities.

1.6. SIGNIFICANCE OF STUDY

The significant of the study is using of recognition system which different area of applications which will be stated below.

1. **Handwriting recognition (HWR):** is the ability of a computer to receive and interpret intelligible handwritten input from sources such as paper documents, photographs, touch-screens and other devices. The image of the written text may be sensed "off line" from a piece of paper by optical scanning (optical character recognition) or intelligent word recognition (Singh, 2013)

2. **Magnetic ink character recognition code (MICR Code)**: is a character-recognition technology used mainly by the banking industry to ease the processing and clearance of cheques and other documents. The MICR encoding, called the MICR line, is at the bottom of cheques and other vouchers and typically includes the document-type indicator, bank code, bank account number, cheque number, cheque amount, and a control indication (Ibrahim, 2006)

3. **Automatic number plate recognition system (ANPR)**: is a technology that uses optical character recognition on images to read vehicle registration plates. It can use existing closed-circuit television, road-rule enforcement cameras, or cameras specifically designed for the task, it can be used to store the images captured by the cameras as well as the text from the license plate, with some configurable to store a photograph of the driver. Systems commonly use infrared lighting to allow the camera to take the picture at any time of the day, ANPR technology must take into account plate variations from place to place (Ibrahim, 2006).

4. **Captcha**: it requires that the user type the letters of a distorted image, sometimes with the addition of an obscured sequence of letters or digits that appears on the screen. Because the test is administered by a computer, in contrast to the standard Turing test that is administered by a human, a CAPTCHA is sometimes described as a reverse Turing test (Luis, Manuel, & John, 2003).

CHAPTER TWO

LITERATURE REVIEW

2.1. CHARACTER RECOGNITION

Recognition is the process of identify and respond correctly to (a sound or character), Pattern recognition refers to the process of analyzing an input image, a segment of speech, an electronic signal, or any other sample of data and classifying it into one of several categories. For character recognition, for example, the categories would correspond to the several dozen or so alphanumeric characters. Character recognition is needed when the information should be readable both to humans and to a machine and alternative inputs cannot be predefined. In comparison with the other techniques for automatic identification, optical character recognition is unique in that it does not require control of the process that produces the information. However, Character recognition is a subset of the pattern recognition area. Character recognition is a process of detecting and recognizing characters from input image and converts it into American Standard Code for Information Interchange (ASCII) or other equivalent machine editable form (Pranob, 2012). However, it was character recognition that gave the incentives for making pattern recognition and image analysis matured fields of science (Eikvil, 1993).

Character Recognition is developed to identify either printed characters or discrete run-on handwritten characters. It is a part of pattern recognition that usually deals with the realization of the written scripts or printed material into digital form. (Kundavinachiyar, 2014), then it is needed when the information should be readable both to humans and to a machine and alternative inputs cannot be predefined.

Character recognition remains one of the vital research areas mainly because its application to human-machine and machine-machine communication (Hansen, 2014) .

One example application that needs this technology is in machine processes such as cognitive computing, machine translation, (extracted) text-to-speech, key data and text mining, vehicle number plate recognition, handwritten recognition etc. (wikipedia, 2016). With millions of vehicles on the roads today, human resources alone are insufficient in recognizing, tracking or controlling their movements. (Kundavinachiyar, 2014)

Character recognition is mainly of two types online and offline. In online character recognition, data is captured during the image process with the help camera (Singh, 2013).

2.1.1. Offline Character Recognition

Generally all printed or type-written characters are classified in offline mode. Off-line character recognition refers to the process of recognizing characters in a document that have been scanned and capture from a surface are stored digitally in gray scale format. The storage of scanned and captured image are bulky in size and many processing applications such as searching for a content, editing, maintenance are either hard or impossible directly with the help of a digital device such as camera (Mori, (2002)). Character recognition systems translate such scanned images printed, typewritten or handwritten image into machine encoded text. This translated machine encoded text can be easily edited, searched and can be processed in many other ways according to requirements. It also requires tiny size for storage in comparison to scanned and capture image (Singh, 2013).

2.1.2. Online Character Recognition

The online mode of recognition is mostly used to recognize only handwritten characters. In this the handwriting is captured and stored in digital form via different means. Usually, a special pen is used in conjunction with an electronic surface. As the pen moves across the surface, the two- dimensional coordinates of successive points are represented as a

function of time and are stored in order. Recently, due to increased use of handheld devices online handwritten recognition attracted attention of worldwide researchers. This online handwritten recognition aims to provide natural interface to users to type on screen by handwriting on a pad instead of using keyboard. The online handwriting recognition has great potential to improve user and computer communication (Singh, 2013).

The character recognition system involves many steps to completely recognize and produce machine encoded text. The various phases involved in character recognition are termed as: Image Acquisition, Pre-processing, Segmentation, Feature extraction and Classification. The block diagram of a typical recognition system (Gay, 2012) is shown in figure 2.1. Below:

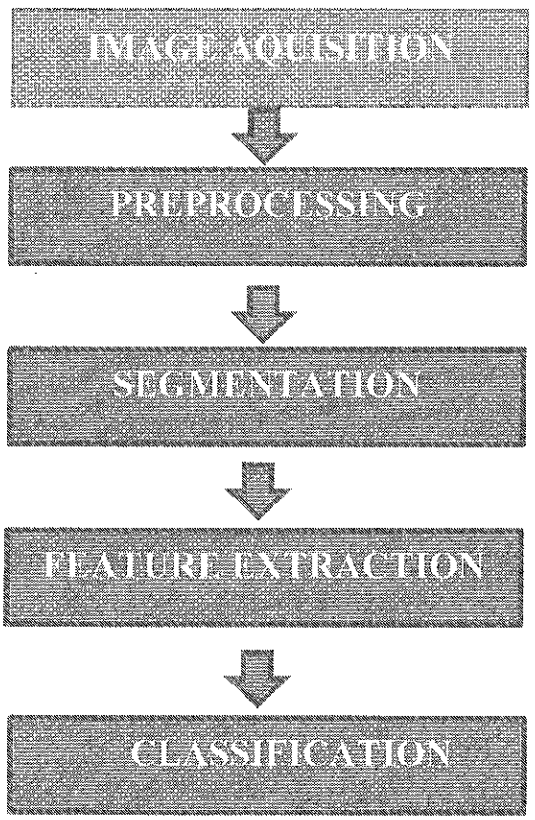


Figure 2. 1 Phases Involved In Character Recognition *(Thomé, 2012)*

2.2. IMAGE ACQUISITION

The character recognition system acquires an input image through a digital scanner or any other suitable digital input device. The input captured may be in color, gray or binary from scanner or digital camera (Kumar, 2015).

At the image acquisition, the recognition system acquires a scanned image as an input image. The image should have a specific format such as JPEG, BMT, etc. Electronic devices such as optical (digital/video) cameras, webcams, etc. can be used to capture the acquired images. The images will be stored as color JPEG format on the camera (Zakariya, 2014), Resolution at which the capturing is done plays crucial role in accuracy of character recognition. Captured image is at lower resolution the performance of the system will degrade at the same time storage size of database will also be low. However the captured image is at higher resolution the performance of the system increases but overall storage size for database will increases therefore scanning and capturing of image should be at optimal resolution (Rohithram & Saidas, 2016).

2.3. IMAGE PREPROCESSING

The preprocessing stage plays an important role in the character recognition process. Preprocessing converts the acquired image into a more usable form for the next stages. The major objectives of our preprocessing stage are to reduce the amount of noise present in the document and to reduce the amount of data to be retained (Eikvil, 1993).

The importance of the preprocessing stage of a character recognition system lies in its ability to remedy some of the problems that may occur due to some of the factors like scanner quality, scan resolution, type of printed documents (laser printer or photocopied), paper quality, fonts used in the text, linguistic complexities, and dictionary used. "Foxing" and "text show through" found in old paper documents,

watermarks and non-uniform illumination are examples of problems that affect the accuracy of OCR compared to a clean text on a white background (Alginahi, 2010). Thus, the use of preprocessing techniques may enhance a document image preparing it for the next stage in a character recognition system. In order to achieve higher recognition rates, it is essential to have an effective preprocessing stage, therefore; using effective preprocessing algorithms makes the optic character recognition system more robust mainly through accurate image enhancement, noise removal, image thresholding, skew detection/correction, page segmentation, character segmentation, character normalization and morphological techniques (Kundavinachiyar, 2014) (Kauleshwar, 2013), which are at the present explained

2.3.1. Image Enhancement Techniques

Image enhancement improves the quality of images for human perception by removing noise, reducing blurring, increasing contrast and providing more detail. This section will provide some of the techniques used in image enhancement (Alginahi, 2010).

In image processing, filters are mainly used to suppress either the high frequencies in the image, therefore Smoothing the image, or the low frequencies, Enhancing or detecting edges in the image. Image restoration and enhancement techniques are described in both the spatial domain and frequency domain, i.e. Fourier transforms. However, Fourier transforms require substantial computations, and in some cases are not worth the effort (Alginahi, 2010).

2.3.2. Normalization

The preprocessing begins with data normalization. This is an important step in recognition because styles differ greatly with respect to the skew, slant, height and width of the characters. The acquired image is processed by normalization and the results in regulating the size, position and shape of the characters. This algorithm adjusts the contrast and brightness of the image (Saghaei, 2016). In image processing, normalization is a process that changes the range of pixel intensity values. The matrix values of the image can be normalized along the column and row using the norms and norm commands in Matlab. Further, complications during feature extraction are removed if normalization is done in the earlier stages (Poovizhi, 2014).

Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching or histogram stretching. In more general fields of data processing, such as digital signal processing, it is referred to as dynamic range expansion, The purpose of dynamic range expansion in the various applications is usually to bring the image, or other type of signal, into a range that is more familiar or normal to the senses, hence the term normalization. Often, the motivation is to achieve consistency in dynamic range for a set of data, signals, or images to avoid mental distraction or fatigue. For example, a newspaper will strive to make all of the images in an issue share a similar range of grayscale (González, 2007).

