A Model for Car Plate Recognition & Speed Tracking (CPR-STS) using Machine Learning Algorithms

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Abstract

The transportation challenges experienced in major cities as a result of influx of people in search of greener pastures is increasing on a daily basis. This results in an increase in the number of cars plying and competing for driving space on narrow roads. Many drivers violate traffic laws as a result of this and how to prosecute them without chasing them remains an issue to be addressed. Therefore, this research presents a model that can be used to solve this challenge using machine learning algorithms. The model consists of recognition modules such as image acquisition, Gaussian blur, localization of car plate, character segmentation and optical character recognition of car plate. K-NN Algorithm was used for training licensed plate font type spanning A-Z and 0-9 while the speed tracking module used a camera which is automatically self-initiated to track the speed of any moving object within its range of focus. The performance of the model was evaluated using metrics such as recognition accuracy, positive prediction value, negative prediction value, specificity and sensitivity. A tracking accuracy of 82% was achieved.

Keywords: Pattern Recognition, Car Plate Recognition, Speed Tracking, Optical Character Recognition (OCR), Machine Learning, Image Processing.

1. INTRODUCTION

The demand for machines that can think and perform independently has constantly been a priority on the list of human desires. This dates back to the ancient Greece when the idea of programmable computers was first conceived [1]. Observers wondered if a time would come when such computers would be able to reason and make decisions independently. Today artificial intelligence (AI) as a thriving field with several practical application and active research areas has witnessed steady growth and improvement in the concept of machine independence resulting from the creation of such systems. Scientist in various part of the world has particularly looked into automating routine labor to reduce human effort, improve throughput and manage time [2]. Hence, in the early days of artificial intelligence, the field rapidly tackled and solved problems that are intellectually and routine difficult for humans. As such, activities or jobs whose result and success require a high level of accuracy but are relatively straight forward for computers served as the foundational areas to invest in and improve upon [3]. Gathering knowledge from experience and historical data has served as a basis for creating several solutions to tackle various issues relating to routine tasks in different fields. Indeed, AI can boast of successful implementation in Agriculture, Security, Fraud detections and prevention, Medicine, manufacturing, sport and many more. In security, AI is not a new concept. Massive amount of data in its various forms collected with the use of video cameras and sensors serve as input to machine learning and security systems to advance machine learning and make systems and devices smarter. Video analyzing, drones & robots, natural language processing, anomaly detection and activity recognition are areas that have been incorporated into the security sector to help improve the sector [4][5]. Recognizing the need to improve security on the university campus and a desire to reduce the current challenges in ensuring security based on manual approach, this research work proposes a technological approach which would automate security by controlling access (Automated gate control) and improving surveillance using vehicle movement logging around the campus by using Car plate recognition and speed tracking system (CPR-STS).

2. RELATED WORKS

Machine learning powers many aspects of modern society from web searches to email spam and malware filtering, social media services, product recommendations, online customer services and fraud detection. Machine learning systems are used to identify objects in images, transcribe speech into text, match news items, recommend products based on user's interest and also select relevant results of search [6]. Pattern recognition is the study of how machines can observe the environment, learn to distinguish patterns of interest from their background, and make effective decisions about the categories of the patterns [7][8]. A pattern could be a finger print image, a handwritten cursive word, a human face or a speech signal. Automatic (machine) recognition, description, classification and grouping of patterns are key issues that is constantly been addressed in variety of disciplines where pattern recognition has been incorporated [9]. The process of recognition and classification may consist of one of the following two tasks: supervised classification and unsupervised classification depending on information availability [6][9]. The design of pattern recognition system essentially involves the following three aspects: Data Acquisition and preprocessing, data representation and decision-making. The problem domain indicates the choice of sensors, prepossessing technique, representation scheme, and the decision making model used. This result in several algorithms that can be used for the purpose of pattern recognition. In this research K-Nearest Neighbor algorithm was used.

