Pattern Recognition: A Decipherable Tool for Intelligent Transportation System in Nigeria

[1]Oluwafisayo Babatope AYOADE ; [2]Bamidele A. OLUWADE &[3]Ayorinde Oladele IDOWU
[1,2]Computer Science Department, University of Ilorin, PMB 1515, Ilorin, Kwara State, Nigeria
[3]Computer Science Department, College of Education, PMB 250, Ikere Ekiti, Ekiti State,Nigeria

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ABSTRACT: *This paper presents a system framework as an intelligent system for the detection, identification and recognizing vehicle plate numbers violating traffic lights on Nigerian roads using Pattern Recognition as a constructive instrument. Intelligent Transportation System (ITS) is the application of advanced sensor, computer, electronics, and communication technologies and management strategies to improve the safety and efficiency of the surface transportation system. ITS is an important implementation technique for analyzing and handling traffic control management of real time moving vehicles on roads in urban environment. The scientific discipline of machine learning or artificial intelligence with the purposes of classifying data (patterns) into a number of categories or classes is known as Pattern Recognition. The intelligent system uses the Nigerian vehicle license number plates for image processing and character recognition technology in order to identify the vehicle plate number that violates traffic lights automatically through surveillance cameras and intelligent image analytic software. The traffic control management is control by automatic signaling system where coloured lights, i.e. Red, Yellow and Green, are used for interpretation for traffic controlling operations signals. The system uses Pattern Recognition models to isolate the features of the vehicle license plate of each region to be extracted in order to correctly differentiate the identified license plate from other regions. The paper will be highlighting the various pattern recognition models that are suitable for the vehicle license plate number character recognition and pattern database matching.*

Key Words: *Pattern Recognition, Intelligent Transportation System, Traffic Light, Vehicle License Plate*

I.INTRODUCTION

Road Transportation, in Nigeria, is one of the most common means of transportation compared to other types such as air, water and rail. With the country's technological advancement and democracy era, not minding the economy depravity, a large number of Nigerians have been afforded to own a car which has greatly increased adversely the number of road users over a decade. Technological advancement in the area of transportation has make life easy in contrast to the traditional way of transportation e.g. animals, walking, etc. which has positively increase the number of car owners. This development has also greatly increased the rate of traffic violations especially in cities and mega cities. Road accidents are supposed to be caused by various reasons ranging from

drivers' carelessness, drunkenness, deplorable state of the road, etc., but it has been shown that the statistical value of road accidents has spontaneously risen over the years especially in traffic lights violations which supposed to reduce the rate of accidents. In this vein, the Nigerian government has tried in so many ways to put in place measures to control the high rate of road accidents. One of these measure is the issuance of primary identifier which is the vehicle identification number that is actually the legal license plate number unique to every car registered in Nigeria be it private, public or government registered vehicles.

Intelligent Transportation Systems (ITSs), as defined by [1], [2] are the applications of advanced sensor, computer, electronics, and communication technologies with management strategies (in an integrated manner) to improve the safety and efficiency of the surface transportation system. ITSs also are advanced applications which without representing intelligence as such, aim to provide innovative services relating to different modes of transportation and traffic management in order to enable various users to be better informed and drive safer, more coordinated, and 'smarter' use of transport networks [1]. EU Directive 2010/40/EU on their own part defines ITS as a systems where information and communication technologies are applied in the field of road transportation, including its infrastructure, vehicles, users, traffic management, mobility management, as well as the interfaces with other modes of transport [3].

ITS also is one of the most important implementations for analyzing and handling traffic control management of moving vehicles on roads in urban and mega cities. Combined automated traffic management systems are now being implemented across different cities in developed countries and other developing countries [1], [3]. The main objective of such system is to track down vehicles that violated traffic regulations using surveillance cameras and intelligent image analytic software. Owing to growth in the number of road users, like other modern cities in developed countries, Nigeria needs an intelligent, reliable and efficient traffic management system to cope with the constantly increasing traffic violations and accidents on their major roads [4].

