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Design of Electronic System for Speed Detection of Vehicles

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ABSTRACT

This paper proposes a novel vehicle speed identification electronic system, which is cost effective and simple. The number of vehicles on the roads is increasing day by day and it is vital to detect the speed of the vehicle to avoid the accidents. There are several methods reported in past for the speed detection using laser gun. However, those methods are costly and use complex algorithms. The countries with developed economies can afford the expensive technology however, the countries with the struggling economies still rely on the manual and semi-automated methods of vehicle speed detection. The proposed method is based on the images processing of the vehicle plate number, which are captured using camera. The experiments were performed to evaluate and validate the reliability of the proposed method. The results show that the proposed electronic system offers efficient in detecting the speed of vehicles at lower cost.

Key words: Vehicle speed detection, image processing, magnetic sensors, laser gun.

1. INTRODUCTION

Highlight It is sad fact of modern life that thousand men, women and children die every year due to road accidents and number of those who are injured is alarmingly great. Some after medical treatment recover but many of them got permanent disabilities. The number of vehicles on the roads is continually increasing with the growth of the world population. The number of accidents also increasing due to limited capacity of the infrastructure to handle the increasing number of vehicles [1-7]. One of the prominent reasons of the road accidents is the over speeding. The city management authorities and traffic handling institutes are constantly looking for the technologies to monitor the speed of the vehicles and to charge heavy fines to those vehicles which are crossing the speed limits [8-15].

The speed detection of the vehicle using normal camera was performed by [1]. They used image processing technique to capture the image and process it to identify the vehicle speed. Their method shows the promising results however the use of complex image processing technique was a major drawback. In another study, a modified image processing method was used by [2] for the real time speed detection of the vehicles. It uses the geometric optics to map the coordinates of the captured image and then identify the speed of the vehicle with an error of 4 %. The speed detection of the vehicle using two reference points was performed by [3]. The system was designed to monitor the speed using the reference point and the current position of the vehicle and then calculating the time difference between two points. Although their system was able to track the speed of the vehicle, but the use of lengthy and complex image processing and image refining steps made it hard to use for commercial purpose. In [4] an unmanned aerial vehicle was developed to collect dynamic traffic information. The data of the moving vehicles on the road was collected using unmanned vehicle and position and velocities of the vehicles were analyzed through collected data. It was shown that the system is robust and accurate. But high cost of the system was a major drawback. To overcome the disadvantages of the conventional speed measurement using laser gun, an image based speed detection system was developed by [5]. The relative motion between the vehicle and the moving vehicle was detected and used to analyze the speed. They were able to track the vehicle speed with 95 % accuracy. A frame differencing method was used by [6] to detect the speed of the car and motorbike. They used the developed system for the smart surveillance application. However, the resolution problem, system generated noise in images and high complexity were the major drawbacks identified. A smart traffic accident tracing system using vision technology was developed by [7]. The system possesses the capability to identify the cause of the road accidents by tracking the images of the vehicles. In [8], a magnetic field gradient sensor based system was constructed to identify the speed of the vehicles. However, the magnetic sensors are costly and have installation issues. A number plate based vehicle identification system was developed by [9]. The 98 % accuracy of the algorithm was reported. However, they did not utilize it for the vehicle speed identification. The irregular character space between two characters on the number plate was reported to be a key problem in automatic plate recognition system and this issue was addressed by [10]. However, they performed only the simulation study and practical application in real time environment was not tested.

The vehicle cruise control was designed by [11-16] using the FPGA technique. It was shown that the FPGA based cruise control can provide more accuracy, reliability and can reduce the number of accidents. A similar technique as reported in [11] was used by [17] for the smart speed detection in car parking area. However, these studies did not consider the use of FPGA algorithms in speed detection of the car on the roads.

It is observable from the literature that many researches were conducted for the development of electronic systems to avoid the accidents as represented in [15-17]. Moreover, automatic speed detection of vehicles systems was reported in [18-27]. However, the cost and complexity of the system are identified as major limitations. Thus, this paper proposes a novel vehicle speed identification system, which is cost effective and simple. The experiments were performed to validate the developed algorithm.

