# DETERMINATION AND IDENTIFICATION OF DANGEROUSLY LANE CHANGING VEHICLES IN TRAFFIC BY IMAGE PROCESSING TECHNIQUES

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**ABSTRACT**

Due to increase of vehicle usage all around the world, the importance of safety driving in traffic is increasing. All of the countries around the world are taking actions to increase the safety driving habitats and decrease the number of traffic accidents. One of the applied precautions is to put necessary automatic auditing mechanisms into service for controlling the drivers as they drive since reckless drivers may not obey many traffic rules. In this study, image and video processing based methods are applied to identify the dangerously lane changing vehicles/drivers in the traffic. The proposed method focuses on to detect three different violations in traffic: the vehicles frequently changing traffic lanes, the vehicles changing lanes when it is forbidden, and the vehicles overtaking the other vehicles using the right lanes instead of left one. The proposed method is based on the image and video processing techniques. It first detects the vehicles in video sequences, then tracks the vehicles in the following frames and determines the lane changes of the vehicles. In the vehicle detection phase an image subtraction method is used. In the vehicle tracking phase, Kalman filtering tracking algorithm is used. After determining the lane changes of the vehicles/drivers, a rule based decision system is used to find out the vehicles/drivers improperly changing lanes and those vehicles are marked on the video. The proposed method is tested on the videos captured from real traffic environments and promising results are obtained.

***Keywords*** **–** traffic, lane changes, vehicle detection and tracking, video processing

## 1. INTRODUCTION

It is seen that the number of the vehicles in the traffic is getting higher in every year. Due to this increase, the number of accidents is also getting high, which may lead to the loss of human life. It is reported that the cost of traffic accidents is estimated to be around U.S. $518 billion in a year [1]. It is also estimated that by the 2020, traffic accidents will become third leading cause of disability and death [1]. In order to overcome this problem, it is necessary to monitor the traffic, especially in crowded roads and in high traffic conditions. Besides it is also necessary to monitor the reckless drivers, who may cause the traffic accidents.

In order to monitor traffic conditions and reckless drivers in the cities, a camera network system may be installed in the crowded locations. Those systems are composed of surveillance cameras deployed in the predefined points and they are connected to a central location with a network. For example, MOBESE (Mobile Electronic System Integration) is installed in almost all of the cities in Turkey [2]. In that system, a set of cameras is installed in the entrance of the cities and in the intersections of the roads. A sample of that kind of camera is given in Figure 1. Those systems are used not only to monitor the traffic conditions and reckless drivers, but also to monitor the vehicles, to find out the number of vehicles entering the cities, to determine the suspicious vehicles and to query the vehicles.

**Figure 1.** A Sample Surveillance Camera Used For Monitoring The Traffic [3]

Those surveillance cameras are also used to monitor the reckless drivers and to determine the drivers who don't obey the rules. But their usage is limited in a few detection areas such as detecting the vehicles running the red lights and exceeding the speed limits. The license plates of the detected vehicles are obtained using one of the license plate recognition systems such as [4, 5, 6] and, then, necessary actions are taken. One of the disadvantages of these systems is that they are capable of detecting only limited scenarios and they need to be improved. In this study, we proposed an image processing-based system that will use the available camera systems and that will detect the following three different violations in traffic: i.) Detecting the vehicles/drivers frequently changing traffic lanes, ii.) Detecting the vehicles/drivers changing lanes when it is forbidden, and iii.) Detecting the vehicles overtaking the other vehicles using the right lanes instead of left one.

The organization of the paper is as follows: in Section 2 the materials and methods followed to detect the vehicles, to differentiate them from each other, to track the vehicles, to determine the moving patterns of the vehicles and to mark the vehicles which do not obey the traffic rules are given. In Section 3 the experimental results are presented. Finally in Section 4 the discussion and conclusion are given.

## 2 MATERIALS AND METHODS

In this study, an image and video processing based method is suggested to detect the aforementioned traffic rule violations. The block diagram of the proposed method is given in Figure 2.

As can be seen from Figure 2, the proposed method is composed of the following sub-modules: vehicle-background separation, identification of vehicles, tracking the vehicles, determining the movement patterns of the vehicles, determining the vehicles that violate the aforementioned rules. The details of these sub-modules are given below.