Vehicle License Plate Recognition systems, an integral part of ITS, is popular and has been studied extensively especially in developed countries such as USA [5-10], UK [6], South Korea, Germany [7], China [2], [8], Ireland, Japan, Australia,
Sweden [3][9], Canada, Denmark [10][11][12],
India [4][18-
23], Malaysia [14], Iran [15][16][17], Iraq [18], Brazil [19] and also in some African countries like Tanzania [20], Egypt [21], etc. Ironically, while a distinctive feature of this system in traffic control management is being applied widely in most of these countries, a countable number is being restricted to a specific region or city in developing countries like Nigeria which has not witness any type of this system [4]. The only work carried out on this wise was that of [22] making use of Hidden Markov Model for character classification. Likewise, many intensive research studies in areas of vehicle license plate recognition have been conducted in other developed countries using different models, nevertheless; there is little recorded research studies conducted in Nigeria. This is due to the irregularity of standardization in the Nigerian vehicle license plates in the past (i.e., the pattern/format, standard, dimension and the layout of the license plates, policy making and regulations) [22].

Therefore, major big cities in Nigeria accommodating road crossing traffics are controlled by automatic colored lights signaling system for interpretation of three types of signals for traffic controlling operations. For instance, green light signals by passing a stopped vehicle, yellow light signals a moving vehicle to slow down their speed and be ready to stop or a preparing a stopped vehicle to go while the red light signals the vehicle to stop.

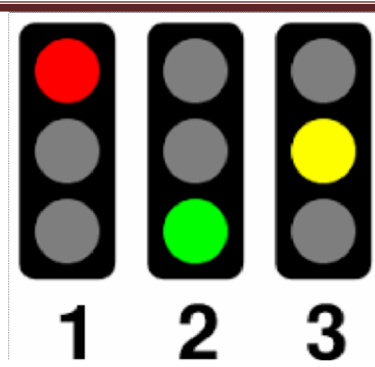


Fig. 1.Traffic Light Signals – Red, Green, Yellow [23]

Unfortunately, in many road crossing in Nigeria, it is not so occasionally. It is expected that when red light is shown on a lane, the signal conveys the message to all vehicles moving towards the crossing line to slow down and stop immediately. To make the procedure more systematic and convenient, a uniform thick white line is drawn on each lane before the road crossing. This line is commonly known as stop-line. Each vehicle coming towards the crossing must stop before this line if red signal light is seen by it. Even if the front wheel of the vehicle touches the stop-line partially then it is tagged a violating vehicle.

Stop-line is usually placed perpendicular to the direction flow of traffic and is placed in the plane of the road. Presently in Nigeria, the task for detecting the stop-line violating vehicles on a red light traffic signal is done manually by traffic police or the road safety agencies like Federal Road Safety Commission (FRSC). Unfortunately, most of the Nigerian road users do not comply with all these regulations. For instance, in a busy environment with hundreds of vehicles passing through the crossing it might not always be possible to manually generate a full list of all the violating vehicles. This is one of the primary motivations behind this paper work.

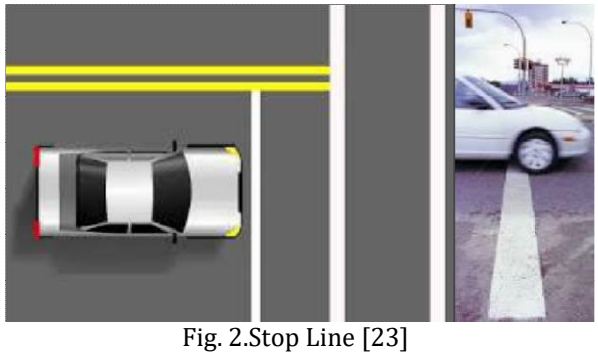


Fig. 2.Stop Line [23]

One of the effective solutions to control and manage traffic violation, previously being monitored by the human system (i.e. Police, Traffic Police, FRSC), is by employing an intelligent system that recognizes vehicle license plate numbers (pattern) using Pattern Recognition models. The paper's focus on intelligent system would identify violating vehicles, via various techniques which is going to be based on algorithms rather than manual system procedures. Such algorithm comprising of different techniques will be using Pattern Recognition for this purpose. Image processing, one of pattern recognition techniques, deals with image sequences taken from vehicles at designated traffic lights points. All Nigerian vehicles (e.g., Diplomats, Federal, and State, Regulatory Agencies & Institutions, Private and Commercial vehicles) have their own vehicle license plate numbers which is a unique property and which takes into account for identifying vehicles. Quite a few monitoring functions can be supported by application of computer vision and pattern recognition techniques, such as the detection of traffic violations, traffic light violators, illegal turns, and illegal oneway defaulters through recognition of vehicle license plates numbers.