2. THE SYSTEM DEVELOPMENT

In this paper, the system was developed using components such as two cameras for capturing the image of the vehicle at gate 1 and gate 2 and the computer with MATLAB software. The schematic diagram of the developed system is shown in Figure 1. The speed detection algorithm was developed in MATLAB. The algorithm is divided into following parts: Capturing the image, pre-processing, plate region extraction, segmentation of character in the extracted number plate, character recognition, comparison with database and Indicate result. The flow chart of the proposed system describing the procedures in details of the development the speed monitoring system as illustrated in Figure 2. The operation method has been explained below:

- The camera 1 takes a picture of the plate number of the vehicle when it enters at gate 1.
- The system records the time of entry of the vehicle at gate 1.
- The camera 2 takes a picture of the plate number of the vehicle when it enters at gate 2 and records the information of the vehicle plate number.
- The image is converted from RGB to grey scale.
- Detect candidate text regions using MSER function in MATLAB " detectMSERFeatures" that finds all the regions within the images including many stable regions that are not text.
- Remove non-text regions based on Stroke Width Variation, a common metric used to discriminate between text and non-text. Stroke Width is a measure of the width of the curves and lines that make up a character. Text regions tend to have little stroke width variation whereas non-text regions tend to have larger variations.
- Merge the text regions for final detection. The individual text characters must be merged into words or text lines.
- Recognize the detected text using OCR function to recognize the text.
- The second camera records the exit time and speed is calculated based on the following equation:

Speed = Distance / Time

- If the vehicle crossed the road according to the estimated, time and it considered not violation either in the case of crossing.
- The case of crossing the vehicle before the specified time, it shows that the vehicle was above the speed allowed on the road and so they are contrary to the speed of traffic.