2.3.3. Smoothing

The cursive English word and number is smoothed to modify and remove rough edge to obtain more enhanced writing with less noisy shape. The output will be more stable and recognizable as it gives a straight form of the character. (Kundavinachiyar, 2014) Smoothing is often used to reduce noise within an image or to produce a less pixelated

image. Most smoothing methods are based on low pass filters. See Low Pass Filtering for more information. Smoothing is also usually based on a single value representing the image, such as the average value of the image or the middle (median) value (northstar, 2014).

In statistics and image processing, to smooth a data set is to create an approximating function that attempts to capture important patterns in the data, while leaving out noise or other fine-scale structures/rapid phenomena. In smoothing, the data points of a signal are modified so individual points (presumably because of noise) are reduced, and points that are lower than the adjacent points are increased leading to a smoother signal. Smoothing may be used in two important ways that can aid in data analysis are by being able to extract more information from the data as long as the assumption of smoothing is reasonable and by being able to provide analyses that are both flexible and robust (Jeffrey, 1998).

Interpolation is where the smoothened stroke is interpolated to give a fixed number of points, equally spaced along the curve length. The number of points is chosen based on the average number of points per stroke in the given dataset (Kundavinachiyar, 2014).

This theoretically perfect reconstruction requires interpolation using infinite summations which in practice, forces us to look for approximations. One of the most common applications of 2-D interpolation in image processing is in image resizing (zooming and shrinking) (Gonzalez, 2002).

2.3.4. Noise Removal

The advancements in technology produced image acquisition devices with better improvements. While modern technology has made it possible to reduce the noise levels associated with various electro-optical devices to almost negligible levels,

there are still some noise sources which cannot be eliminated. Images acquired through modern sensors may be contaminated by a variety of noise sources. By noise we refer to stochastic variations as opposed to deterministic distortions, such as shading or lack of focus. There are different types of noise that are related to the electronic capturing devices or the light source used such types of noise are photon, thermal, On-Chip electronic and quantization. Most of the noise may be eliminated by the capturing sensors or the CCD cameras (Alginahi, 2010)

2.3.4. Binarization

The conversion of the grayscale image to black and white is called binarization. Binary images are also called as Bi-level or two-level. First, the original RGB image should be converted to grayscale and then the image is converted to black and white image. Most of the OCR packages work on the binarized images. The conversion is possible because of the threshold values and the values which are higher than the threshold are white and the values which are lower than this threshold are black. Otsu's method is used to perform threshold based on cluster i.e. from gray level image to binary image (Poovizhi, 2014).

2.3.5. Sampling

Discretization of analog signal is called sampling. The smallest element which is the result of discretization of the space is called pixel. The process of selecting the subset of individuals from the large sample of population and examining those samples, can generalize the results to the whole population (Poovizhi, 2014). The example of sampling is show below.

2.3.6. Thinning

Thinning is a pre-process which results in single pixel width image to recognize the handwritten character easily. It is applied repeatedly leaving only pixel-wide linear

representations of the image characters (Suganthi, 2013). Figure 2.2. Shows the thinning process.

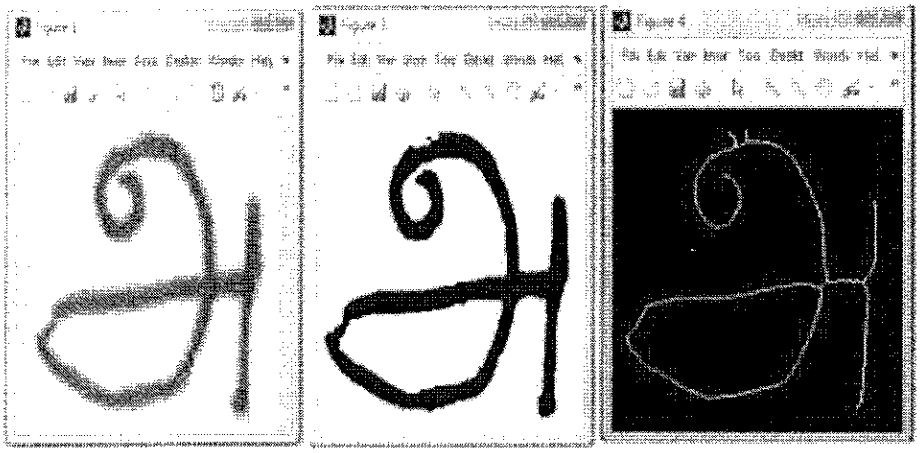


Figure 2. 2 Thinned Image *(Suganthi, 2013)*

2.4. SEGMENTATION

It investigates the image for components that match predefined classes. This segmentation move toward on recognition. Segmentation is carried out for recognition assurance, including syntactic or semantic exactness of the overall consequence (Rastogi & Agarwa, 2013).

It contains various segmentation like word segmentation, line segmentation and character segmentation. approach for character segmentations are based on projection analysis and connected section labeling .Segmentation is a significant stage, since the amount one can reach in separation of characters directly power the recognition rate of the characters.. (Eikvil, 1993)

Character segmentation is basically the process of separating out the individual digits from a stretch of numbers images capture. In segmentation, the input image is segmented into individual character and then each character is resized into m*n pixels towards the

extracting the features. In this method the characters are segmented based on stroke. (Kundavinachiyar, 2014), Character Segmentation is an important step in the vehicle registration plate recognition system. However, with the influence factors such as image noise, spacing, brightness, and different sizes and so on, there are quite a lot of difficulties faced. there are many techniques developed for character segmentation and most of them are script specific and may not work with other scripts. Even in printed handwritten documents, character segmentation is required due to touching of characters when written by hand. For example, printed Latin characters are easy to segment using horizontal and vertical histogram profiles. however, smaller fonts and those containing serifs may introduce touching which will need further processing to solve the touching problem (Poovizhi, 2014). This module is thus responsible for the separation of the foreground region from the background region. The foreground region is a collection of text characters placed on the same line as well as on different lines. The segmentation process works in two steps which are the Line Segmentation, word segmentation and Character Segmentation and they are explained below:

- **Line Segmentation**

Line segmentation is the separation of the different lines of characters present in the image. Each line is defined by a minimum vertical gap between the characters present on a line and on the line above and below it. This gap can be used for the detection and separation of different lines of characters (Jambekar, 2013).

- **Character Segmentation**

This is the separation of characters present in the same line. Once the lines are separated, each character is extracted from the line. There is a constant horizontal gap between characters which is used for the separation of characters. Thus, images corresponding to

individual characters are extracted which are fed to the recognition module (Jambekar, 2013).

- **Word Segmentation**

Word segmentation is a process of dividing a string into its component words. Word splitting is the process of parsing concatenated text to infer where word breaks exist. By using vertical projection profile, one can get column sums. By looking for minima in horizontal projection profile of the page, we can separate the lines and then separate words by looking at minima in the vertical projection profile of a single line. By using the valleys in the vertical projection of a line image, one can extract words from a line and also extracting individual characters from the word. (Amendeep, seema, & sunil, 2015)

There are types of character segmentations are:

- **Region Based Segmentation**: Region based methods are robust because they cover more pixels than edges and thus you have more information available in order to characterize your region (Amendeep, seema, & sunil, 2015).
- **Pixel Based Segmentation**: It is the simplest approach and is done based on pixel gray level values. It is also called as point based segmentation (Amendeep, seema, & sunil, 2015)
- **Edge Based Segmentation**: An edge based segmentation approach can be used to avoid a bias in the size of the segmented object without using a complex thresholding scheme. Edge-based segmentation is based on the fact of the first-order derivative that is position of an edge is given by an extreme (Amendeep, seema, & sunil, 2015)

- **Model Based Segmentation**: The human vision system has been able to recognize objects even if they are not completely clear or represented. It is obvious that the information that can be gathered from local neighborhood operators is not sufficient to perform this task. Instead Specific knowledge about the geometrical shape of the objects required, which can then be compared with the local information. This train of thought leads to model-based segmentation. (Alginahi, 2010)

Though, there are several segmentation techniques and can be broadly classified into following three categories: Explicit Segmentation, implicit segmentation and Holistic approaches

2.4.1. Explicit Segmentation

The procedure of Cutting up the image into major components is given a fussy name, "dissection". Dissection is a process that examine an image without using correct category of shape information. The computation for good segmentation is the conformity of general property of the segments with these predictable for valid characters. Moreover, explicit segmentation can be subjected to estimate using linguistic framework.

In the explicit segmentation, the input word image of a sequence of characters is portioned into sub images of individual characters, which are then classified. This process is termed as a dissection (Choudhary, 2014) .Vertical segmentation approach lies in the category of explicit segmentation. In this approach, after the preprocessing of the input handwritten word image, the word image is scanned from top to bottom (Choudhary, Rishi, & Ahlawat, 2013). The positions of all these columns are saved for which the sum of foreground black pixels is either 0 or 1. These columns are known as PSC (Potential segmentation columns) (Choudhary, Rishi, & Ahlawat, A new approach

to detect and extract characters from off-line printed images and text, 2013). In the word images, each column for which the sum of foreground pixels is 0 or 1 is a PSC.