However, as part of the country's security measures, the government has mandated every citizen to be enrolled in the National Database under the supervision of the National Identity Management Commission (NIMC). The enrollment cut across every sector in order to curb crimes and violators of law and order. The electronic identity card issued by the NIMC bears the necessary information of individuals which makes it difficult for impersonation. The Federal Road Safety Commission (FRSC) and Vehicle Inspecting Officers who are the main factors in vehicle plate number issuance are in collaboration with the NIMC to have a robust database of the entire road users. The paper highlights will be making use of the Vehicle Inspecting Office and FRSC database with respect to the NIMC database of the Ekiti State Section Command as a case study.

II. PATTERN RECOGNITION

Patterns could be relatively defined as an entity that could be represented in various multiple occurrences such as fingerprint images, handwritten words, speech signals, DNA sequences, security bar codes, web page links, and human face identification [24]–[27]. Pattern Recognition (PR), on the other hand, is a branch of machine learning that focus on the recognition of patterns in a way to observe the environment or learn in distinguishing patterns of concentration by making sounds and reasonable decisions about the categories of patterns to be identified [23]–[32]. Humans always have a premonition and stimulus on the facts of how patterns are displayed and recognized in nature when procedures and methods of recognizing the pattern are developed. Different studies on machine discernment have also being a positive impact on better understanding and obligation for pattern recognition. In another perspective, models in pattern recognition are also applied to numerical studies which are not related to nature [25], [27], [28], [32].

Pattern Recognition schemes are implemented in so many ways, from the labeled trained data called *supervised learning* to the unlabeled data which can be solved or identify using other forms of algorithm to discover the heretofore unknown patterns called *unsupervised learning*. Different studies have been interwoven with Pattern Recognition. Studies like machine learning, data mining and knowledge discovery in databases (KDD), have been overlapping in scope with PR. Having an understanding of each of these studies briefly usually makes the process of image recognition easier and better. For clarity purpose, machine learning is the mutual term used for supervised learning methods (labeled trained data) which normally initiates from Artificial Intelligence (AI) while data mining and KDD, closely related in the business environment, have a bigger concentration on unsupervised methods (unlabeled data) [23], [32], [33]. In similarity, PR and machine learning have a close connection. In PR, there is a bigger attention and curiosity in enacting, elucidating and visualizing the pattern while on the other hand machine learning conventionally focuses on exploiting the pattern recognition rates [23].

PR can be categorized into various types of learning techniques used to produce the result value. As a general note, the supervised learning consisting of a set of occurrences assumes a set of training data that has been delivered and properly labeled with the correct output. Alternatively, unsupervised learning accepts training data that has not been hand-labeled like the supervised learning and endeavors to find the characteristic pattern in the data that can be used to determine actual result value for the new data occurrences [23].

Pattern Recognition of vehicle license plate numbers is carried out in the following manner

- Image acquisition (vehicle license plate localization),

- pre-processing of image (detecting the license plate),
- vehicle license plate extraction,
- character segmentation (vehicle license plate vertical and horizontal scanning),
- character recognition (recognizing the letters and numbers on the vehicle license plates), and
- vehicle license plate matching process (pattern template matching with the database)