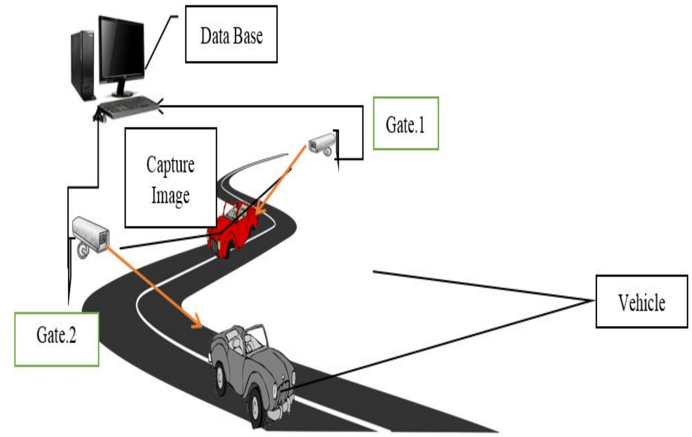


Figure 1: The schematic diagram of the proposed system

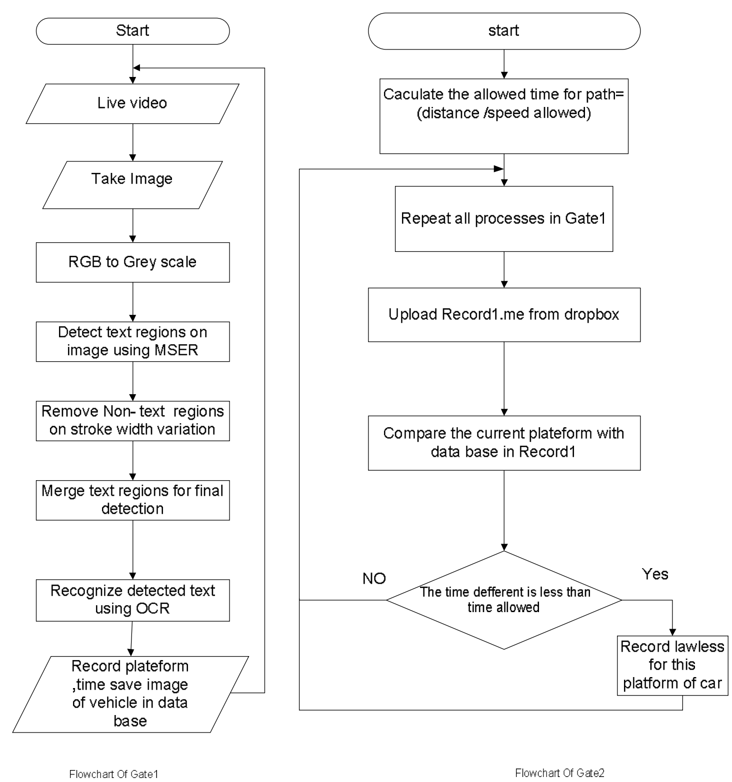


Figure 2: The flow chart of the developed system

Different images of vehicles having different colors and structure types are taken and stored in PC. The screenshot of the simulation and are displays below. Two original images of vehicle are shown in Figure 3. The mobile camera has been used to capture the vehicle platform through IP camera application. Original image of vehicle is shown in Figure 4.

(a)

(b)

Figure 3: Images taken at (a) Gate 1 (b) Gate 2

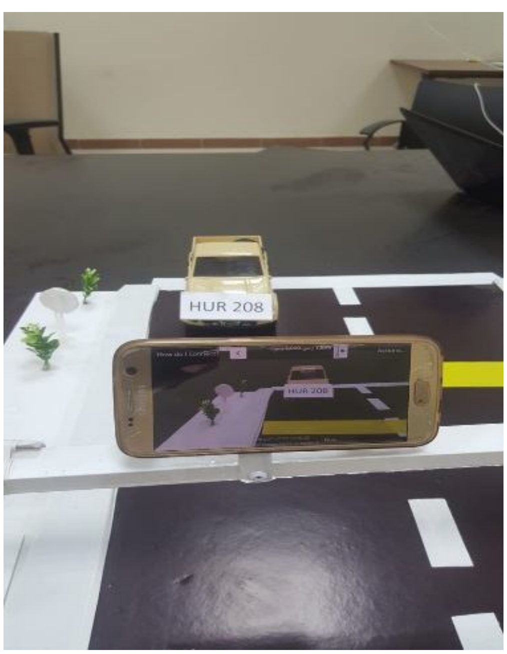


Figure 0: IP camera taking the image of the car

The steps used to detect the vehicle paltform using the MATLAB are described below:

Step 1: Detect Candidate Text Regions Using MSER

The MSER feature detector works well for finding text regions. It works well for text because the consistent color and high contrast of text leads to stable intensity profiles. Use this function to find all the regions within the image and plot these results. Notice that there are many non-text regions detected alongside the text. Original image of vehicle is shown in Figure 5.

Figure 0: Use of MSER for finding the text regions

Step 2: Remove Non-Text Regions Based on Basic Geometric Properties

Although the MSER algorithm picks out most of the text, it also detects many other stable regions in the image that are not text. So, removing the non-text regions is an important step as shown in Figure 6.

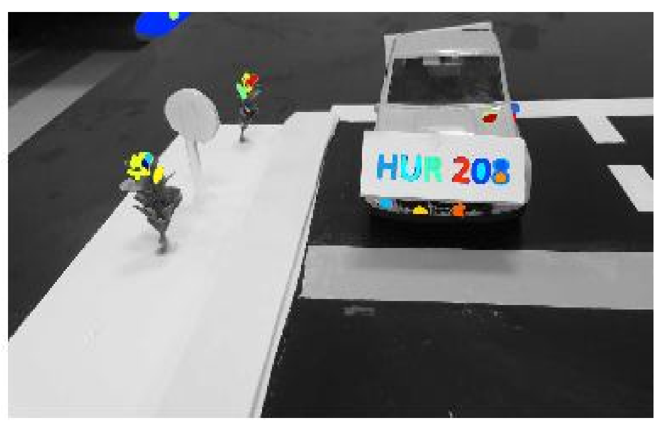


Figure 6: Removal of Non-Text regions based on basic geometric properties

Step 3: Remove Non-Text Regions Based on Stroke Width Variation

Another common metric used to discriminate between text and non-text is stroke width. Stroke width is a measure of the width of the curves and lines that make up a character. Text regions tend to have little stroke width variation, whereas non-text regions tend to have larger variations. To help understand how the stroke width can be used to remove non-text regions, estimate the stroke width of one of the detected MSER regions. It can be done by using a distance transform and binary thinning operation. Get a binary image of the region and pad it to avoid boundary effects during the stroke width computation. The step 3 results are shown in Figure 7.