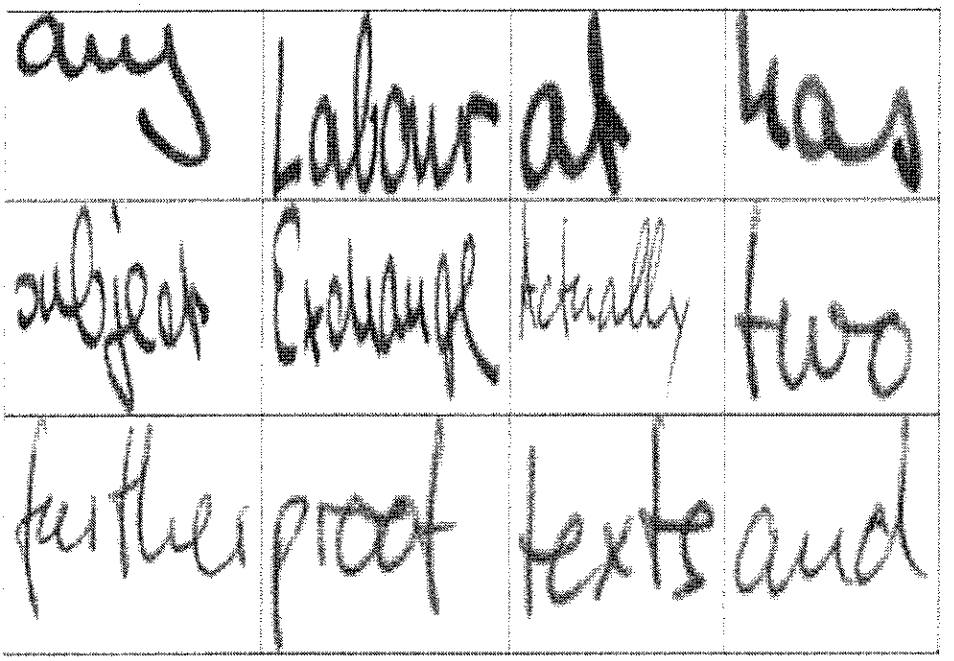


Figure 2. 3 word image samples

By using PSC, vertically cuts the word image as shown in fig. 3. All the PSC, for which distance is less than a threshold value, are integrating into a single column. Pre-processing algorithm & character segmentation algorithm.

2.4.2. Implicit Segmentation

It investigates the image for components that match predefined classes. This segmentation move toward on recognition (Rastogi & Agarwa, 2013). Segmentation is carrying out for recognition assurance, including syntactic or semantic exactness of the overall consequence.

Implicit segmentation is also called recognition based segmentation. In this approach segmentation and recognition of characters are achieved at the same time. In this, the

system searches the image for the components that image classes in its alphabet, implicit segmentation approach is to split words into segments that should be characters, and then pass each segment to a classifier. If the classification results are not satisfactory, call segmentation once more with the feedback information about rejecting the previous result. The implicit segmentation approach provides all the tentative segments and let recognizer to decide best segmentation hypothesis. However, there is a tradeoff in selecting the number of segments for a word. Less number of segments is the base of efficient computation but wide character cannot be covered in the hypothesis. Whereas, large number of segments, it is computationally expensive (Choudhary, Rishi, & Ahlawat, 2013)

2.4.3. Holistic Approaches

Holistic segmentation approach is also known as a segmentation free approach. By using holistic approach, one can extract the entire word as a unit from a string. This approach directly concern with words, not letters. Use of the holistic approach is limited to a predefined lexicon. An application for which the lexicon is statically defined, holistic approach is used, like bank cheque recognition .White space and pitch approach lies in the category of holistic segmentation technique. Vertical white space serves to separate successive characters. In billing application, design of a document specifically designed for OCR, additional spacing is built into the fonts used. The basis provided for estimating segmentation points by pitch, or number of characters per unit horizontal distance. The sequence of segmentation points obtained for a given line of print should be approximately equally spaced at the distance corresponding to the pitch (Rastogi & Agarwa, 2013).

2.5. FEATURE EXTRACTION

Feature extraction is the process of extracting the relevant features in the character image. The main aim of the feature extraction is to increase the recognition rate. Efficiency of the character recognition system depends on the feature extraction step (Arya & Anil, 2015). Reduce the amount of data by extracting relevant information usually results in a vector of scalar values. (Hansen, 2014) Two types of features are used to recognize the characters, brightness and shape. Brightness features can be captured from the image data directly. For shape features, after image thinning, linear regression is used to extract straight lines and circular regions common in several characters and numbers (Stephen, Kenji, & Minoru, 2012). The objective of feature extraction is to capture the essential characteristics of the symbols, and it is generally accepted that this is one of the most difficult problems of pattern recognition (Venkata & Sastry, 2016). Usually captured image consist of large number of words and sentence. For recognition we have to extract each character. Character extraction involve 3 stages. Firstly detected each line of text from the captured image. From each line Words are detected and from each word Character is segmented. Each character in a captured image is extracted and further used for feature extraction (Rohithram & Saidas, 2016). Feature extraction is of three types which are: Statistical features, Global transformation and moments and Structural features (Arya & Anil, 2015).

Statistical Feature: these are based on how the data is collected and selected, it helps to create a hypothesis about the data and Statistical feature extraction is based on probability theory and hypothesis. Partitioning into regular or irregular regions, profiles and projections, distances and crossings are the statistical feature extraction methods (Arya & Anil, 2015).

One of the most common features based on pixel values are image moments, Transformation such as Fourier and wavelet have been used to extract features from images, (Usman, 2014) They may also be used for reducing the dimension of the feature set. The followings are the major statistical features zoning, character loci, crossing and distances (Gaurav & Pradeep, 2014)

Global Transformation and Moments: These features are invariant to global deformations like translation and rotations. A continuous signal generally contains more information that needs to be represented for the purposes of classification. One way to represent a signal is by a linear combination of a series of simpler well defined functions (Gaurav & Pradeep, 2014). The coefficients of the linear combination provide a compact encoding known as series expansion. Common transform and series expansion features are Fourier transform, Gabor transforms, Wavelets, Moments and curvelets etc (Usman, 2014).

Structural Features: They are based on geometrical and topological properties of the character. Loops, curves, lines, T-point, cross, aspect ratio, strokes and their directions, inflection between two points, chain code etc. are the structural features (Usman, 2014; Arya & Anil, 2015).

Simple shape based features can be easily extracted from images and that yield good results. feature vector consisting of a several shape based features such as number of connected components, number of descenders/ascenders, dots, loop, etc. extraction features by combining Gradient, Structural and Concavity features. This combination of features has shown to capture the local, intermediate and global information, fuzzy polygonal approximation with constrained collinear-points suppression of Arabic text contours, which shows tolerance to variations of the handwritten text of different

writers, first characteristic points such as starting, ending, branch points of a word are detected. Then a Beta-elliptic model is applied to extract features that represent the static and kinematic field for handwriting (Usman, 2014).

There are approaches in which feature extraction can done which are fourier transformation, Principal Component Analysis (PCA), Independent Component Analysis (ICA), Gabor Filter, Fractal Theory Technique etc.

2.5.1. Fourier Transformation

Fourier transformation is widely used for shape analysis. The Fourier transformed coefficients form the Fourier descriptors of the shape. These descriptors represent the shape in a frequency domain (Gaurav & Pradeep, 2014).

The lower frequency descriptors contain information about the general features of the shape, and the higher frequency descriptors contain information about finer details of the shape. Although the number of coefficients generated from the transform is usually large, a subset 8 of the coefficients is enough to capture the overall features of the shape. Suppose that the boundary of a particular shape has K pixels numbered from 0 to K - 1. The k-th pixel along the contour has position (xk, yk). Therefore, we can describe the shape as two parametric equations:

$$x(k) = xk, \quad y(k) = yk \qquad (2.1)$$

We consider the (x, y) coordinates of the point not as Cartesian coordinates but as those in the complex plane by writing

$$s(k) = x(k) + I\, y(k) \qquad (2.2)$$

We take the discrete Fourier Transform of this function to end up with frequency spectra. The discrete Fourier transform of s(k) is

$a(u) = \frac{1}{k}\sum_{k-0}^{k-1} a(u)\, e^{-\frac{j2\pi uk}{k}}$ K= 0, 1 …k=1 (González, 2007) (2.3).

Correctly classify all training data

$$wx_i + b \geq 1 \qquad (2.4.)$$

2.5.2. Principal Component Analysis (PCA)

PCA is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components (Gaurav & Pradeep, 2014).

Data with many features are generally used for image classification wherein features are related to image metrics or to pixels. For example, face classification has been done by representing pixels in an image as features. Pixels are arranged in a vector and a set of eigenfaces is obtained by PCA. For classification, a new face is compared to the others by computing a new image according to the transformation obtained by PCA. The advantage is that PCA has independent features (Aguado, 2008).

Another area that has used PCA extensively is image compression. In this case, pixels with the same position are used for the vectors. That is, the first feature vector is formed by grouping all the values of the first pixel in all the images. Thus, when PCA is applied, the pixel value on each image can be obtained by reconstructing data with a reduced set of eigenvalues. As the number of eigenvalues is reduced, most information is lost. However, if you choose low eigenvalues, then the information that is lost represents low data variations (Aguado, 2008). The step involve in PCA are as follows

- The mean valve $\bar{S}$ of the given data set" S" is found
- Subtract the mean value say from S. From these valves a new matrix is obtained. Let say "A"
- Covariance is obtained from the matrix i.e., C = AA^TEigen values are obtained from the covariance matrixes that are V1V2V3V4…VN
- Finally Eigen vectors are calculated for covariance matrix C
- Any vector S or S- $\bar{S}$ can be written as linear combination of eigen vectors shown in Eq. 2.5
- Because covariance matrix is symmetric it form basis V1V2V3V4…

$$V_N \; S-\bar{S} = b_1u_1+b_2u_2+b_3u_3+\ldots+b_Nu_N \qquad (2.5)$$

- Only Largest eigen values are kept to form lower dimension data set (Eq. 2.6)

$$\hat{S}-\bar{S}=\sum_{i=0}^{l} b_i\, u_i : l<N \qquad (2.6)$$

2.5.3. Independent Component Analysis (ICA)

ICA is a statistical technique that represents a multidimensional random vector as a linear combination of non-Gaussian random variables (independent components) that are as independent as possible. ICA has many applications in data analysis, source separation, and feature extraction.