For several years, there has been an increasing interest among researchers in problems related to extracting text from video or images. In the 1990s, significant advances in technology took automatic car plate recognition systems from limited expensive, hard to set up, fixed based applications to simple point and shoot mobile ones. This created a possibility of creating software that can run on cheaper non-specialist hardware that did not require the pre-defined angles [10]. Car plate recognition (CPR) is a mass surveillance method that uses optical character recognition on images to read vehicle registration plates. This task can be accomplished using a computer system, a closed circuit or road-rule enforcement cameras or specially designed/dedicated system. This system has been used for different functions which include improving police force activities, electronic toll collection on pay-per-use roads and cataloguing the movement of traffic or individuals. License plate recognition systems (LPRS) which was invented in 1976 is an image process technology used to identify vehicles license plates by using Optical Character Recognition (OCR) to read the Automatic Number Plate Recognition [11] [12]. Authors in [13] proposed an automatic number plate recognition (ANPR) which is a method that catches the vehicle image and confirm its licence number. ANPR was proposed to be used in the retrieval of stolen vehicle on the highway. In a related manner, [14] asserted that high level of precision is required to recognize car plates when streets are occupied and a number of vehicles are passing through. By optimizing different parameters, 98% exactness was accomplished in the implementation. It is essential for tracking stolen vehicles and monitoring of vehicles to attain 100% exactness level. Also, issues like stains, blurred regions, smudges with various text style and sizes should not be constraints. [15] explained an automatic number recognition system using morphological operations, histogram manipulation and edge discovery for plate localization and character segmentation.

Also authors in [16] and [17] described plate localization as an algorithm that is responsible for finding and isolating the plate on the picture. In this case, the plate is focused on while disregarding any extraneous data in the picture. Some applications of automatic license plate recognition which include apprehension of high speeders by comparing the average time it takes to get from a fixed camera, access control, border control, parking, tolling, stolen cars, enforcement, traffic control, marketing tool, travel, identification of unauthorized vehicles among others were highlighted in [18] and [19]. Authors in [17] however, outlined attendant benefit of putting vehicle plate recognition system in place which include easier vehicle's arrival/departure to/from parking lot, preparing updated and instantaneous reports from the situation within the parking lot, enhancing security in an area, facilitating traffic inflow/outflow during rush hours, possibility of exerting smart control at access points and traffic signals, among others. In this research, pattern recognition as a branch of artificial intelligence was used to build a car plate recognition system which as well serve as a surveillance tool on campus. The system has an add-on of being able to also track the speed of respective vehicles.

3. METHODOLOGY

The research adopts KNN algorithm and Open CV for its training, character recognition and a speed/object tracking algorithm. The process of operation involves getting the image of a vehicle passed into the system and then is processed through an already trained KNN algorithm with character and numbers for recognition. The process includes: Pre-Processing, Plate Localization, Segmentation, Feature Extraction/Character Analysis, Character Recognition, Output and Validation. Open CV and KNN algorithm are fused together to achieve the aim of this work. The reason for choice of this algorithms is due to their high degree of sensitivity of the local structure of data. This design is divided into physical and logical representation. The logical design deals with the identification of system functionality and how users interact with the system to make use of these functionalities. Logically, the process starts with Car Registration, after which a Vehicle Identification can be done, followed by number plate validation and speed Tracking. The architectural framework which showed the units that make up the developed system and their relationship is presented in Figure 1. The vehicle identification module was carried out by training the acquired dataset with K-NN algorithm so that the model could identify any vehicle approaching an access point; the dataset was stored into classification.txt and flattened_image.txt in order to identify vehicles on selected frames (images). The K-NN classifier's performance is tested by varying number of training samples and k value. The recognition rate is calculated by total number of recognized character divided by total number of character in all the images in database. Embedded in the vehicle identification module is optical character recognition algorithm that helps extract vehicle number plate from its image which goes through series of process such as image acquisition, binarization, character segmentation and character recognition. Plate localization involves finding the number plate in the image of the vehicle gotten which thereafter is isolated for further process such as segmentation which does the work of separating the figures and alphabets on the plate into their constituent parts thereby obtaining the characters individually. The speed tracking module adopted object motion speed tracking system through the Open CV library for its processes.