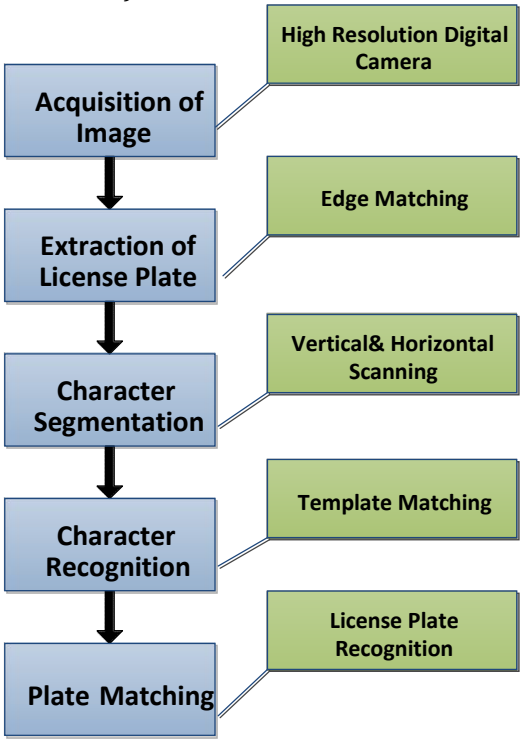


Fig. 3.Pattern Recognition Stages [6]

III. STUDY MOTIVATION

As a result of technological advancement and increase in the number of road and vehicle users in Nigeria, there is need for an intelligent system to be in place to cope with the constantly increasing traffic light violations on Nigerian roads. The paper highlights using PR as a tool favors the recognition system for vehicle license number plate as a possibility of reducing traffic lights violation problems. The vehicle license plate recognition system should be accepted as mandatory due to too much increase of vehicles in Nigeria transportation system. Distractors factors such as sun light, shadow, mud, deleted plate characters, plate numbers ambiguity and irregularities and other factors in the vehicle license plate image make it difficult for existing system to recognize some plate recognition systems (i.e. the use of radio frequencies).

Apart from these factors, procedure applied for recognition also plays a vital role. This is necessary if the quality of the procedure is good, then more varieties of images can be given as input to the system, and this will also reduce the computational speed of the process. The basic issue in realtime recognition system is the accuracy, which this paper will address.

Nevertheless, it has been shown that there are umpteen setbacks parameters on which quality of image recognition depend which are the focus of this paper. Some of these hindrances are

- Image Quality – the image of the license plate to be captured must be of high quality in order to have good attributes for evaluation.
- Reduced tilting and spinning – the camera to capture the license plate image must be position at the right angle of view to guide against tilting and turning. The procedure to use in recognizing the image must also be accurate.
- Right Illumination – vehicle license plates are retroreflective in nature, on this wise the camera illumination (flash) must be of high resolution to brightened the plates to be clearer in order to acquire the right attributes [6],[8], [9], [14], [19], [21], [34]-[38]

As part of the motivation, the paper demonstrates an effective framework using PR techniques as a tool for detection, extraction and recognition of vehicle license plate recognition system. The framework will work efficiently under all conditions of moving vehicles, adaptive to different traffic environment conditions; robustness against progressive or sudden illumination changes, occlusions, as well as image captured identification time of the system which should be as short as possible. The system should detect and recognize all the types of country's vehicles license plate numbers issued by the regulatory body (i.e. VIO as monitored by FRSC) to diplomats, federal, states, private and commercial plates. In addition, it should be resistant to any kinds of disturbances, which may occur in images and mechanical damages on the license plates which may appear in reality. The attributes of the vehicle license plates such as size, colour, font face size, colour of each character, characters' spacing, and characters' height and width, all play important role in the recognition process.