Suppose that we observe am-dimensional zero mean input signal at time t, $v(t) = \{V_1, \ldots\ldots, V_M\}'$ where (') means the transposition of matrices and vectors. Then then-dimensional whitening signal (t), is given by the following equation:

$$\boldsymbol{x}(t) = \boldsymbol{M}\boldsymbol{v}(t) = \boldsymbol{D}^{-1/2}\boldsymbol{E}'\boldsymbol{v}(t), \qquad (2.7)$$

Where M means an n×m (n≥ m) whitening matrithat is given by a matrix of eigen values, and a matrix of eigen vectors, E. Here, assume that v (t) is composed of n statistically independent signals, $s(t) = \{s_1(t), \ldots \ldots, s_n(t)\}$. Then, the following linear transformation from x(t) to s(t) exists:

$$s(t) = \boldsymbol{W}x(t). \tag{2.8}$$

Based on Eqs.(2.7) and (2.8), the relation between inputs and outputs of ICA is given by

$$\tilde{s}(t) = \tilde{\boldsymbol{W}}\boldsymbol{D}^{-1/2}\boldsymbol{E}'v(t) = \boldsymbol{B}v(t). \tag{2.9}$$

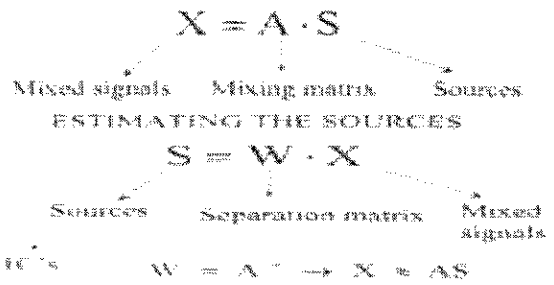


figure 2. 4 ICA is a statistical technique *(Gaurav & Pradeep, 2014)*

2.5.4. Gabor Filter

Gabor filter possess optimal localization properties in both spatial and frequency domain. Gabor filter gives a chance for multi-resolution analysis by giving coefficient matrices. In this approach, a 2D Gabor filter gives an extracted feature. A Gabor is Gaussian modulated sinusoid in the spatial domain and as a shifted Gaussian in frequency domain. It can be represented by:

$$g_{\gamma,n,\varphi,\Delta} = \exp\left(\frac{x^2+\gamma 2y^{-2}}{2\sigma}\right).\cos\left(\frac{2\pi x'}{\Delta}+\varphi\right) \tag{2.10.}$$

$$x' = x\cos\theta - y\sin\theta \tag{2.11.}$$

$$\iint I(\epsilon n)g(x-\varepsilon, y-n)d\varepsilon dn \qquad (2.12.)$$

The Gabor filter can be better used by varying the parameters like, π, γ *and* θ. In equation (2), x and y are image coordinates. π Is the wavelength of cosine equation, γ characterizes the shape of Gaussian, y= 1 for circular shape, y<1 for elliptical shape. Represents the channel orientation and takes values in the interval (0,360). The response of Gabor filter is convolution given by equation (Gaurav & Pradeep, 2014).

2.5.5. Fractal Theory Technique

This feature can be applied to extract the feature of two-dimensional objects. It is constructed by a hybrid feature extraction combining wavelet analysis, central projection transformation and fractal theory. A multi resolution family of the wavelet is used to compute information conserving micro-features. A central projection method is used to reduce the dimensionality of the original input pattern. A wavelet transformation technique is employed to transform the derived pattern into a set of sub-patterns. Its fractal dimension can be computed and used as feature vector (Gaurav & Pradeep, 2014). The key steps of the experimental procedure consist of the following:

Step 1: Central projection of two-dimensional patterns: We denote each of the two-dimensional patterns in question by p(x; y). Thus, the central projection of p(x; y) can be expressed as follows:

$$r(x_k) = \sum_{i=0}^{M} p(x_k \cos\theta_i, x_k \sin\theta_i). \qquad (2.13)$$

Step2: Wavelet transformation of the one-dimensional patterns: Let f(xk)=cj; k, where k=0;1;:::;2N−1 and

$$V_0 = \{c_{j,0}, c_{j,1}, \ldots, c_{j,2N-1}\}. \qquad (2.14)$$

Thus, the expressions for the wavelet transformation of V0 can be written as follows:

$$c_{j+1,m} = \sum_{k=0}^{5} h_k c_{j,k+2m}; \qquad d_{j+1,m} = \sum_{k=0}^{5} g_k c_{j,k+2m} \tag{2.15}$$

Where m=0; 1… N−1 (Yuan Y & Tao, 2002).

2.6. CLASSIFICATION

Classification is the process of identifying each character and assigning to it the correct character class. In the following sections two different approaches for classification in character recognition are discussed. First decision-theoretic recognition is treated. These methods are used when the description of the character can be numerically represented in a feature vector. (Eikvil, 1993). A general approach to improving the recognition speed is to perform coarse classification, preclassification, or candidate selection before the fine classification.

Most commonly seen classifiers are Artificial Neural Network, SVM, KNearest Neighbor and Nearest Neighbor classifier. Now a day Genetic Algorithm has been successfully applied for classification. In addition to these classifiers MQDF, Adaboost, Multilayer perceptron and Decision tree are used for the classification in character recognition system

2.6.1. Artificial Neural Network (ANN)

The word network in the term 'artificial neural network' refers to the inter–connections between the neurons in the different layers of each system. An example system has three layers. The first layer has input neurons, which send data via synapses to the second layer of neurons, and then via more synapses to the third layer of output neurons (Omidiora, Adeyanju, & Fenwa, 2013). More complex systems will have more layers of neurons with some having increased layers of input neurons and output neurons.

The synapses store parameters called "weights" that manipulate the data in the Calculations Simple models of nerve cells (neurons) and the way they interact; can be used for function approximation, machine learning, pattern recognition, etc. (Bodenhofer, 2014), The use of neural networks to recognize characters (and other types of patterns) has resurfaced. Considering a back-propagation network, this network is composed of several layers of interconnected elements. A feature vector enters the network at the input layer. Each element of the layer computes a weighted sum of its input and transforms it into an output by a nonlinear function. During training the weights at each connection are adjusted until a desired output is obtained. (Eikvil, 1993).

A neural network is a set of connected input/output units in which each connection has a weight associated with it. During the learning phase, the network learns by adjusting the weights so as to be able to predict the correct class label of the input values. Neural Network learning is also known as connectionist learning due to the connection between units.

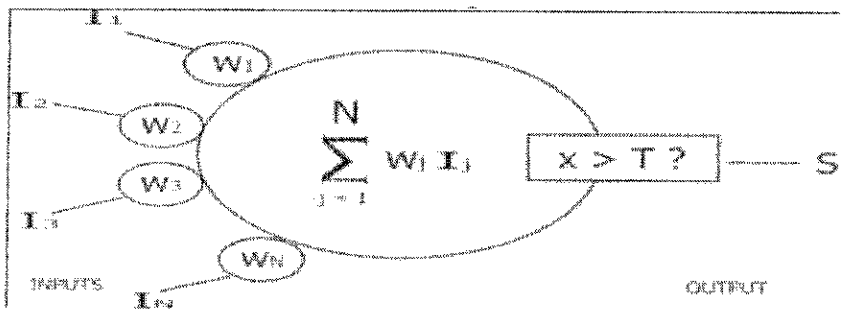


Figure 2. 5 the mathematical representation of the ANN *(Suruchi, Anjali, & Ashok, 2012)*.

Neural network recognizers learn from an initial image training set. The trained network then makes the character identifications. Each neural network uniquely learns the properties that differentiate training images. It then looks for similar properties in the target image to be identified. Neural networks are quick to setup; however, they can be

inaccurate if they learn properties that are not important in the target data (Suruchi, Anjali, & Ashok, 2012).

2.6.2. Support Vector Machine (SVM)

SVMs are relatively new approach compared to other supervised classification techniques, they are based on statistical learning theory developed by the Russian scientist Vladimir Naumovich Vapnik back in 1962 and since then, his original ideas have been perfected by a series of new techniques and algorithms. (Gay, 2012).

Support Vector Machines, are supervised learning machines based on statistical learning theory that can be used for pattern recognition and regression. Statistical learning theory can identify rather precisely the factors that need to be taken into account to learn successfully certain simple types of algorithms, however, real-world applications usually need more complex models and algorithms (such as neural networks), that makes them much harder to analyze theoretically (Scholkopf, 1998).

SVMs can be seen as lying at the intersection of learning theory and practice. They construct models that are complex enough (containing a large class of neural networks for instance) and yet that are simple enough to be analyzed mathematically. This is because an SVM can be seen as a linear algorithm in a high-dimensional space.

SVM is a binary linear classifier. Given a set of training examples, each marked as belonging to one of two categories; SVM training algorithm builds a model that assigns new example into one category or the other by constructing a hyper plane or set of hyper planes in a high- or infinite-dimensional space (Adeyanju, Fenwa, & Omidiora, 2014).

Support Vector Machines (SVM), represent the cutting edge of ranking algorithms and have been receiving special attention from the international scientific community. Many successful applications, based on SVMs, can be found in different domains of knowledge, such as in text categorization, digital image analysis, character recognition and bioinformatics.

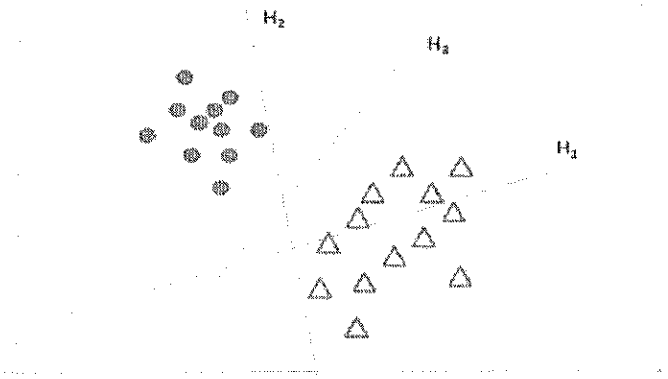


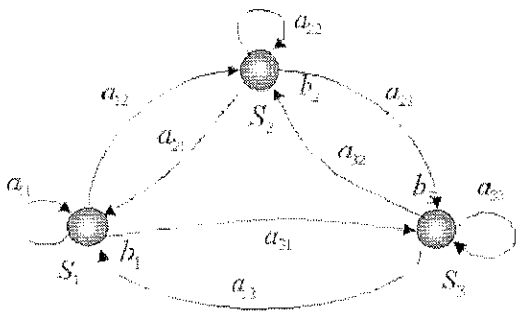
Figure 2. 6 Separation hyperplanes of SVM *(Gay, 2012)*.