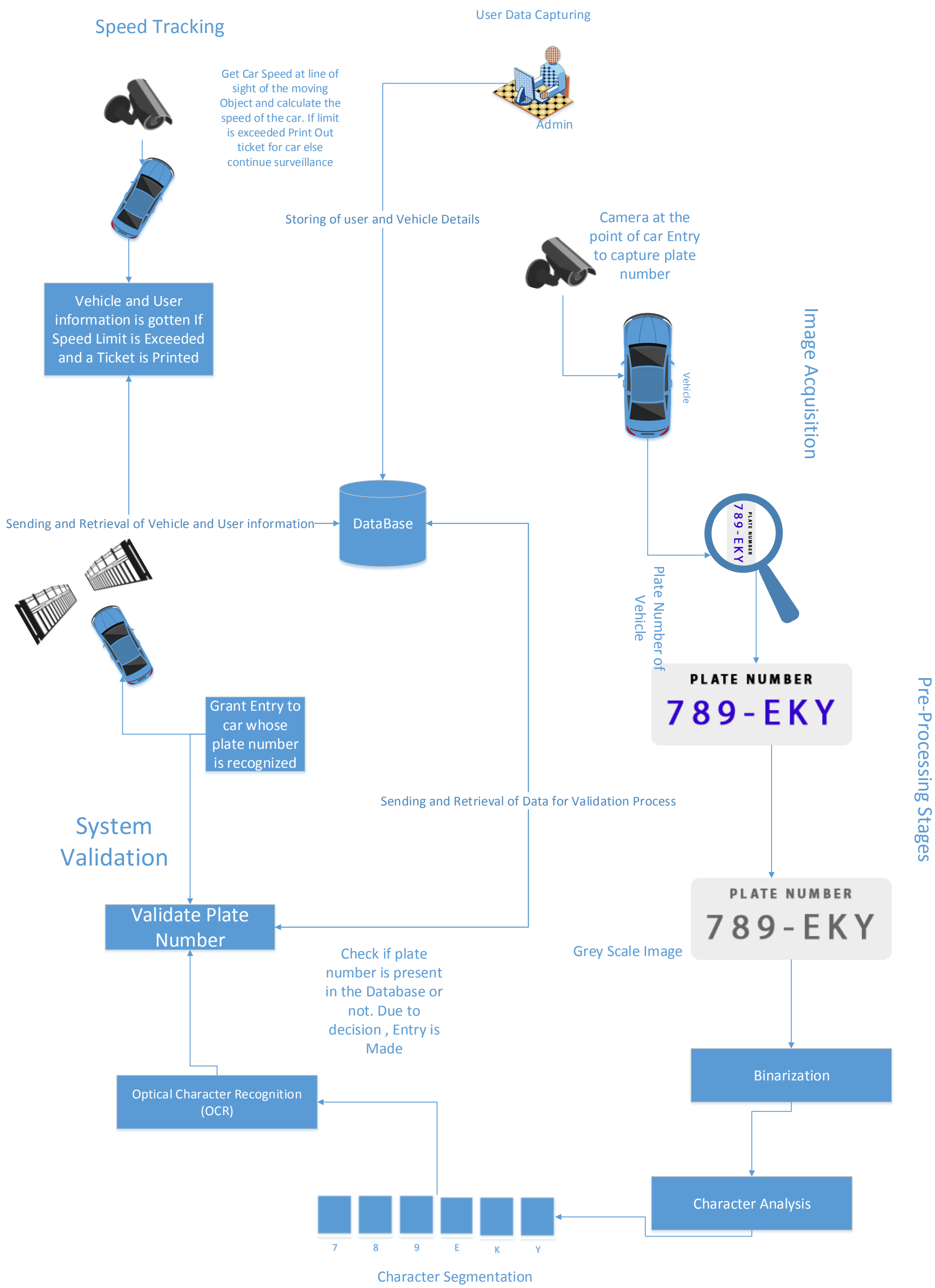

FIGURE 1: Architectural Framework of the Model.

The speed tracking module uses a camera which is automatically self-initiated to track the speed of any moving object within its range of focus; the module thereafter stores record of the vehicles at range and gives some information in a web view layout such as the screenshot of the vehicle on motion, its speed in kilometer per hour (kmph), date and time taken.