Figure 7: Removal of non-text regions based on stroke width variation

Step 4: Merge Text Regions for Final Detection Result

At this point, all the detection results are composed of individual text characters. To use these results for recognition tasks, such as OCR, the individual text characters have been merged into words or text lines. This enables recognition of the actual words in an image, which carry more meaningful information than just the individual characters. For example, recognizing the string 'EXIT' versus the set of individual characters. One approach for merging individual text regions into words or text lines is to first find neighboring text regions and then form a bounding box around these regions. To find neighboring regions, expand the bounding boxes computed earlier with region props. This makes the bounding boxes of neighboring text regions overlap such that text regions that are part of the same word or text line form a chain of overlapping bounding boxes. The results of step 4 are shown in Figure 8.

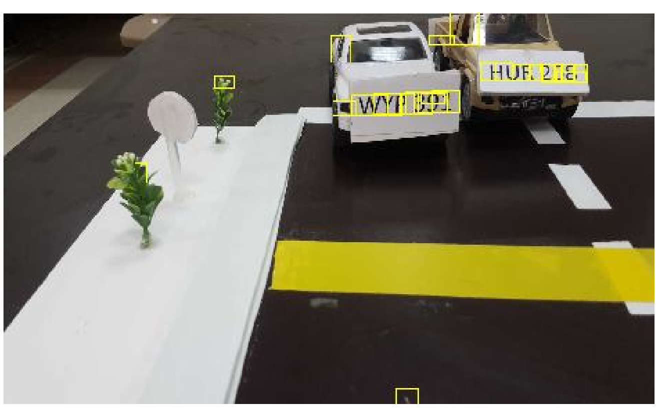


Figure 8: Merge text regions for final detection result

Step 5: Recognize Detected Text Using OCR

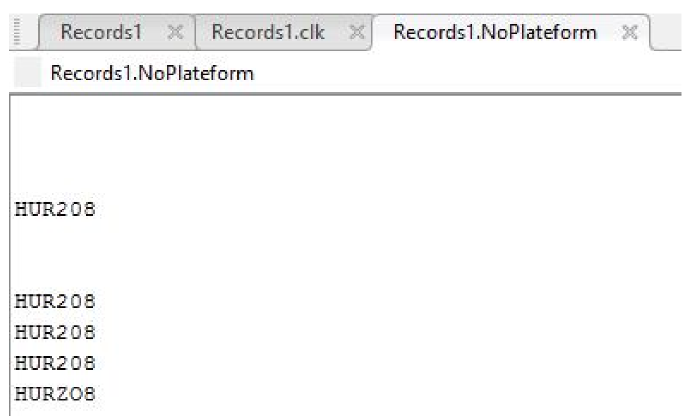
After detecting the text regions, OCR function has been used to recognize the text within each bounding box. Note that without first finding the text regions, the output of the OCR function would be considerably noisier. The results of the step 5 are given in Figure 9.

