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Automatic Braking And Evasive Steering For Active Pedestrian Safety

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Abstract - Active safety systems hold great potential for reducing accident frequency and severity by warning the driver and/or exerting automatic vehicle control ahead of crashes. This paper presents a novel active pedestrian safety system that combines sensing, situation analysis, decision making, and vehicle control. The sensing component is based on stereo vision, and it fuses the following two complementary approaches for added robustness: 1) motion-based object detection and 2) pedestrian recognition. The highlight of the system is its ability to decide, within a split second, whether it will perform automatic braking or evasive steering and reliably execute this maneuver at relatively high vehicle speed (up to 50 km/h). We obtained a significant benefit in detection performance and improved lateral velocity estimation by the fusion of motion-based object detection and pedestrian recognition.

Index Terms: *Active safety intelligent transport system (ITS), pedestrian detection, vehicle control.*

I. INTRODUCTION

Pedestrian's safety is an important problem of global dimensions. According to the World Bank website, pedestrians account for 65% of the fatalities out of the 1.17 million traffic related deaths around the world, with 35% of these being children. In the United States, according to the National High- way Traffic Safety Administration report, there were 4641 pedestrian fatalities during 2004, which accounted for 10.9% of the total 42 636 traffic-related fatalities. In Britain, pedestrians are twice as likely to be killed in accidents as vehicle occupants. In developing countries such as India and China, the problem is much worse. During 2001, there were 80 000 fatalities on Indian roads, which grew in last decade at 5% per year .In fact, 60%–80% of the road fatalities are the VRUs, many of them from low-income groups. In China, pedestrians and bicyclists accounted for 27% and 23% of the fatalities, respectively, in 1994, compared to 13% and 2% in the United States. With the rapid increase in the number of vehicles in these countries, the number of accidents and fatalities is likely to increase before they can be reduced.

In developing countries, there are a large number of two wheelers, three wheelers, bicyclists, and pedestrians sharing the same road space with cars, buses, and trucks. Passive pedestrian safety measures involve vehicle structure (e.g., bonnets and bumpers) that expand during collision to minimize the impact of the pedestrian leg or head hitting the vehicle. For example, Mercedes-Benz introduced the active bonnet as the standard for the new E-Class 2009. The system includes three impact sensors in the front section and special bonnet hinges that are pretension by powerful springs. Upon impact with a pedestrian, the rear section of the bonnet is pushed upward by 50 mm in a fraction of 1 s, thus enlarging the deformation zone.

Figure 1. Typical dangerous situation: a child unexpectedly running onto the street.

The system is reversible and can manually be reset by the driver. Although important, passive pedestrian safety measures are constrained by the laws of physics in terms of the ability to reduce collision energy and, thus, injury level. Moreover, passive measures cannot account for injuries sustained in the secondary impact of the pedestrian hitting the road. Much effort is therefore spent toward the development of active driver assistance systems, which detect dangerous situations involving pedestrians ahead of time, allowing the possibility of warning the driver or automatically controlling the vehicle. Such systems are particularly valuable when the driver is distracted or visibility is poor (see Fig. 1).The first night vision systems that detect and highlight pedestrians have reached the market (e.g., Mercedes-Benz E-Class 2009 and BMW 7 series 2008). Volvo has recently introduced in the S60 limousine a collision mitigation braking system for pedestrians based on monocular vision and radar. In this paper, we present a novel active pedestrian safety system, which combines sensing, situation analysis, decision making, and vehicle control. This paper is outlined as follows. Section II discusses previous work. Pedestrian recognition is discussed in Section III. Motion-based object detection is discussed in Section IV. Situation analysis, decision making, and vehicle control are discussed in Section V. The implementation of the proposed system is discussed in Section VI. Finally; the conclusion is given in Section VII.

