Advanced Materials Research *Online: 2012-01-03*
ISSN: 1662-8985, Vols. 433-440, pp 6230-6234
doi:10.4028/www.scientific.net/AMR.433-440.6230

Recognition of Driver Turn Behavior Based on Video Analysis

Yufeng Lu and Chunling Li
School of Mechanical Engineering, Shandong Institute of Light Industry, Jinan, China
luyf78@126.com, lcl_alice@126.com

Keywords- recognition of turn behavior; video analysis; standard deviation; hands position;

Abstract—In view of the shortcoming of driver state detection system which may take turn behavior as driver distraction, a new method to recognize turn behavior was proposed based on video images analysis. The driver hands position in different driving behavior were analyzed and we found that the position of driver's hands changed more violent when in turning than in other driving behavior. So we may use standard deviation of driver hands position to recognize driver turn behavior. In order to improve the hands locating speed the Particle Filtering was used to track the driver hands. And experiments resulted that the recognition algorithm can identify the driver's turn behavior.

Introduction

Many studies revealed that driving distraction degrades driving performance and compromises driving safety. A detection system that may predict distraction and alert the driver by monitoring faces' feature could reduce the number of distraction crashes. However this system will recognize driver turning as a distraction falsely. In order to eliminate this adverse effect a driver turning recognition is needed.

Detecting the turning signal seems to be the simplest method to recognize turning intent. But the driver may change lane or turn when he uses the signal. So the binary signal can not reveal driver's intent clearly[1]. Lee[2] proposed a method to recognize driver's turn intent using two correlation coefficients. In the system the driver's image and the front-road image were captured, and the orientation information including the car heading direction, the driver's sight line and the lane path from the two captured images were mapped into a global coordinate to calculate two correlation coefficients. Four driving patterns including the driving in a straight lane, the driving in a curve lane, the driving of changing lanes, and the driving of making a turn are able to be recognized so far. But in a practical situation when the car was standing for the green traffic light or a chance to make a left turn, the system couldn't recognize this driving event well because there are not appropriate lane ropes. In order to identify the driver's steering, parking Liu used the steering angle, steering rate, vehicle speed and acceleration of vehicle to create a hidden Markov model of driving behavior. The identify rate was up to 50% [3].

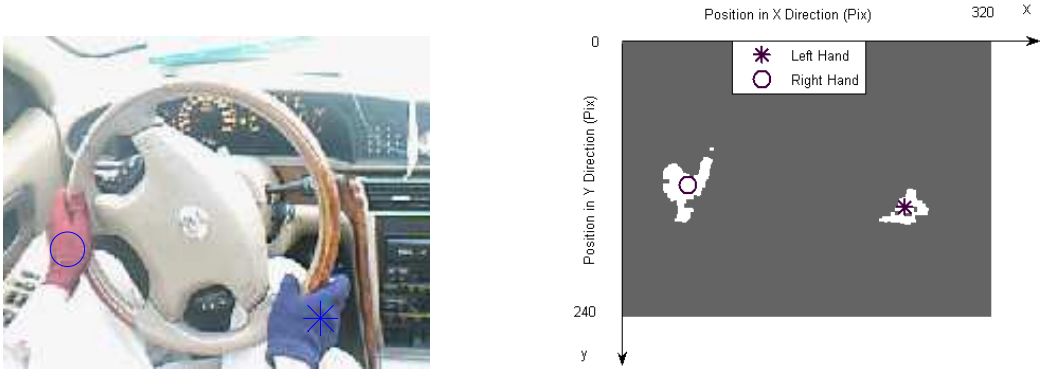
In addition to application of the vehicle parameters driver's facial gestures, eye gaze direction can also be used to identify the driver behavior [4]. Cheng establish a steering model according to the driver face pose, hand gesture to identify the driver steering behavior [5]. But this does not fit in this application. Because the purpose of this paper is to identify the driver turn to prevent the deviation from the driver's attention turned to the situation when mistaken for a visual distraction behavior, it can not then apply the line of sight (facial gestures) to identify the driver turn behavior. Therefore, we propose a new method based on standard deviation (SD) of driver's hands to identify driving turn.

Shift in the intersection department typically requires changes in vehicle direction 90 degrees. People will encounter in the T junction or a crossroads similar to the process of turning, or in the trunk by a branch road to the steering office. These junctions have a varying number of lanes, connecting one-way or two-way street. Turn at the crossroads. Here we turned a crossing of the first case study.