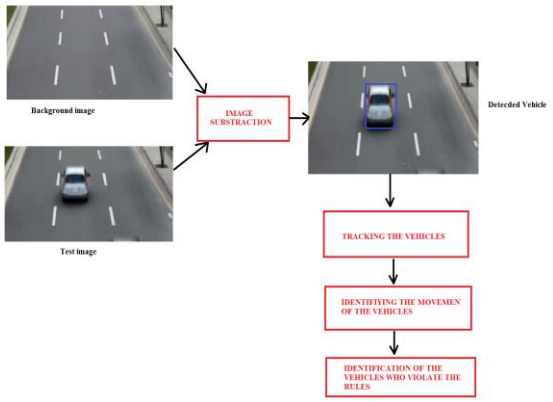


**Figure 2**. The block diagram of the proposed method

Vehicle-background separation and identification of vehicles: In order to determine the position of the vehicles in the images, first of all, an empty image of the road is obtained whenever there is no vehicle in the road. This image will be called as background image furthermore. Whenever a new image is introduced, the difference between the image and the background image is obtained by the image subtraction method. The different regions are marked as the vehicles in the images. Also all the regions marked as vehicles are uniquely labeled. The labels start from 1, and sequentially increase for each vehicle. A sample image including the vehicles is shown in Figure 3. The vehicles and their labels are also shown in Figure 3.

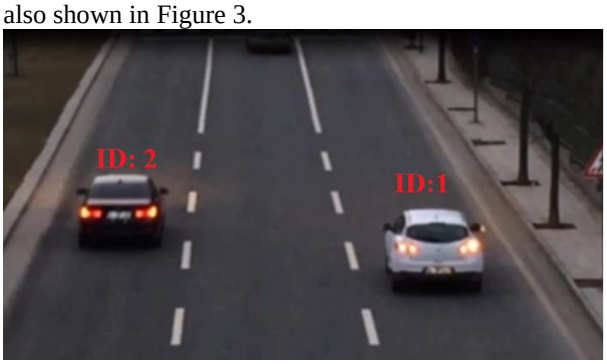


**Figure 3.** An example image showing the detected vehicles and their assigned id's. The vehicles are assigned id 1 and id 2.

Tracking the vehicles: In order to determine the behaviors of the vehicles, the vehicles should be tracked in the images while they are moving. In order to track the vehicles in the images, the Kalman filtering approach is followed. Kalman filtering is an approach that is commonly used for vehicle tracking. It uses the measurements obtained over time and produces the estimates of the unknown positions of the vehicles. The algorithm was first proposed by Rudolf E. Kalman in 1960 [7]. The Kalman filtering approach is mainly used for guidance, navigation, and control of vehicles [8-9], and it is used in many other fields [10-12]. The details of the Kalman filter can be found in the references [7-9] and will not be repeated here.

The Kalman filtering approach is used to track the vehicles in the predefined region. An example showing the tracking performance in the predefined region is shown in Figure 4.

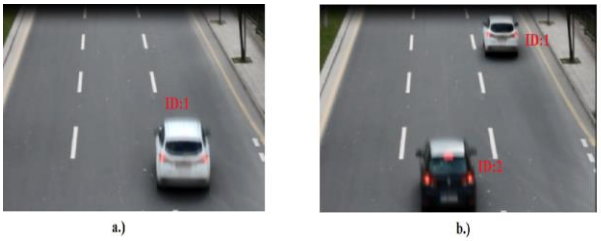


**Figure 4.** An example showing the vehicle tracking module of the proposed system. a.) white car enters the predefined region and it is assigned ID 1. b.) the

white car is tracked till the end of the region, as shown. Besides another car enters the region and it is assigned ID 2.

Determining the vehicles that violate the rules: After tracking the vehicles in the predefined regions, it is necessary to determine if the vehicles violates the aforementioned rules. In this step the main purpose is to detect the vehicles/drivers:

i.) frequently changing traffic lanes,
ii.) changing lanes when it is forbidden, and
iii.) overtaking the other vehicles using the right lanes instead of left one.

In order to detect those vehicles/drivers, first of all the movements of the vehicles are tracked whenever they move in the region. Their directions with respect to time and other vehicles are marked and analyzed. In this step the lanes of the roads are also used to detect the movement of the vehicles. The results obtained using the proposed method will be given in the next section.