Figure 9: Recognize detected text using OCR as secondary

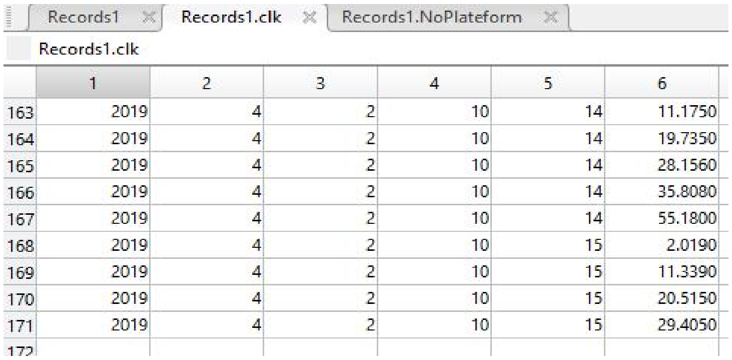
3. RESULTS AND DISCUSSIONS

In this work, the proposed system was developed, tested and validated in order to detect the speed of the vehicles for avoidance of the accidents. At the Gate 1, the time and date of entry are recorded, and the vehicle plate number is captured and stored in the cloud document storage (Dropbox), as record 1. The data of the three original images of vehicle are shown in Figure 10.

(a)



(b)



Records1 | Records1.clk | Records1.NoPlateform

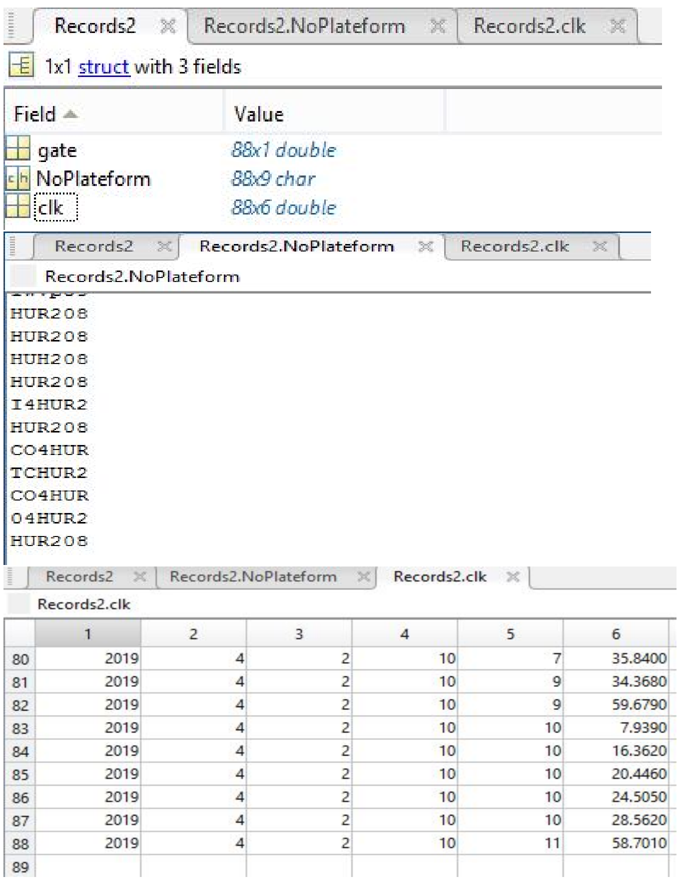
Records1.clk

	1	2	3	4	5	6
163	2019	4	2	10	14	11.1750
164	2019	4	2	10	14	19.7350
165	2019	4	2	10	14	28.1560
166	2019	4	2	10	14	35.8080
167	2019	4	2	10	14	55.1800
168	2019	4	2	10	15	2.0190
169	2019	4	2	10	15	11.3390
170	2019	4	2	10	15	20.5150
171	2019	4	2	10	15	29.4050
172						

(c)

Figure 10: The data recorded at Gate 1

At Gate 2, the time and date of exit are recorded, and the vehicle plate number is captured and stored in the cloud document storage as record 2. The data of the three original images of vehicle are shown in Figure 11.