4. RESULTS AND DISCUSSION

The model recognizes vehicles that are already registered on the system and automatically either allow or deny access by controlling the gate. Beyond gate access, the model as well has the capability to monitor the speed of vehicles. At different part of the campus, movement of vehicles are automatically logged into the system; this enable tracking of vehicles on campus.

4.1 Components of the Developed System

The implementation of the system is divided into the Web View and System Desktop Application. The web layout consists of web pages such as the user login page (which grants access to authorized and registered users), vehicle registration page, vehicles entry page etc.

The System desktop application is divided mainly into 3 modules

a) Vehicle Identification
b) Vehicle Authentication
c) Speed Tracking

Vehicle Identification

The vehicle identification module consists of algorithms fused together to help identify vehicles entering into the school. Embedded in the vehicle identification module is the character recognition module that helps extract vehicles number plate from its image as shown in Figure 2. This module is made up of image acquisition, threshold binarization, character segmentation and character recognition.

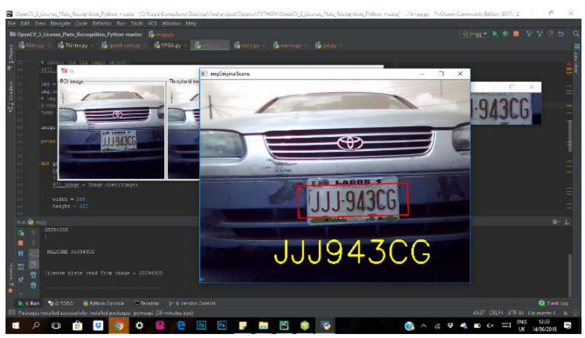

FIGURE 2: Vehicle Plate Identification.

Vehicle Authentication

The Vehicle Authentication section is the section which takes care of the authenticity of the vehicle i.e. the database verification process. All vehicles in the school must have gone through the registration phase with the admin and must have been registered through the web registration page; only vehicles registered are allowed access into the school except otherwise as shown in Figure 3.

Speed Tracking

The Speed Tracking module adopts the Object Motion Speed Tracking system which helps track the speed of moving object i.e. cars moving at a particular speed range. This module uses the Open CV library well enough in its processes. The speed tracking module uses a camera which is launched by the module itself and tracks the speed of any moving object within its range of focus. As shown in Figure 4, the module also stores record of the cars/ vehicles at range and gives some information in a web view layout which are the Screenshot of the vehicle on motion, its speed in kilometre per hour (kmh), date and time taken.

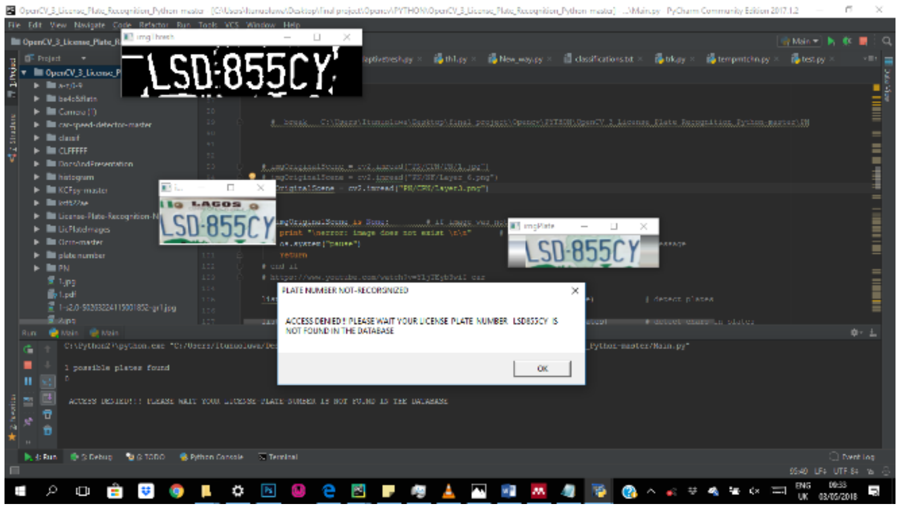

FIGURE 3: Vehicle Authentication.