2.6.3. Hidden Markov Models (HMM)

For the first time hidden Markov models have been applied by Rabiner in 1993. Hidden Markov models is a tool for representing probability distribution ever sequences of observation and it is also one of ways of mathematical model reception of some observable signal. HMM carries to a class of stochastic models. Stochastic models tries to characterize only static properties of a signal, not possessing the information on its specific properties, It generates a sequence of observables by moving from latent state to latent state according to the transition probabilities and emitting an observable (from a discrete set of observables, i.e. a finite alphabet) from each latent state visited according to the emission probabilities of the state.

In a basis of stochastic models the assumption that the signal can be described by some parametrical casual process and Parameters of this process can be precisely enough estimated by some, quite certain way is necessary. Hidden Markov Models are normal for applying, when there are many data sets of small volume. Thus it is supposed, that all sets begin with some fixed condition and the probability of value depends basically on number of that position in a set. Applications of Hidden Markov Models are the following Speech recognition; Image recognition; Biocomputer science (Research of fibers and DNA); Compression and decompression of audio and video signals; and other cases (Dudochkin, 2005).

For example the sequence of conditions S in which the choice of objects was made, it does not interest us. It the name "Hidden" Markov model also speaks - the sequence of conditions from us "is hidden". The model is " a black box " - after performance of the set quantity of steps it gives out a certain sequence O = $O_1, O_2, \ldots\ldots, O_T$



$$O = \{Y, G, R, G, G, B, R, R, Y, B\}$$

$$S = \{2, 1, 1, 3, 2, 2, 2, 3, 3, 1\}$$

Figure 2.6.2. HMM example

2.6.4. Genetic Algorithm (GA)

Pioneered by John Holland in the 1970's, Got popular in the late 1980's it Based on ideas from Darwinian Evolution, Can be used to solve a variety of problems that are not easy to solve using other techniques

Genetic Algorithms are the heuristic search and optimization techniques that mimic the process of natural evolution. Thus genetic algorithms implement the optimization strategies by simulating evolution of species through natural selection, Genetic algorithms evaluate the target function to be optimized at some randomly selected points of the definition domain. Taking this information into account, a new set of points (a new population) is generated. Gradually the points in the population approach local maxima and minima of the function (Rojas, 1996).

Rather than starting from a single point (or guess) within the search space, GA are initialized with a population of guesses. These are usually random and will be spread throughout the search space. A typical algorithm then uses three operators, selection, crossover and mutation (chosen in part by analogy with the natural world) to direct the population (over a series of time steps or generations) towards convergence at the global optimum (Coley, 1999).

Typically, these initial guesses are held as binary encodings (or strings) of the true variables, although an increasing number of GAs use "real-valued" (i.e. base-10) encodings, or encodings that have been chosen to mimic in some manner the natural data structure of the problem. This initial population is then processed by the three main operators.

GAs do not require knowledge of the first derivative or any other auxiliary information, it allow a number of problems to be solved without the need to formulate restrictive

assumptions, For this reason, GAs are often called blind search methods, GAs use probabilistic transition rules during iterations, unlike the traditional methods that use fixed transition rules, This makes them more robust and applicable to a large range of problems, GAs can be easily used in parallel machines Since in real-world design optimization problems, most computational time is spent in evaluating a solution, with multiple processors all solutions in a population can be evaluated in a distributed manner, This reduces the overall computational time substantially (Anita, 2015).

2.6.5. Fuzzy Logic (FL)

Fuzzy Logic was initiated in 1965 by Lotfi A. Zadeh, professor of computer science at the University of California in Berkeley, Fuzzy logic is a multi-valued logic that allows intermediate values to be defined between conventional evaluations like yes/no, true/false, black / white etc. An attempt is made to attribute a more human-like way of logical thinking in the programming of computers (Zadeh., 1973).

Fuzzy logic is been used when answers do not have a distinct true or false values and there are uncertainly involved (Venkata & Sastry, 2016). Fuzzy Logic has emerged as a profitable tool for the controlling and steering of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data (Hellmann, 2002).

Fuzzy Logic provides a different way to approach a control or classification problem. This method focuses on what the system should do rather than trying to model how it works. One can concentrate on solving the problem rather than trying to model the system mathematically, if that is even possible. On the other hand the fuzzy approach requires a sufficient expert knowledge for the formulation of the rule base, the combination of the sets and the defuzzification. In General, the employment of fuzzy logic might be helpful,

for very complex processes, when there is no simple mathematical model (e.g. Inversion problems), for highly nonlinear processes or if the processing of (linguistically formulated) expert knowledge to be performed. According to literature the employment of fuzzy logic is not recommendable, if the conventional approach yields a satisfying result, an easily solvable and adequate mathematical model already exists, or the problem is not solvable.

2.6.6. Template Matching

Template matching is one of the Optical Character Recognition techniques. Template matching is the process of finding the location of a sub image called a template inside an image. Once a number of corresponding templates is found their centers are used as corresponding points to determine the registration parameters (Nadira, Nik, Nik, Siti, & Zain, 2014). Template matching involves determining similarities between a given template and windows of the same size in an image and identifying the window that produces the highest similarity measure. It works by comparing derived image features of the image and the template for each possible displacement of the template (Nadira, Nik, Nik, Siti, & Zain, 2014).

Template matching involves determining similarities between a given template and windows of the same size in an image and identifying the window that produces the highest similarity measure. It works by comparing derived image features of the image and the template for each possible displacement of the template. This process involves the use of a database of characters or templates. There exists a template for all possible input characters. For recognition to occur, the current input character is compared to each template to find either an exact match, or the template with the closest representation of the input character. If I(x, y) is the input character, Tn(x,y) is the template n, then the

matching function s(I,Tn) will return a value indicating how well template n matches the input character. Some of the more common matching functions are based on the following Matching approaches formula: (2.16) City block, (2.17) Euclidean distance, (2.18) Cross Correlation, (2.19) 2-D Normalized Correlation

$$s(iTn) = \sum_{i=0}^{w} \sum_{j=0}^{h} |I(i.j) - Tn(i,j) \quad (2.16)$$

$$s(iTn) = \sum_{i=0}^{w} \sum_{j=0}^{h} (I(i.j) - Tn(i,j))^2 \quad (2.17)$$

$$s(iTn) = \sum_{i=0}^{w} \sum_{j=0}^{h} I(i.j)Tn(i,j)) \quad (2.18)$$

$$s(iTn) = \frac{\sum_{i=0}^{w} \sum_{j=0}^{h} (I(i.j) - |I|)Tn(i,j) - |Tn|)}{\sum_{i=0}^{w} \sum_{j=0}^{h} (I(i.j) - |I|)^2 Tn(i,j) - |Tn|)^2} \quad (2.19)$$

2.7. COLOUR MODELS

A color model is a system for creating a full range of colors from a small set of primary colors. There are two types of color models: additive and subtractive. Additive color models use light to display color, while subtractive color models use printing inks. The most common color models that graphic designers work with are the CMYK model for printing and the RGB model for computer display (González, 2007).

2.7.1. RGB COLOR MODEL

The RGB color model is an additive color model. In this case red, green and blue light are added together in various combinations to reproduce a wide spectrum of colors. The primary purpose of the RGB color model is for the display of images in electronic systems, such as on television screens and computer monitors and it's also used in digital photography. Cathode ray tube, LCD, plasma and LED displays all utilize the RGB model (Scott, 2012).

In order to create a color with RGB, three colored light beams (one red, one green, and one blue) must be superimposed. With no intensity, each of the three colors is perceived as black, while full intensity leads to a perception of seeing white. Differing intensities produce the hue of a color, while the difference between the most and least intense of the colors make the resulting color more or less saturated. Note the white centers that appear in the two color charts above. For web-page design the colors used are commonly specified using RGB.

2.7.2. THE CMYK COLOR MODEL

The CMYK color model (four-color process) is a subtractive color model. Primarily used in printing, CMYK works by partially or completely masking colors on a white background. The printed ink reduces the light that would otherwise be reflected. That's why this model is called subtractive because inks 'subtract' brightness from a white background from four colors: cyan, magenta, yellow and black. It is frequently suggested that the 'K' in CMYK comes from the last letter in 'black' and was chosen because B already refers to blue. However, this explanation is incorrect (Gonzalez, 2002). The 'K' in CMYK stands for 'key' since in four-color printing cyan, magenta, and yellow printing plates are carefully keyed or aligned with the key of the black key plate. Black is used because the combination of the three primary colors (CMY) doesn't produce a fully saturated black. This is evident in the central black color created by the overlapping circles in the color chart above (Scott, 2012).

CMYK color model to RGB color model conversion: Most devices that deposit colored pigments on paper, such as color printers and copiers, require CMY data input or perform

an RGB to CMY conversion internally. This conversion is performed using the simple operation.

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{2.20}$$

2.7.3. THE HSI COLOR MODEL

The HSI (hue, saturation, intensity) color model, decouples the intensity component from the color-carrying information (hue and saturation) in a color image. As a result, the HSI model is an ideal tool for developing image processing algorithms based on color descriptions that are natural and intuitive to humans, who, after all, are the developers and users of these algorithms. We can summarize by saying that RGB is ideal for image color generation (as in image capture by a color camera or image display in a monitor screen), but its use for color description is much more limited. The material that follows provides an effective way to do this (Gonzalez, 2002).