IV. RELATED WORKS

A considerably amount of studies have been carried out on image recognition of vehicle license plate numbers using pattern recognition as an intelligent tool but most of the research works (survey, test and results) are carried out in developed countries while few have been done in African communities. Few research works have addressed this vital study in Nigeria due to the unstable reforms in the vehicle license plate. The most related works to this paper are that of [34], [37], [38] where their focus is on real-time (moving) vehicles approaching the red light point. Each of the studies was able to capture, identify and recognize the characters of the captured vehicle license plate. Other studies like [1]–[3], [6]–[8], [10]–[22], [35]–[37], [39]–[55] used different pattern recognition methods to identify, capture, extract and recognize the vehicle plate number at still or packed environments. For instance [42] was a study that was carried out in the US using two algorithms – Integral Channel Features and Aggregate Channel Features detection models. The former has been used severally but the latter was a new technique employed by the researcher to make performance differences between the two techniques. Also in [14] which was carried out in Malaysia, two algorithms were employed i.e. Connected component analysis and Perceptron Neural Networks (PNN), to recognize the characters of the vehicle license plates. The result shows that the techniques were effective for real time plate recognition. In addition, [8] and [20] were conducted in China and Tanzania respectively. In [8], statistical character method coupled with structural character method were used to obtain the character while fuzzy recognition method was later used for decision making while in [20], MATLAB algorithm was used for the character recognition. Another work for Malaysia was that of [50] where they used smearing algorithm to detect and identify vehicle license plates in still position in a large space. They believe that this algorithm can also be used for frameless vehicle license plates. [52] conducted a research on car license plates using neocognitron Artificial Neural Networks. In their work, they used an image processor, segment processor and combine it with five coupled neocognitron artificial type of neural network to perform their character recognizer. Their work was able to introduce the neocognitron neural networks for the purpose of removing the manual process of training the set of large numbers of ambiguous characters. They have success report of 94% using this type of neural networks for character recognizer. [1] on another platform focused on license plate recognition algorithm on ITS using optical character recognition and probabilistic neural network (PNN). The PNN model was trained to identify alphanumeric characters and their study had a success of 86% success but they believed they should have gotten a better result if the limitations of illumination and background complexity are taken care off. The only work that was carried out on Nigerian vehicle license plate was that of [22] where they used Hidden Markov Model (HMM) to perform the feature extraction and classification of the vehicle license plates. The work was a success at the time they carried it out but the only problem was that the policy and pattern of the country's vehicle license plates has changed and in that effect their proposed model can only be modify in order to be applicable for classification of Nigerian license plates at this time. Other mentioned related works used various algorithms from, ELMAN Neural Networks, Genetic Algorithms (GA), and profile method segmentation, etc. Each of the algorithms employed has played one or more important role in recognizing vehicle license plate number with recorded advantages and disadvantages

V. PROPOSED METHODOLOGY

A. Image Acqusition

Depending on the position of the vehicle license plate numbers, recognition systems normally consists of at least two high speed cameras (one high resolution digital camera and one infrared (IR) camera) to capture images of license plates. Furthermore, a software processor capable of performing sophisticated optical character recognition (OCR) to transform the image of the license plate into alphanumeric characters is needed. In addition, dedicated application software for comparing the transformed image characters to plate matching database of the monitoring agencies is highly recommended. Likewise, a user interface to display the images captured, the results of the optical character recognition (OCR) transformation, and an alert competence to notify operators when a violated vehicle license plate matched the monitoring agency's database/hotlist is observed is also recommended.

However, license plate number identification is an essential area in the development of intelligent traffic control systems. The usage of vehicles in Nigeria has increased rapidly due to high rate of urbanization and modernization, especially as Federal, States and Local Governments bodies are advancing, and thus, traffic violation is on the rise in big cities which has become major issues due to

inadequate road infrastructure, lack of monitored and efficient policies and laxity of the existing human system. Therefore, control of vehicles and identification of traffic light violators to maintain order and discipline is becoming a big problem on most Nigerian roads. For this reason, development of an intelligent transportation regulatory system using the vehicle license plate number through patter recognition techniques to control traffic light violations is seen as a highly essential requirement at this time.

In developing countries like Nigeria, the attributes of vehicle license plates are strictly maintained. These attributes such as size of plate, color of plate, font face/size/color of each character, spacing between subsequent characters, background and foreground license plate color, etc.; are maintained very specifically. Figure 4 shows a sample of the approved Nigerian vehicle license plate, showing the various parts and their significance.

Some of the images of past and present standard vehicle license plates issued by the Vehicle Inspecting Office (VIO) controlled on the roads by Federal Road Safety Commission (FRSC) in Nigeria are shown in Figure 5.