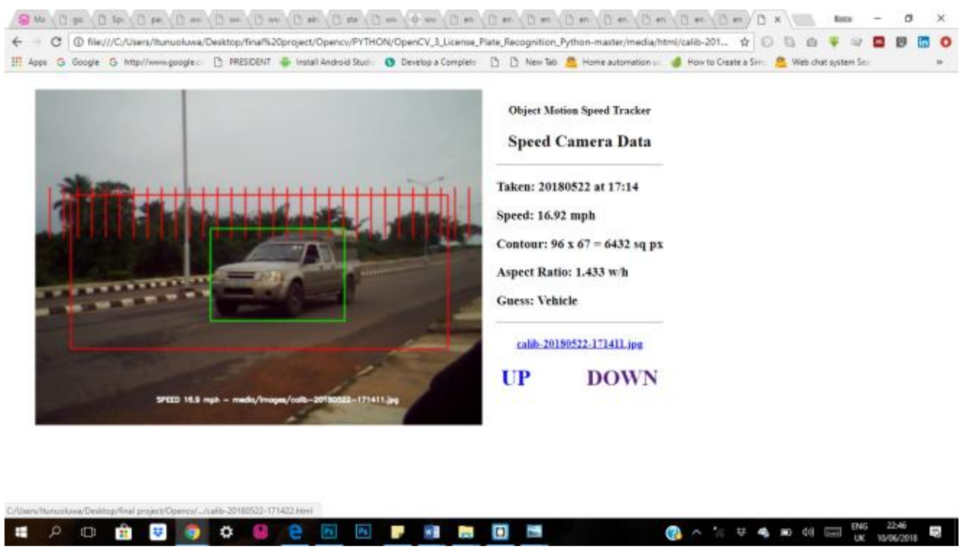

FIGURE 4: Speed Tracking Details.

4.2 Performance Evaluation

The performance evaluation of the system was carried out using accuracy, sensitivity, specificity, positive prediction value, negative prediction value, false positive rate and false negative rate. All these are a function of the True Positive (TP), False Positive (FP), True Negative (TN) and False Negative (FN) values. TP measures the number of characters that were accurately recognized and extracted as characters from the number plate. TN measures the number of non-characters that were predicted as not characters. FN measures the number of characters in the number plate that were predicted as not characters. FP measures the number of non-characters predicted as characters.TP, TN, FP, and FN values obtained are: 41, 23, 6 and 3 respectively.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} = \frac{41}{18 + 23 + 3 + 6} = 0.82 \ \ (82\%)$$

$$Sensitivity = \frac{TP}{TP + FN} = \frac{18}{24} = 0.75 \ \ (75\%)$$

$$Specificity = \frac{TN}{TN + FP} = \frac{23}{26} = 0.88\ (88\%)$$

$$\text{Positive Prediction Value} = \frac{TP}{TP + FP} = \frac{18}{21} = 0.86\ (86\ \%)$$

$$\text{Negative Prediction Value} = \frac{TN}{FN + TN} = \frac{23}{29} = 0.79\ (79\ \%)$$

$$\text{False Positive Rate} = 1 - Specificity = 1 - 0.88 = 0.12 = 12\ \%$$

$$\text{False Negative Rate} = \frac{FN}{FN + TP} = \frac{6}{24} = 0.25\ (25\ \%)$$

Therefore, with a total number of 50 images with True Positive=18, True Negative=23, False Positive=3, False Negative=6 which gives an Accuracy level of 82%, Sensitivity level of 75%. Specificity level =88%, Positive Prediction Value of 86%, Negative Prediction Value of 79%, False Positive Rate(FPR) of 12%, False Negative Rate(FNR) = 25%. With the FNR higher than the FPR the system is said to be save for implementation.

5. CONCLUSION

This research has illustrated how vehicle number plates can be extracted from moving vehicle images captured in real time. The implemented model will in no small measure proffer solution to age long challenge of having long queues of vehicles at access points with limited personnel attending to them; with this, less time will be wasted and vehicle overcrowding will be reduced to the barest minimum. With the STS fraction of the model, cases of hit-and-run and injurious driving at restricted zones will be curtailed and put in check.

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