Converting colors from RGB to HIS given an image in RGB color format, the H component of each RGB pixel is obtained using the equation

$$H = \begin{cases} \theta & IF\ B \leq G \\ 360 & IF\ B > G \end{cases} \tag{2.21.}$$

The saturation component is given by

$$S = 1 - \frac{3}{(R+G+b)}[\min(R, G, B)] \tag{2.22.}$$

Finally, the intensity component is given by

$$I = \frac{1}{3}(R + G + B) \tag{2.23.}$$

2.8. TRAFFIC REGULATION IN NIGERIA

The traffic on the roads is increasing day by day. There is dire need of developing an automation system that can effectively manage and control the traffic on roads. The traffic

data of multiple vehicle types on roads is also important for taking various decisions related to traffic (Mokha, 2015) .

The objectives of these traffic regulations are to protect and control pedestrian and vehicular traffic, assure access at all times of emergency equipment, minimize traffic disturbances during class hours and facilitate the work of the college by assuring access to its vehicles and by assigning the limited parking space for the most efficient use.

In exercise of powers conferred on it by section 5 of the Federal Road Safety Commission (Establishment) Act, 2007 ('the Act') and of all other powers enabling it in that behalf, the FEDERAL ROAD SAFETY COMMISSION ("Commission") makes the following Regulation Commencement. PART I

The objectives of these Regulations are to give effect in Nigeria to the Geneva Convention on Road Traffic of September 19, 1949 and the Vienna Convention on Road Signs and Signals of November 8, 1968 ; and provide operational requirements, rules and regulations for the registration and licensing of vehicles, establishment and regulation of driving schools, vehicle identification numbers, learner's permit and driver ' s license, drivers and conductors registration and badges, taxis, stage carriages, omnibuses and motorcycles for hire, use of school buses, speed limits, use of sirens, traffic signs and trafficators, road crossing, parking of vehicles, driving and general duties of driver of vehicles or passengers on public roads, hindering or obstructing traffic on public road, damage to public road, pedestrian crossing, driving under the influence of alcohol and drugs, use and construction of vehicles and trailers, special provisions relating to use of the expressway , reporting of road crashes, and motorcycle and bicycles on public roads.

Objectives is to make provisions relating to exempted bodies, operators of transport services , operation of ambulance services and towing vehicles and provide miscellaneous motor traffic regulations to ensure road safety (Federal Republic of Nigeria Official Gazette, 2012)

2.8.2. License plate number

The license plates are divided into several categories based on colors and arrangement of the characters on the plates. A motor vehicle license of any class shall not be refused on the ground that the construction or fixed equipment of the vehicle is not suitable if a certificate of fitness as a vehicle of that class has been issued and is in force in respect of the vehicle. In private vehicles, the plates have a blue and white characters, for taxis it is white backgrounds with red characters, government vehicle it is green character and white background and a variety of other kinds based on special regions, etc. (Anagnostopoulos et'al, 2006). Moreover, there are single and double row plates. The characters on the plates are all alphanumeric (All upper-case). Registration Number serves as a unique identity for vehicle, for collating information and monitoring of the owner's safety compliant records. Appraisals will be made periodically during compliance assessment reviews, crash investigations and facility inspections. (Siam, 2014)

Nigerian vehicle registration plates in current used were introduced in 1992 and revised in 2011. In size and shape, they are based on those of the United States. Nigeria and Liberia are the only two African countries that do not use the European license plate format.

The license plates are generally white and the number itself is imprinted in blue. In the upper left-hand corner they carry the Flag of Nigeria or the national coat of arms. The state name and slogan is displayed at the top center of the plate, and the "Federal Republic

of Nigeria" is written at the bottom. The unique plate combination itself is in the format ABC-123DE. The first three letters indicate the Local Government Area in which the vehicle was registered, which are followed by three digits and two letters. The background consists of an outline of a map of Nigeria. Before 2011, the three letters indicating the Local Government Area were at the end, in the format AB123-CDE, Other types of license plates are also in use. Commercial vehicles are written in red rather than blue, and government plates are in green. Diplomatic plates have a red background with white lettering, and consist of up to three numbers, followed by CD or CMD and another number. Instead of the name of the state, they read CORPS DIPLOMATIQUE. Cars of the consular corps have instead the letters CC or CORPS CONSULAIRE. The Nigeria plate license number image is shown below

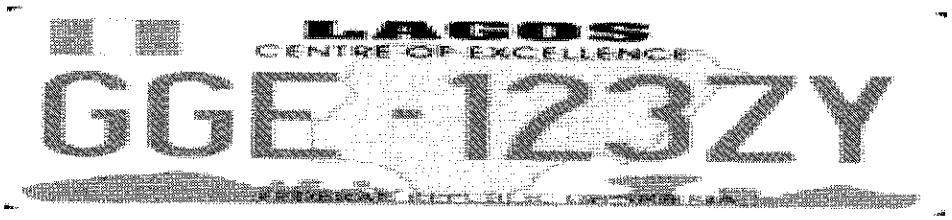


Figure 2. 7 Nigeria license plate number

2.9. RELATED WORKS.

Soumya & Bidyut,(2009) proposed a color image edge detection which use the average maximum color difference value is used to predict the optimum threshold value for a color image and thinning technique is applied to extract proper edges algorithm. It applied over large database of color images both synthetic and real life images and performance of the algorithm clearly shows that the output of the proposed method is easily comparable and in some cases better than the existing methods.

Roy & Ghoshal, (2011) presented a new method of segmenting the characters of the license plate based on a majority pixel value data. They have also addressed the issue of building the databases as per user convenience so that the user has the option to train the neural network with the fonts those are more relevant and mostly used in any particular geographical location. This is totally optional i.e. the user can change the network if they want to for better results. This algorithm has been tested on 150 images and it is found that the accuracy of the system is about 91.59%. The major sources of error were the skewness of the number plate and extreme variation in illumination conditions, which can be aptly removed by enhancing the approach further

Rohini, Jagade, & Sushilkumar,(2013) proposed a segmentation method in which the character segmentation regions are determined by using projection profiles and topographic features extracted from the gray-scale images. Then a nonlinear character segmentation path in eachcharacter segmentation region is found by using multi-stage graph search algorithm. Finally, in order to confirm the nonlinear character segmentation paths and recognition results, recognition-based segmentation method is adopted. Through the experiments with various kinds of printed documents, it is convinced that the proposed methodology is very effective for the segmentation and recognition

of touched and overlapped characters. The developed a method have optimized result of 96% accuracy.

Omidiora, Adeyanju, & Fenwa,(2013) compared system, studying classifiers for recognition of on line and offline handwritten digits. The paper compared four gadget studying classifiers particularly Naive Bayes, example based Learner, selection Tree and Neural network for unmarried digit popularity. The experiments had been performed the usage of the WEKA gadget learning device on two datasets; the MNIST offline handwritten digits and a collection of on line ISGL handwritten digits received with a pen digitizer. Experiments were designed to allow for assessment within the datasets in a pass validation and across them where the online dataset is used for training and the offline dataset for checking out and vice versa. Outcomes suggest that the instance based totally Learner classifier done barely first-rate with a maximal accuracy of 97.86% followed by means of the neural community classifier. The choice tree gave the worst performance of the 4 classifiers. The research investigated the performance of these classifiers in recognition of other characters (alphabets, punctuation and other symbols) and as well as extend the recognition task to other levels of text granularity such as words, sentences and paragraphs.

Kundavinachiyar, (2014) focuses on an application that performs cursive handwritten English character recognition in hand held devices. The objective is to make use of the visual capabilities of the built in camera of Android devices to extract cursive handwritten English character. The image taken is further processed by preprocessing technique which is segmented based on the stroke and is recognized with the help of Support vector machine (SVM), the result shows that the trained support vector machine classifier has shown higher efficiency in terms of speed, memory, and classification accuracy as

compared to other relate approaches dealing the handwritten character recognition problem. The recognized character was used to create a text file and it is editable by user for their application.

Adeyanju, Fenwa, & Omidiora, (2014) Examines the impact of utilizing some non - picture includes on the acknowledgment rate of three classifiers: Instance Based Learner (IBk), Support Vector Machines (SVM) and the Multilayer Perceptron (MLP) Neural Network for independently composed alpha-numeric character acknowledgment. Our examinations were directed utilizing the WEKA machine learning device on disconnected and online manually written obtained locally. A rate split (66%-34% prepare test) assessment approach was embraced with the characterization exactness measured. Comes about demonstrate that non-picture extra components enhanced the precision over the three classifiers for the on the web and disconnected character datasets, the outcome is a mix of utilizing the right/left hand and number of strokes elements gave the best exactness of 71.63% for the online dataset and was acquired by utilizing SVM. The outcomes gotten from utilizing the IBk and SVM classifiers were fundamentally superior to utilizing MLP for the online dataset.

Adeyanju, Ojo, & Omidiora, (2016) Presents a typewritten characters acknowledgment framework utilizing Hidden Markov Model (HMM). Character acknowledgment frameworks change over pictures of printed, typewritten or manually written records into PC lucid writings that can be effortlessly altered or looked. Character acknowledgment for typewritten records is however troublesome because of broken edges, touching characters, shape difference, skewing, and overwhelming printing coming about because of the affect. Three reports (old update, old war letter and recently typewritten article) were utilized to make three datasets of typewritten characters each comprising of 1995,

702 and 2049 characters individually. The examination result demonstrated that, acknowledgment exactness values are 94.88%, 91.45% and 97.24% for old notice, old war letter and recently typewritten paper datasets.

Saghaei, 2016) Proposed a programmed and automated permit and number plate acknowledgment (LNPR) system which can extricate the tag number of the vehicles going through a given area utilizing picture preparing calculations. No extra gadgets, for example, GPS or radio recurrence identification (RFID) should be introduced for actualizing the proposed system. Utilizing unique cameras, the framework takes pictures from each passing vehicle and advances the picture to the PC for being handled by the LPR programming. Plate recognition programming utilizes diverse calculations, for example, confinement, introduction, standardization, division lastly optical character acknowledgment (OCR). The subsequent information is connected to contrast and the records on a database. Exploratory outcomes uncover that the displayed system effectively identifies and perceives the vehicle number plate on genuine pictures. This system can likewise be utilized for security and activity control.