We characterize an intersection turn as one that requires a change in vehicle heading of approximately 90 degrees. Drivers would encounter such turns when maneuvering a vehicle at T and four-way intersections as well as turnouts into side streets.

Detection and Traction of Driver's hands

A camera was placed top right upon the steering wheel to capture driver's hands images. The angular separation between camera axes and steering wheel plane is 19.6^0 and the camera axes pass through steering wheel's centre. The image of driver's hands is shown in Fig. 1 a).



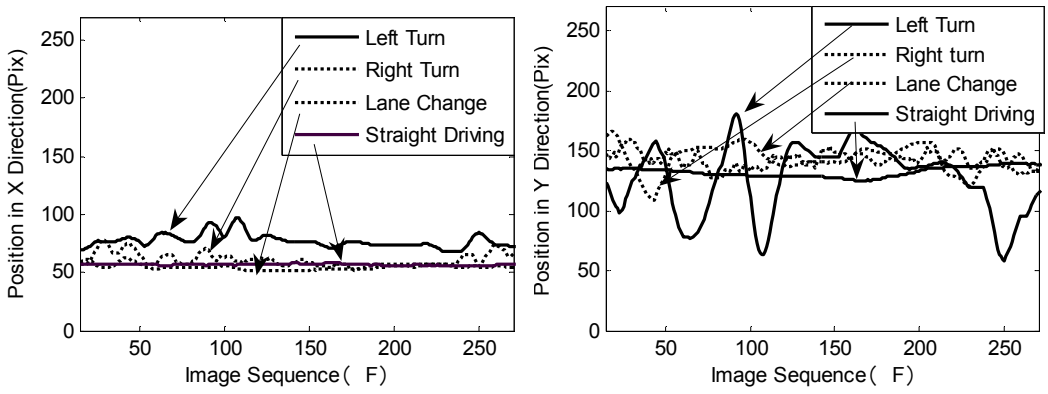
a) image of driver's hands b) location of hands

Figure 1. Image of driver's hands and location results

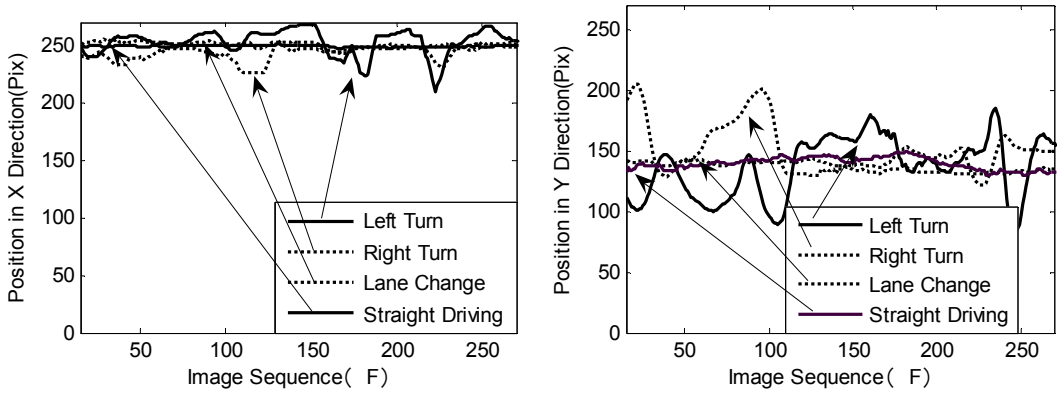
In order to differentiate driver's left and right hands driver wore different color gloves (left was red and right was blue). The hands were localized based on color difference, results in Fig. 1 b). To improve localizing speed further, Particle Filtering was used to track the hands[6].

Analysis of Hands Position

To analysis driver hands position the videos were collected when drivers were driving in left turn, right turn, change lanes, Straight driving, each with 50 segments and lasting about 20 seconds. Determine the drivers left and right hand center x, y position, changes in the center of the hand shown in Fig. 2.



a) Position of left hand



b) Position of left hand

Figure 2. Position of hands in different drive behaviors

From Fig. 2 we can clearly see that turning behavior is different to other acts. The position of driver's hands changed more violent when in turning than in others. Since the driver's hand position in turn was changed dramatically we can hand the standard deviation to determine driving acts. Twenty videos of each driving behavior were selected to calculate the standard deviation of hand position, the on average results were shown in TABLE Ⅰ:

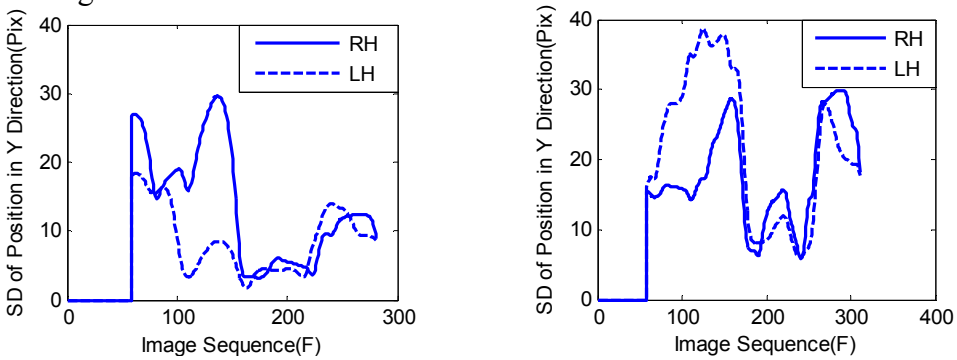
Recognition of Turn Behavior

According to Fig. 2 and TABLE Ⅰ, we can see that driver hands' movement is more complex when in turn than in other situations. We may set appropriate threshold of hand position's standard deviation to identify the driver steering behavior. This move aims to prevent the detection system to take visual dispersion behavior as distraction at this time, which requires time statistical window can not be too long. So 50 images was selected to calculate the standard deviation

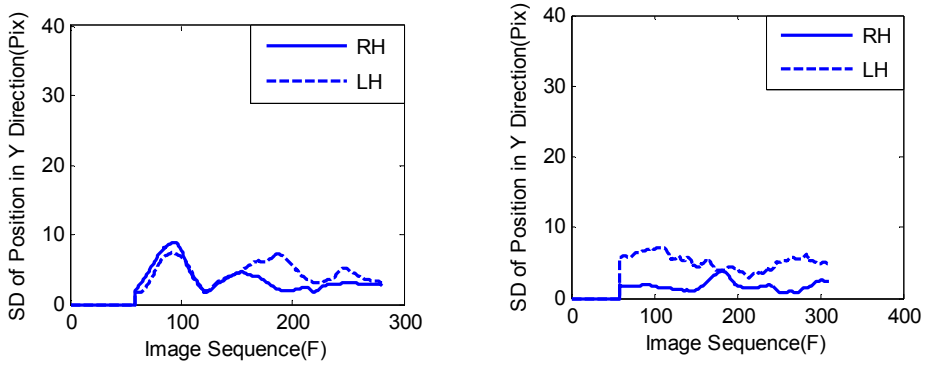
TABLE I. SD OF HANDS POSITION (PIX)

	SD of Left Hand		SD of Right Hand	
	x	***y***	***x***	***y***
Left Turn	7.1	29.2	10.9	24.4
Right Turn	6.5	13.9	7.3	20.6
Lane Change	2.3	6.4	2.4	4.0
Straight Driving	1.7	4.2	1.9	4.1

(frame rate = 30 frames / sec). The position of driver's right hand changes more intense in the y direction than in x direction. So go to the driver hand position in the y direction as the standard for judging. Then the standard deviation was calculated from the 50th image of driver hands' video, the results shown in Fig. 3.



a) Right turn b) Left turn



c) Lane change d) Straight driving

Figure 3. SD of driver hands in Y direction

From Fig. 3 we can clearly find that the standard deviation of hands' poison was significantly larger in turn than in other driving behaviors. The different is more obvious in the beginning and the end of turning behavior. In the middle of the turn period driver needs to maintain steering angle steady so the standard deviation of hand position decreased. In the course of the driving driver may leave one hand off the steering wheel, such as in the shift, adjusting the radio, etc. But the driver can not leave the steering wheel with both hands at the same time. So both hands' poison standard deviation was chose to judge the turn. We took the behavior as turn only when the standard deviation of both hands simultaneously exceed a threshold. Taking two kinds of phenomena into account on the steering behavior recognition and assuming that driver is not turning at the first part of the video. We propose a recognition algorithm of turning behavior as shown in Fig. 4.