Fig. 4.Nigerian approved Vehicle License Plate Number with its features

B. Plate Detection and Localization

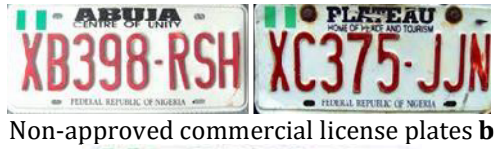
Image detection, recognition and traffic observations are important parts of intelligent transportation systems. Information about current situations of traffic violations can be automatically extracted by image processing techniques. Besides license plates detection, identification of vehicle license plate recognition with the regulatory agencies' database (VIO in support by FRSC) is very significant for this work. Different hindrances facing the processing of images captured from the vehicle license plates are numerous. Obstacles like poor image resolution; distance of license plates to the dedicated camera, low Vehicle Identification Number

camera quality, motion blurring, poor lighting and low contrast due to overexposure, reflection or shadows, dirt on the plate, are covered within this work. Image enhancement techniques which is very crucial process based on filters is expected to be used to remove noise and unwanted light defects on the image to obtain clear and readable images; are all going to be evaluated in this work. Figure 5 (a) and (b) shows Nigerian Vehicle License Plates numbers indicating approved and non-approved license plates; for both private and commercial road users. The distinct in the colours makes the feature segmentation and classification of the characters easier and the outcome of the result more successful.

Non-approved private license plates

a

Approved private license plates



Non-approved commercial license plates **b**

Approved commercial license plates

ig. 5.(a.) Private (b) Commercial Vehicle License Plates

Other samples of Nigeria vehicle license plate numbers are shown below in Figure 6 showing the trend of changes in the country's vehicle license plate numbers from 1976 till now for both private and commercial vehicle users.

Fig. 6.Trend of Nigerian Vehicle License Plate Numbers

In order to identify a violated vehicle by reading its license plate successfully, it is necessary to locate vehicle license plate image provided by issuing agencies (with respect to its characteristics – holder's designated body, characters & numbers) through some acquisition systems like a video or high-tech still surveillance camera. A number of commercial software in this area is readily available when images are provided in different styles and formats.

C. Image/Pattern Segmentation

One of the pronounce and efficient method that has been used over time in character segmentation is connectedcomponent based method [3], [9], [34], [54]. The new Nigerian license plate numbers is designed in such a way that the features of the plate (i.e. digits and the characters) are in fixed position as well as lying in a horizontal orientation. In the past, license plate numbers can either be in horizontal or vertical orientation which can pose a problem in segmentation. In the event that the characters or digit of the license plate number image are not fixed or in a horizontal position, the image is rejected. For the purpose of this, horizontal projection algorithm is applied for character segmentation since the orientations of the license plates are in horizontal form and also it accommodates both horizontal and vertical positions.

D. Image Pre-Processing and Recognition

Image processing or character recognition techniques like edge-detection, thresh-holding, re-sampling and filtering could be used, as first starters, to locate the vehicle image and isolate the vehicle license plate and the characters from the vehicle image. These techniques alone will not be sufficient to meet the requirements of modern systems but can be coupled with other renowned techniques to achieve the right result. Intelligent vehicle license plate recognition system with reference to PR, as depicted in this work, is required to operate robustly in environments with complicated backgrounds and light intensity variations. Each of these techniques is focused on producing a result that is not of high computational cost.

A comprehensive well featured system for license plate image detection and recognition that would be obtainable would be available. Image detection and recognition system with applications in pattern recognition and machine vision which ranges from complex security systems to common areas from urban traffic control to semi-urban areas would be considered in this work. The system will cover complex characteristics of the image due to diverse hindrances effects such as fog, rain, shadows, uneven illumination conditions, occlusion, variable distances, velocity of car, scene's angle in frame, rotation of plate, number of vehicles on the scene andothers.

E. Plate Matching

The rule of thumb for plate matching involves the process of employing template matching where it involves the use of a database (such as VIO or FRSC or NIMC) of characters or templates. The main objective of this work is to reveal a system that solves the practical problem of traffic violation on Nigerian roads using vehicle license plate identification for physical moving vehicles

with emphasis on traffic light violations using pattern recognition techniques.

