Computers and Electrical Engineering 42 (2015) 23–29

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

A lane detection approach based on intelligent vision ☆

Shu-Chung Yi [a,b,*], Yeong-Chin Chen [b], Ching-Haur Chang [c]

[a] Department of Computer Science and Information Engineering, National Changhua University of Education, No. 2, Shi-Da Road, Changhua City, Taiwan
[b] Department of Computer Science and Information Engineering, Asia University, 500 Liufeng Rd., Wufeng, Taichung, Taiwan
[c] Department of Photonics and Communication Engineering, Asia University, 500 Liufeng Rd., Wufeng, Taichung, Taiwan

A R T I C L E I N F O

Article history:
Received 17 March 2013
Received in revised form 8 January 2015
Accepted 9 January 2015
Available online 18 February 2015

Keywords:
Lane departure
Lane detection
Image processing
Intelligent transportation system (ITS)

A B S T R A C T

This paper proposes driver assistant system architecture based on image processing techniques. A camera is mounted on the vehicle front window to detect the road lane markings and determine the vehicle's position with respect to the lane lines. A modified approach is proposed to accelerate the HT process in a computationally efficient manner, thereby making it suitable for real-time lane detection. The acquired image sequences are analyzed and processed by the proposed system, which automatically detects the lane lines. The experimental results show that the system works successfully for lane line detection and lane departure prediction.

1. Introduction

Traffic accidents have become one of the most serious modern problems. The reason is that most accidents occur due to driver negligence. Rushed and careless driving can push other drivers and passengers into danger on roads. Many accidents can be avoided if dangerous driving conditions are detected early and other drivers are warned. Cameras and speed detectors are used on most roadways today to monitor and identify drivers that exceed the permitted speed limit. This is a primitive approach because there are limitations. If the drivers slow down before the speed detectors they will not be detected, even though they had exceeded the permitted speed earlier.

There were 13,954 fatal crashes in Taiwan because of failure to stay in the proper lane or running off the road in 2004. Table 1 shows the numbers and percentages of total drivers as more than one factor may be present for the same driver [1].

Failure to stay in the proper lane occurs in 24% of all fatal crashes. This is the most important precursor event in car accidents.

Side impact collision is one of the common types of car accidents. Side impact collisions occur when drivers carelessly change road lanes or merge onto the highway. These accidents are mainly due to the approaching vehicle driver moving into the rear mirror blind-spot of the vehicle in the adjacent lane or the driver loses concentration. Lateral vehicle detection and distance measurement will help drivers control their cars safely. Many studies [2,3] have investigated driving-assistance systems to improve driving safety.

Over the past few years more researches have been conducted on intelligent transportation systems (ITS). A research community [4] has been devoted to the lane departure warning topic (LDW) [5–7]. A significant portion of highway fatalities

☆ Reviews processed and approved for publication by the Editor-in-Chief.

* Corresponding author at: Department of Computer Science and Information Engineering, National Changhua University of Education, No. 2, Shi-Da Road, Changhua City, Taiwan.

E-mail addresses: scyi@cc.ncue.edu.tw (S.-C. Yi), ycchenster@gmail.com (Y.-C. Chen), chchang@asia.edu.tw (C.-H. Chang).

http://dx.doi.org/10.1016/j.compeleceng.2015.01.002
0045-7906/

each year are attributed to vehicle lane departures. Many automobile manufacturers are developing advanced driver-assistance systems, many of which include subsystems that help prevent unintended lane departure. A consistent approach among these systems is to alert the driver when an unintended lane departure is predicted. A vision system mounted on the vehicle detects the lane markings on the road and determines the vehicle's orientation and position with respect to the detected lane lines.

Lane detection is a vital operation in most of these applications as lanes provide important information like region-of-interest, for further processing. In most cases lanes appear as well-defined, straight-line features in the image (especially in highways), or as curves that can be approximated by smaller straight lines. The linear HT (Hough transform), a popular line detection algorithm, is widely used for lane detection [8]. The HT [9] is a parametric representation of points in the edge map. It consists of two steps, i.e., "voting" and "peak detection" [10].

In the voting process every edge pixel $P(x,y)$ is transformed into a sinusoidal curve by applying the following:

$$\rho = x\cos\theta + y\sin\theta \quad (1)$$

where ρ is the length of the perpendicular from the origin O to a line passing through (x,y), and is the angle made by the perpendicular with the x-axis, as shown in Fig. 1. The resulting values are accumulated using a 2-D array with the peaks in the array indicating straight lines in the image.

The peak detection involves array accumulation analysis to detect straight lines [11,12].

The high computational time incurred by conventional Hough voting, attributed to the trigonometric operations and multiplications in (1) applied to every pixel in the edge map, makes it unsuitable for direct use in lane detection, which demands real-time processing. Hierarchical pyramidal approaches were proposed in [13,14,6] to speed up the HT

Table 1
Related factors for drivers involved in fatal crashes.

Factors	Number	Percent
Failure to keep in proper lane or running off road	13,954	24.0
Driving too fast for conditions or in excess of posted speed limit or racing	11,818	20.3
Under the influence of alcohol, drugs, or medication	7072	12.2
Failure to yield right of way	4611	7.9
Operating vehicle in erratic, reckless, careless, or negligent manner	3905	6.7
Inattentive (talking, eating, etc.)	3671	6.3
Swerving or avoiding due to wind, slippery surface, vehicle, object, nonmotorist in roadway, etc.	2666	4.6
Failure to obey traffic signs, signals, or officer	2607	4.5
Overcorrecting/oversteering	2466	4.2
Vision obscured (rain, snow, glare, lights, building, trees, etc.)	1679	2.9
Drowsy, asleep, fatigued, ill, or blackout	1653	2.8
Making improper turn	1537	2.6
Driving wrong way on one-way traffic way or on wrong side of road	936	1.6
Other factors	9420	16.2
None reported	20,216	34.8
Unknown	780	1.3
Total drivers	58,080	100.0

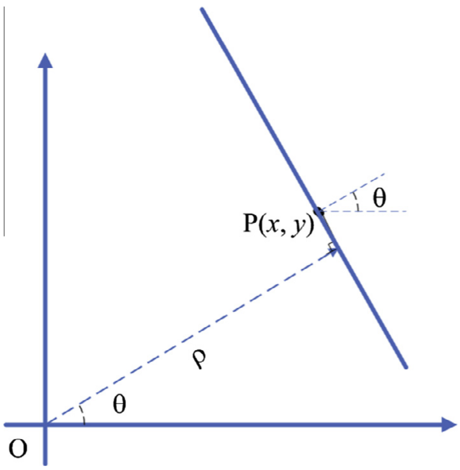

Fig. 1. The relation of lane line and Hough transform.