The purpose of setting flag is to distinguish between the start and end part. Calculating the number of non-turn frames aims to prevent recognizing of non-turn as turn for a long time after making non-turn as turn falsely. The purpose of this paper is to recognize whether the driver during steering or not. Therefore we no longer distinguish between right turn and left turn. And the straight lane driving, lane changing is defined as the other types. The standard deviation of hand position threshold was set as 10 pixels. The data sources of TABLE Ⅰ were involved in the identification experiment, and the recognition results shown in TABLE Ⅱ.

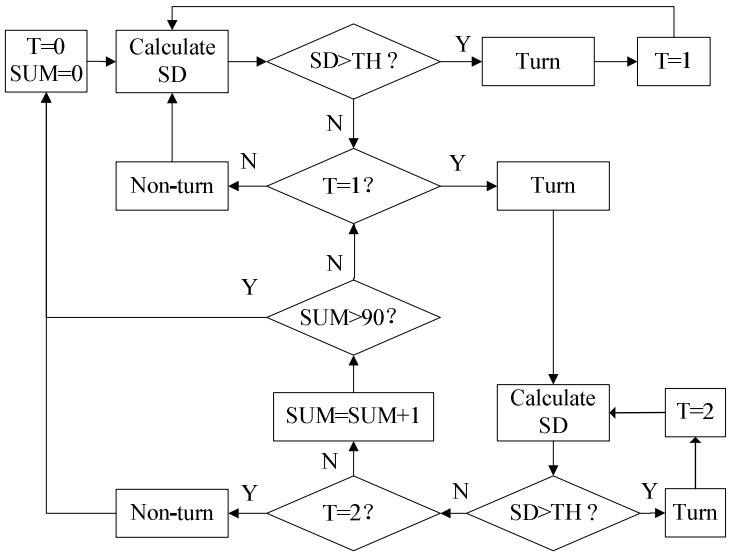


Figure 4. Algorithm of turn recognition (SD—standard deviation of both hands' position; TH—threshold; T—Flag; SUM—sum of non-turn frames)

TABLE II. RESULT OF BEHAVIOR RECOGNIZING (%)

True behavior	Left Turn	Right Turn	Straight Driving	Lane Change
Recognized as Turn	93.5	94.6	4.7	5.2

Overall the recognition rate is very high. Analyzing of wrong identification examples we found that taken turn as non-turn occurring in the first 15 frames of turn videos. Taking non-turn as turn occurred in the videos' end and the error frames were generally 5 or less. A small amount of images were also identified as turn in lane changing, straight lane driving and the main reason is due to small threshold value. Increasing the threshold may prevent this part of the identification error, but will increase the identification of other cases of error rate.

Conclusion

The recognition of driver's turn behavior was studied in this paper and a method based on standard deviation of driver hand position was proposed. And locating and tracking both hands in video images were studied too. First, analyzing the driver hands position in different driving behavior and we found that the position of driver's hands changed more violent when in turning than in others. And we may use this character to identify the driver turn behavior from other behavior. To improve the hands locating speed the Particle Filtering was used to track the driver hands. Finally, turning behavior recognition algorithms were presented, and experiments resulted that the recognition algorithm can identify the driver's turn behavior.

Acknowledgment

I would like to thank Prof. Chen for his helpful discussions and suggestions and other professors in the School of Mechanical Engineering, Shandong Institute of Light Industry.

References

[1] D. D. Salvucci, A. Liu. The Time Course of A Lane Change: Driver Control and Eye-Movement Behavior. Transportation Research Part F. 2002(5):123-132

[2] Jiann-Der Lee, Jiann-Der Li, Li-Chang Liu. A Novel Driving Pattern Recognition and Status Monitoring System. Lecture Notes in Computer Science. 2006, 4319: 504-512

[3] M. Land, D.N. Lee. Where We Look When We Steer. Nature. 1994, 369(6483): 742-744

[4] N. Kuge, T. Yamamura, O. Shimoyama. A Driver Behavior Recognition Method Based on a Driver Model Framework. Soc. Automotive Engineers Publication. 2000,109(6): 469-476

[5] Shinko Yuanhsien Cheng, Mohan Manubhai Trivedi. Turn-Intent Analysis Using Body Pose for Intelligent Driver Assistance. IEEE Pervasive Computing. 2006,5(4): 28-37

[6] K. Nummiaro, E. Koller-Meier, L. V. Gool. An Adaptive Color-based Particle Filter. Image and Vision Computing, 2003, 21 (1): 99-110