For proper license plate matching, separate template for each conceivable input character is created. In this sense, recognition is achieved by comparing the current input character with each of the database template for a possible match. For instance, if H(a,b) is the conceivable input character from the detection, and Z(a,b) is the template in the database of template *n*, then the template matching function say c(H,Z*n*) will return an output of the most possible likelihood of a match between template *n* and the conceivable input character.

The feature classes would then be compared with the target database of the issuing agency feature classes. The recognition structure would combine adaptive iterative thresh holding with a pattern/template matching procedure for the process of detecting a match with the database. The work is expected to be robust to illumination, character size and thickness, skewing and small character breaks. A plus to this work would be its competency in moving vehicles compare to previous works which focus on still or packed vehicles. With this aptitude, the system framework does not require any additional sensor input except the captured vehicle license plates image. This paper demonstrates that expected developed system would also be systematically robust not only for this purpose but would also be efficient in suitability for other image recognition application. Furthermore, the paper highlights shows that the system does not need any installation on targeted vehicles, such as transmitter or responder for perfect recognition. Figure shows a block diagram of the methodology for recognizing vehicle license plate number.

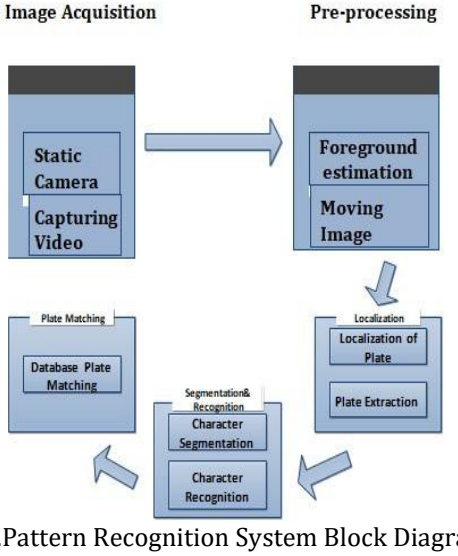


Fig. 7.Pattern Recognition System Block Diagram [38]

VI. DISCUSSION

PR system is an ideal system that process patterns in different areas to handle real objects and noisy data as input into the system for recognition. Detection of moving violating vehicles is the first relevant step of information needed in recognizing the license plate of the violated vehicle. In addition, background subtraction is the ideal approach for foreground segmentation. Different background subtraction methods are needed in order to overcome the problem of illumination variation, shadows, background clutters and camouflage. Thereafter, Vehicle License plate extraction, an important stage in pattern recognition for intelligent transport system, should also be considered and this is a paramount aspect of the license plate recognition system. The extracted vehicle license plates would then be segmented into individual characters using a region-based method. For each character, feature classes would also be created in these order: from left to right, from right to left, from top to bottom and from bottom to top. Hence, PR system should be adequately accepted for image processing

VII. RECOMMENDATIONS

This paper recommends prompt implementation of this study by the government and public awareness and to the users of the road against traffic lights violations in Nigeria. Another point of reference is the positioning of the recognizing devices (cameras) must be placed in a position to only identify the license plate numbers. Also, the government is enjoined to enforce a law towards banners, posters, sign boards, etc., close to the image acquisition area so as to guide against conflicts between license plate numbers and other images. Reducing the rate of accidents on the road at traffic lights junction will reduce the high rate of accident victims in hospital and death as well.

VIII. CONCLUSION

Vehicle License Plate character recognition in Nigeria is paramount especially in the areas of traffic lights violation. PR system is the brain behind regulating intelligent transportation system in Nigeria. The paper has been able to demonstrate the importance of PR with respect to curbing traffic lights violations and as such reduce the high crime rates in Nigeria. The paper has also been able to show that combining different techniques can improve the positive output of plate matching. This combination can be done right from the detection stage after acquisition. Detection process or techniques that will be of

good value but less computational cost is advised. Extraction process such as feature extraction and adaptive iterative thresh-holding can also be used for adequate template matching.

In another dimension, proper documentation on the part of the database template matching agencies is highly recommended. During the stage of vehicle user's biodata registration, appropriate names, address and other documentation must be done in order to guide against system failure during plate matching. This is necessary because of the previous history of nonchalant attitude to proper documentation among workers of these agencies due to laziness and not giving the work to the right expertise.

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