## 3 RESULTS

In order to test the performance of the proposed method, we collected some video sequences in the two intersections in the Ankara. The intersections have moderate traffic in the day times. The intersections have been chosen to have moderate traffic; otherwise in the heavy traffic there wouldn't be any opportunity to find vehicles violating the rules.

A total of 30 minutes of video was recorded at each intersection with a standard 720P camera. The resolution of the videos is 1280x720. The cameras are located in an upper position around the intersections that will see the vehicles coming from one direction. The cameras are located in a place that they will record the traffic in the intersections near the 30 meter traffic lights. According to traffic rules, it is forbidden to change lanes when the distance to the traffic light is less than 30 meter.

After acquiring the video sequences, the images have been analyzed by the proposed method. The tests are performed offline. Before the tests the lanes of the roads are marked manually in order to determine the positions of the lanes. Also before the tests the background images in which there is no vehicle on the road, have been obtained to detect the vehicles. By using the proposed method, the vehicles violating the rules have been identified. In Figure 5 the vehicles violating the rules have been shown.

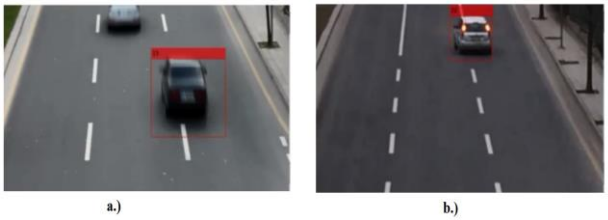


**Figure 5.** The vehicles violating the traffic rules. The cars shown in a.) and b.) are changing lanes whenever it is forbidden.

During the tests it is detected that a total of 13 vehicles have violated the traffic rules. 12 of them changed the lanes whenever it is forbidden. Two examples of them have been shown in Figure 5. A vehicle has changed lanes twice during the tests. This vehicle has also been detected to violate the rules. This violation has been categorized into the rule that "frequently changing traffic lanes".

Unfortunately it was not possible to find an example that violates the target rule 3, namely "Overtaking the other vehicles using the right lanes instead of left one". This is due to fact that the recording areas were a very close area and they were places near to traffic light, where it was not possible to speed up and to overtake. In order to test the performance of that rule, we need to record long time videos in a long range conditions.

## 4. DISCUSSION AND CONCLUSIONS

In this study, image and video processing based methods are applied to identify the dangerously lane changing vehicles/drivers in the traffic. The proposed method focuses on to detect three different violations in traffic, namely i.) Detecting the vehicles/drivers frequently changing traffic lanes, ii.) Detecting the vehicles/drivers changing lanes when it is forbidden, and iii.) Detecting the vehicles overtaking the other vehicles using the right lanes instead of left one. The main contribution of this study is that it focuses on to detect the dangerously lane changing vehicles in the traffic, which has not been worked in detail.

The proposed method is tested in two video sequences captured in intersections in the Ankara. The videos are analyzed offline and it is found that the proposed method is capable of detecting the vehicles that violate the traffic rules. In this respect we can conclude that the proposed method gives promising results.

One of the advantages of the proposed method is that it can easily be integrated with the surveillance cameras that are used for security reasons and to track the traffic. The system does not need any specialized camera or other equipment. So it can be easily integrated to available systems and it can detect the rule violations in traffic, which is not available right now.

The proposed system has also some disadvantages. First of all, the proposed system is capable of detecting and tracking the vehicles in the daylight conditions and it has not been designed to work in dark environments. The lighting conditions may also affect the detecting performance of the system. In order to overcome this problem, the system needs to be improved in order to work in nights as well.

Another disadvantage of the proposed system is that it has not been tested in long range road environments. In long range environments it is possible to see that some of the vehicles may be incorrectly tracked by the system. For this reason the system should be tested for the aforementioned conditions. In a next study we plan to test the system in long range recording conditions.

**Acknowledgements:** This project is supported by Atilim University as an Undergraduate Research Project (ATÜ-LAP-C-1415-13). The project group student members are Mehmet Serkan Bil, Çağlar Mehmet Metin, Tolga Üstünkök, Ersin Tiryaki, Bülent Şengüler, Ümit Barış Değdaş, Batuhan Çoşar, and Eren Ezgi Çamalan. We would like to extend our gratitude to all the project group student members for realizing this project.

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