CHAPTER THREE

DESIGN METHODOLOGY

3.1. OVERVIEW OF THE NIGERIAN VEHICLE LICENSE PLATE NUMBER RECOGNITION SYSTEM

Automatic recognition of Nigerian vehicle license plate has become a very important in our daily life because of the increase in the number of vehicles. Hence it is impossible to be fully managed and monitored manually. There are so many examples like traffic monitoring, tracking stolen cars, managing parking toll, red-light violation enforcement and border and customs checkpoints. This project will deal with the construction of Nigerian vehicle license plate number recognition system. The system will use template matching as algorithms for image processing. The system will be based on a personal computer and software packages available such as MATLAB and a digital camera that helps in capturing images of vehicles. The general algorithm involves the following steps: Image capturing which is achieved by a digital camera, extraction to obtain the vehicle plate sub image, Character segmentation to determine exactly where characters exist inside the plate, Recognition which identifies the numbers contained in the plate and evaluating the performance of the algorithm.

The proposed system consist of several component such as image acquisition by capturing, image preprocess, segmentation, feature extraction, template matching and evaluation as show in the figure 3.1. Below:

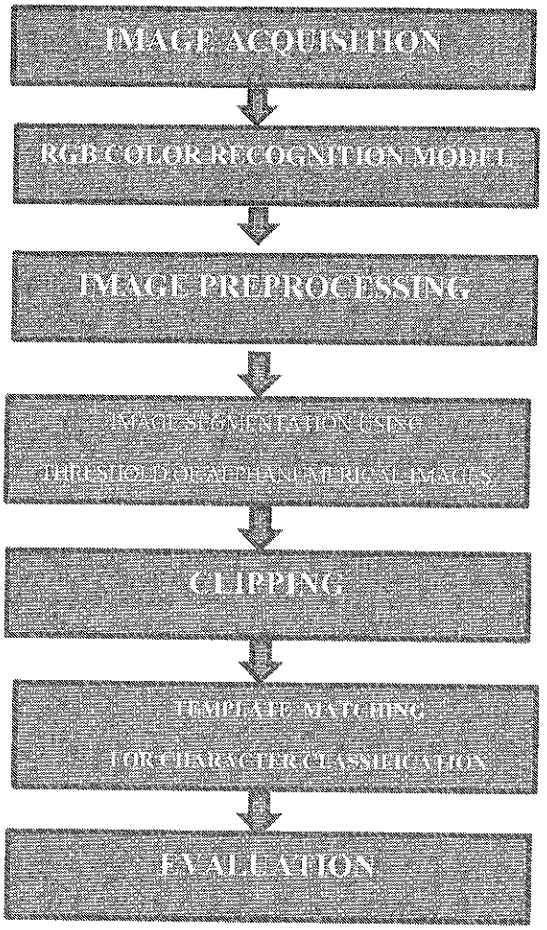


Figure 3. 1 the block diagram of the proposed Nigerian license plate number recognition system,

The image acquisition block show how the image is captured by using digital camera as discussed in section 3.1 , color recognition model block using mean of mean algorithm as discussed in 3.2, the preprocessing block using greyscale conversion, image enhancement and thresholding, image segmentation as discussed in section 3.3, block using multiple thresholding and dilate as discussed in section 3.4, the clipping block for dissection of the image as discussed in section 3.6, classification block using template matching and evaluation block using the evaluation matrices discussed in section 3.7

3.1. IMAGE ACQUISITION

The first phase of the proposed project is image acquisition this will be done by using high resolution camera and the camera will be used to capture at least 44 plate number cutting across all the category of the Nigeria license plate number and it will be stored in JPG format in the computer for further image processing for character recognition.

3.2. RGB COLOR RECOGNITION MODEL

In the RGB model, each color represents the basic color components Red, Green, and Blue. RGB color images are represented in the RGB color model as red, green and blue using 8-bit monochrome standard. The corresponding RGB color image has 24 bit/pixel – 8 bit for each color band (red, green and blue). The RGB color represents to referring to arrow or column as a vector, it can be referred as a single pixel red, green and blue values as a color pixel vector (R, G, and B).this is done by the following step:

- The RGB image is separated into different color band which is the red band, green band and blue band.
- The mean of each color band of the image is calculate by getting each pixel that contain the color band.
- Calculate the of the mean of mean the color band
- Compute the color band with highest mean

3.3. IMAGE PREPROCESSING

The preprocessing stage plays an important role in the proposed recognition process. Preprocessing converts the acquired image into a more usable form for the next stages, the major objectives of our preprocessing stage are to reduce the amount of noise present in the image and to reduce the amount of data to be retained. This preprocessing stage includes a number of techniques that be used in order to achieve these objectives

3.3.1. RGB Image to Grayscale Image

Conversion The captured plate number image is in RGB image. So it is necessary to convert from RGB to Grayscale for Grayscale Image pre-processing. This method matches the luminance of the grayscale image to the luminance of the color image. First get the values of three primary colors (Red, Green and Blue) and encodes this linear intensity values using the gamma expansion on matlab.

3.3.2. Enhancement

Image enhancement is a process principally focuses on processing an image in such a way that the processed image is more suitable than the original one for the specific application. The word "specific" has significance. It gives a clue that the results of such an operation are highly application dependent. In this system is going to using Linear contrast stretch and sharpening so as to increase the accuracy of the system

Sharpening techniques improve the clearness of digital images by enhancing the marks of the objects which are present in the image of the plate.

Linear contrast stretch technique modifies the linear contrast stretch that was related to the value transformation of the brightness part of the image. It can be measured by the lowest value of the brightness contrast (grey level = 0) to the highest value of the brightness contrast (grey level = 255) to full the grey scale level. A brightness value of between 0-255 would be spread out

3.3.3. OTSU method

the proposed system will use OTSO method the image for image preprocess which is used to automatically perform clustering-based image thresholding, the reduction of a

graylevel image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it will then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal (Roy & Ghoshal, 2011).

In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$\sigma_{\omega}^2(t) = \omega_0(t)\sigma_0^2 + \omega_1(t)\sigma_1^2(t) \qquad (3.1)$$

Weights ω_0 and ω_1 are the probabilities of the two classes separated by a threshold t , σ_0^2 and σ_1^2 are variances of these two classes. The class probability $\omega_{0,1}$ is computed from the L histograms

$$\omega_0(t) = \sum_{i=0}^{t-1} p(i) \qquad (3.2)$$

$$\omega_1(t) = \sum_{i=t}^{l-1} p(i) \qquad (3.3)$$

OTSU shows that minimizing the intra-class variance is the same as maximizing inter-class variance

$$\sigma_b^2(t) = \sigma^2 - \sigma_0^2\omega(t) = \omega_0(\mu_0 - \mu T)^2 + \omega_1(\mu_1 - \mu\tau)^2 \qquad (3.4)$$

$$= \omega_0(t)\omega_1(t)[\mu_0(t) - \mu_1(t)]^2 \qquad (3.5)$$

Which is expressed in terms of class probabilities ω and class means μ while the class mean $\mu_{0,1,T}(t)$ is:

$$\mu_0(t) = \sum_{i=1}^{t-1} i\frac{p(i)}{\omega_0} \qquad (3.6)$$

$$\mu_t(t) = \sum_{i=t}^{L-1} i \frac{p(i)}{\omega_1} \quad (3.7)$$

$$\mu_T(t) = \sum_{i=0}^{L-1} ip(i) \quad (3.8)$$

3.4. IMAGE SEGMENTATION

Character Segmentation is an important step in this proposed system. However, with the in fluency factors such as image noise, spacing, brightness, different sizes and so on, there are quite a lot of difficulties faced. This phase is basically the process of separating out the individual digits and alphabet from a stretch of numbers images capture. The segmentation process works in steps which are word segmentation and Character Segmentation

3.4.1. MULTIPLE THRESHOLD OF ALPHANUMERICAL IMAGES

Before any segmentation to be carried out in this proposed system, we have to convert the images captured into grayscale. This is basically changing all the pixels to just black and white pixels depending on whether the pixels are above or below a defined threshold.

This threshold selection will be a function of the intensity range of the pixels in the image. The average of the minimum and maximum threshold values is normally enough to optimize the conversion.

3.4.2. DISSECTION

In character segmentation will be done in the proposed system by using the procedure of Cutting up the image into major components is given a fussy name, "dissection". Dissection is a process that examine an image without using correct category of shape information. The computation for good segmentation is the conformity of general

property of the segments with these predictable for valid characters and the dissection image will be sized according to the size of the template which is 24*45 pixel.

3.5. CLASSIFICATION AND RECOGNITION

3.5.1. TEMPLATE CREATING AND LOADING

The creation of template is done by using adobe photoshop, the template is created for each of the character and it be in black color (alphabet and digit), the template is store in BMP picture format and have a picture size of 24*45 pixel.

This is the process of loading the template to match the dissect image in the memory so as to make the system check the template that fit the pattern which was clip. The template is sized with the same size of the clip image which will help that system to be able to recognize the clip image.

3.5.2. TEMPLATE MATCHING

Template Matching has the algorithm that applied to recognize the characters, grey-scale images were used to recognizing the alphabet and digit in the plate number by comparing between two images.

The template-matching algorithm to implements in the prototype of the system has the following steps:

i) Firstly, the character image from the detected string is selected.

ii) After that, the image to the size of the first template is rescaled.

iii) After rescale the image to the size of the first template (original) image, the matching metric is computed.

iv) The highest match found is stored. If the image is not match repeat again the third step.

v) The index of the best match is stored as the recognized character.

3.6. EXPERIMENTAL SETUP

Experiments have been performed to test the proposed system. Matlab (R2015a) is the software tool that was used for recognition of Characters and RGB color model image pixel calculation in the Nigerian plate number. The experiments were performed on 25 images and it cut across the three categories of the Nigerian plate number (private, commercial and government).