Records2 | Records2.NoPlateform | Records2.clk

1x1 struct with 3 fields

Field	Value
gate	88x1 double
NoPlateform	88x9 char
clk	88x6 double

Records2 | Records2.NoPlateform | Records2.clk

Records2.NoPlateform

HUR208
HUR208
HUH208
HUR208
I4HUR2
HUR208
CO4HUR
TCHUR2
CO4HUR
O4HUR2
HUR208

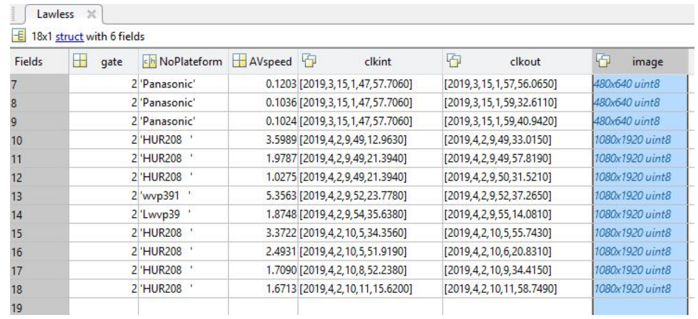
Records2 | Records2.NoPlateform | Records2.clk

Records2.clk

	1	2	3	4	5	6
80	2019	4	2	10	7	35.8400
81	2019	4	2	10	9	34.3680
82	2019	4	2	10	9	59.6790
83	2019	4	2	10	10	7.9390
84	2019	4	2	10	10	16.3620
85	2019	4	2	10	10	20.4460
86	2019	4	2	10	10	24.5050
87	2019	4	2	10	10	28.5620
88	2019	4	2	10	11	58.7010
89						

Figure 11: Data recorded at Gate 2

A vehicle driven by a person quickly to access the gate before the time allowed and a violation is recorded by calculating the time difference shown in the Figure 12.



Lawless

18x1 struct with 6 fields

Fields	gate	NoPlateform	AVspeed	clkint	clkout	image
7	2	'Panasonic'	0.1203	[2019,3,15,1,47,57.7060]	[2019,3,15,1,57,56.0650]	480x640 uint8
8	2	'Panasonic'	0.1036	[2019,3,15,1,47,57.7060]	[2019,3,15,1,59,32.6110]	480x640 uint8
9	2	'Panasonic'	0.1024	[2019,3,15,1,47,57.7060]	[2019,3,15,1,59,40.9420]	480x640 uint8
10	2	'HUR208 '	3.5989	[2019,4,2,9,49,12.9630]	[2019,4,2,9,49,33.0150]	1080x1920 uint8
11	2	'HUR208 '	1.9787	[2019,4,2,9,49,21.3940]	[2019,4,2,9,49,57.8190]	1080x1920 uint8
12	2	'HUR208 '	1.0275	[2019,4,2,9,49,21.3940]	[2019,4,2,9,50,31.5210]	1080x1920 uint8
13	2	'wvp391 '	5.3563	[2019,4,2,9,52,23.7780]	[2019,4,2,9,52,37.2650]	1080x1920 uint8
14	2	'Lwvp39 '	1.8748	[2019,4,2,9,54,35.6380]	[2019,4,2,9,55,14.0810]	1080x1920 uint8
15	2	'HUR208 '	3.3722	[2019,4,2,10,5,34.3560]	[2019,4,2,10,5,55.7430]	1080x1920 uint8
16	2	'HUR208 '	2.4931	[2019,4,2,10,5,51.9190]	[2019,4,2,10,6,20.8310]	1080x1920 uint8
17	2	'HUR208 '	1.7090	[2019,4,2,10,8,52.2380]	[2019,4,2,10,9,34.4150]	1080x1920 uint8
18	2	'HUR208 '	1.6713	[2019,4,2,10,11,15.6200]	[2019,4,2,10,11,58.7490]	1080x1920 uint8
19						

Figure 12: The spreadsheet of the data showing the speed of the vehicle

4. CONCLUSION

In this paper, an electronic system for speed detection of vehicles was developed, tested and validated**.** It concluded that the speed detection of the vehicle is important as it could help to reduce the number of accidents and severe injuries. The existing vehicle speed detection systems are shown to be expensive and computationally complex. This paper has presented an image processing based technique to automatically capture the vehicle number plate image and process it to identify it. The plate number of the vehicles was scanned using two cameras installed on two points. The images of the plate number are processed in MATLAB to de-noise and extracting the plate number information. The speed is detected based on the distance covered by the vehicle between two points. Obviously, the developed system is economical, user friendly and less computational as compared to other existing methods.

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