The prototype of the system will work on the acquire Image which is then preprocessed by Conversion of image in to gray-scale, enhancement by contrasting and sharpening of the image and thresholding then the image will be segmented using multiple thresholding dilating and clipping of the image for recognition of sample image with the template image. The sample image is compared to each of the template images using the correlation function.

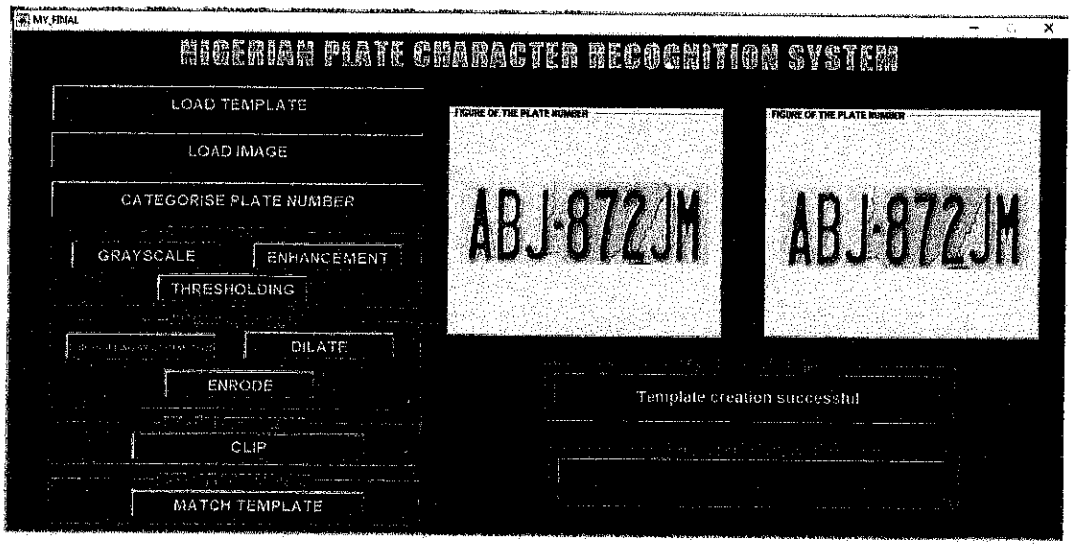


Figure 3.6. GUI of the system to implement

3.7. EVALUATION

This Nigerian license Plate number Recognition system will be based on Character Recognition system. Therefore the performance of the proposed system will be evaluated based on recognition rates and the percentage of characters correctly classified. However, this does not say anything about the errors committed. Therefore in evaluation of the system, will be based on three different performance rates that will be investigated

1. Segmentation Error: The proportion of characters erroneously classified. Misclassified characters go by undetected by the system, and manual inspection of the recognized text is necessary to detect errors

$$\text{Segmentation error} = \frac{\text{Summation of Total character in plate number}}{\text{Summation of total character in recognition}} \quad \ldots\ldots\ldots\ldots\ldots (3.9)$$

2. Recognition rate: The proportion of correctly classified characters.

$$\text{Average accuracy} = \frac{Total\ number\ of\ recogniton\ character}{Total\ number\ of\ characters\ in\ a\ plate} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.10)$$

3. Recognition accuracy: the ratio average summation of the recognition each recognize plate to number of plate and is given by:

$$\text{Recognition accuracy} = \frac{\text{Total summation of the recognition accuracy for each plate}}{Total\ number\ a\ plate} \quad \ldots.(3.11)$$

CHAPTER FOUR

IMPLEMENTATON AND RESULT

4.1. IMPLEMENTATION

For the result of this system, it has a main page which is the interface of the system. Actually, while using the Matlab software, the interface of the system is just has one interface and all the processes of the system was done in the same interface but different functionality. For this system, the recognition process is done using step by step and the user has to click the buttons which are providing in the system. The character recognition process is started with entering the image that the user wants to test and it displayed at the box that was provided in the system.

4.2. COLOR RECOGNITION RESULT

Table 4.1. Shows the result of the Color Recognition to categorize the plate number into its different classes, this test was carried out using 26 Nigerian plate number it goes across all three classes of number plate. This is done by calculating the mean of mean of the color band in the image using the mathlab code below:

```
redBand = color_image(:,:, 1);      %calculate redband from the image
greenBand = color_image(:,:, 2);    %calculate greenband from the image
blueBand = color_image(:,:, 3);      %calculate blueband from the image
%get the mean of mean of the color band
r= mean(mean(redBand));
g= mean(mean(greenBand));
b= mean(mean(blueBand));
```

The problem that result into misrecognition of the plate is as a result of the Nigerian plate background which contain a green map because is system is based of color model it calculate the background color with it and the weather condition which affect camera that capture the image.

Table 4. 1. Color recognition result

Plate number	Actual class	Recognized class	Right /wrong
	Commercial	commercial	Right
	Commercial	commercial	Right
	Government	government	Right
	Government	commercial	Wrong
	Government	government	Right
	Government	government	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	government	Wrong
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	Private	Right
	Private	government	Wrong

Table 4. 2. Summary of the color recognition result

Classes of Nigerian plate numbers	Total number of plate in the class	Number of accurate category of the plate	Number of failure in categorizing of the plate
Private	20	18	2
Commercial	2	2	0
Government	4	3	1

Total number of tested the plate number sample: 26

Total number plate accurately categorized into their class: 23

Total number of failure in categorizing into plate class: 3

Evaluating the RGB color model calculation using mean of mean image base on the data been provided

The percentage of accuracy in the algorithm

$$\frac{Total\ number\ plate\ accurately\ categorized\ into\ their\ class}{total\ number\ of\ tested\ plate\ number} \times 100$$

$$\frac{23}{26} \times 100 = 88.4\%$$

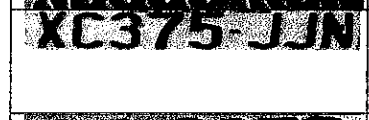
The accuracy of the algorithm is 88.4%

4.3. TEMPLATE MATCHING RESULT

Table 4.3. Gives the results of shows the result of the template matching character in image of the plate number to recognize the character in the plate number, this test was carried out using 26 Nigerian plate number sample, it goes across all three classes of number plate.

Test of the template matching in the system for recognition of the Nigerian plate number character result after when the image have been preprocessed, segmented, clipped and then recognition.

Table 4. 3. The result of testing 26 sample out of the plates acquire result

Tested Plate number	Total character in plate number	Total character in recognition	Total number of match	accuracy	
	8	8	6	0.75	XD398RSN
	8	25	7	0.88	XC3XY3X7X Y995XWYX9 XTJTTJN
	7	10	6	0.86	51FGA23HB
	7	7	6	0.86	51A19FC
	7	10	5	0.71	51HHA09FHJ
	7	8	5	0.71	31CE02FD
	8	9	5	0.63	EKY91SFG4E
	8	10	7	0.88	ADK216ACX L
	8	9	8	1	AAPPA879DA
	8	8	7	0.88	EMP196AA
	8	10	7	0.88	JJJ3Y7EDCG
	8	8	7	0.88	BDG923DZL
	8	10	6	0.75	EVXY765CL V
	8	9	5	0.63	CIR572L5R
	8	8	6	0.75	LNO330AO
	8	10	5	0.63	KJA194X4X
	8	8	8	1	MH531AA
	8	8	5	0.63	SGD2204C
	8	9	6	0.75	FKJ609CAI
	8	8	5	0.63	KRO647CN
	8	11	7	0.88	EMR193A4X C
	8	8	6	0.75	LSR170O2
	8	8	4	0.50	AA68CASS
	8	10	6	0.75	DGE1Y1EME R
	8	8	6	0.75	LSRB41AE
	8	10	7	0.88	SMK756DWL

Total Numbers the plate sample tested: 26

Total accuracy of the plate: 20.2

Summation of total character in recognition =249

Summation of Total character in plate number= 249 – 204= 45

$$\text{Segmentation error} = \frac{\text{Summation of Total character in plate number}}{\text{Summation of total character in recognition}}$$

$$\text{Segmentation error} = \frac{45}{249} = 0.18$$

The percentage of segmentation error =18%

$$\text{Recognition accuracy} = \frac{\text{Total summation of the recognition accuracy for each plate}}{\textit{Total number a plate}}$$

$$\text{Average accuracy: } \frac{20.2}{26} = 0.777$$

The percentage of accuracy of the system: 77.7%

The test of the system show that the using of template matching for classification in recognition of character in Nigerian plate number is very efficiencies.

The color recognition model have 88.8% accuracy while there was segmentation error of 18% the accuracy of character recognition is 77.7%.

However the test was carried out on a manually cropped image and the reason for more detection of the character in the plate number is as a result of the background in the Nigerian plate number, the clipping process clip any line in the plate number which result in segmentation errors

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. SUMMARY

This project proposed and implemented of Nigerian vehicle plate character recognition system using template match; a system whose implementation can re cognized and classify plate number into their classes, in a cost effective manner. Project involved four major stages. The first was preprocessing of the plate number (input) images, pre-processing techniques are Gray scaling, enhancing so as to binarize the image, to make the image easier to process and make it suitable for further preprocessing, Thresholding, in order to bring out the region of interest and more useful features from the images. After preprocessing has been done, segmentation was then performed on the preprocessed images. Segmentation which is done by multiple thresholding before the image is been dilated.

The developed system classification result for the template matching shows that the classifier attained an accuracy of 77.7% and has segmentation error of 18% and accuracy of 88.4% the RGB color model calculation using mean of mean image pixel.

The system can applicable in all branches of transportation sector such as car pack, fast camera, security, traffic control and management, vehicle law enforcement.

5.2. RECOMMENDATION

This project has demonstrated the usefulness and effectiveness of template matching as a problem solving tool even in fields outside computing, such as transportation sector. This project has shown great performance in terms of accuracy in helping recognition Nigerian plate number character, however, it is recommended that more work still needs to be done on:

1. Automatic cropping of the plate number
2. Combining classifier
3. Increase the number of template images which may lead to increase in the accuracy.
4. Implementing this project as an embedded system in order to allow better flexibility.

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