II. PREVIOUS WORK:

There exists an extensive amount of literature on pedestrian safety. Gandhi and Trivedi [2] provide a broad survey on passive and active pedestrian protection methods, discussing multiple sensor types and methods for collision risk assessment. Enzweiler and Gavrila [3] have focused, in a more recent survey, on techniques for video-based pedestrian detection. A large data set (8.5 GB) with several tens of thousands of labelled pedestrians was made public for benchmarking. We can roughly decompose video-based pedestrian detection systems into the following three components: 1) the generation of initial object hypotheses [region-of-interest (ROI) selection];2) verification (classification); and 3) temporal integration (tracking). We only provide a brief discussion; for a more complete discussion, see the survey article [3].The simplest way of obtaining ROIs is through a sliding window approach, where detector windows at various scales and locations are shifted over the image. Significant speedups can be obtained by coupling the sliding-window approach with a classifier cascade of increasing complexity [4], [5] or by restricting the search space, given known camera geometry and certain assumptions (i.e., a flat world, pedestrians on a ground plane, and typical pedestrian sizes). Other ROI selection techniques use stereo vision [6]–[10] or motion cues [11].Pedestrian classification can be performed using either generative or discriminative models. Generative approaches model pedestrian appearance in terms of its class-conditional density function. In combination with the class priors, the posterior probability for the pedestrian class can be inferred using a Bayesian approach. Most generative approaches use shape [9], [12] or combined shape–texture cues [13]. Discriminative models approximate the Bayesian maximum *a posterior* decision by learning the parameters of a discriminant function (decision boundary) between the pedestrian and the nonpedestrian classes from training examples. Among the more popular image features used in this context are Haar wavelets [14], codebook feature patches [8], histograms of oriented gradients (HOGs) [15], and local receptive fields [9]. There is a recent trend toward classifier ensembles [16] or mixture of experts [17] for improved performance. With regard to tracking, one line of research has considered the frame-by-frame association of detections based on geometry and dynamics without particular pedestrian appearance models [6], [9]. Other approaches utilize pedestrian appearance models coupled with geometry and dynamics [8], [10]. Furthermore, some approaches (e.g., [10]) integrate detection and tracking in a Bayesian framework, combining appearance models with observation density, dynamics, and probabilistic inference of the posterior-state density.

A number of pedestrian systems were installed on-board vehicles [9], [18]–[24]. Some of these systems implement not only a perception component but collision risk estimation combined with acoustical driver warning and/or automatic vehicle braking as well; see systems by Daimler [22], Ibeo [20], VW[22], [23], the University of Alcala [21], and the University of Parma [19]. Other work dealt with pedestrian perception, collision risk estimation, and vehicle actuation through simulation [25]. Systems for collision avoidance and mitigation by braking have been in the market for passenger cars and commercial vehicles, and suitable methods for criticality assessment have been proposed (e.g., [26]). However, collision avoidance by steering has not been covered in depth in the literature. Most work on trajectory generation for collision avoidance has been done in robotics. Powerful methods for solving nonholonomic motion planning problems with dynamic obstacles have been proposed (e.g., [27] and [28]), yet the computational complexity of several of the proposed algorithms prohibits the application on current automotive hardware. To overcome this limitation, efficient planning algorithms for evaluating possible collision avoidance maneuvers by human drivers in highly structured scenarios have been introduced [29]. Optimal vehicle trajectory control for obstacle avoidance within the shortest distance is presented in [30]. The PRORETA Project [31] evaluated driver assistance systems that initiate automatic braking when an object vehicle cuts into the ego vehicle's lane and automatic steering when an object vehicle stands in front of the ego vehicle and the driver does not react. Other systems that performed automated steering have been demonstrated at the Defense Advanced Research Projects Agency (DARPA) Urban Challenge [32]. However, the latter systems mostly used expensive sensors that are not suited for the automotive context (e.g., Velodyne scanners) and executed steering maneuvers at relatively low vehicle speeds.

The contributions of this paper are given as follows. The main contribution is the description of an integrated active pedestrian safety system, which combines sensing, situation analysis, decision making, and vehicle control. The secondary contribution concerns the sensing component. It is based on stereo vision and fuses the following two complementary approaches for added robustness: 1) motion-based object segmentation and 2) Pedestrian Recognition (PedRec). The highlight of the system is the ability to decide, within a split second, on whether to perform automatic braking or evasive steering and to reliably execute this maneuver at relatively high vehicle speed (up to 50 km/h).

III. PEDESTRIAN RECOGNITION:

Pedestrian tracking is a deceptively hard problem. When the camera is fixed and the number of targets is small, pedestrians can easily are tracked using simple naive methods based on target location and velocity. However, as the number of targets grows, occlusion creates ambiguity. This can be overcome by delaying decisions and considering multiple hypothesis and efficient solutions exist for solving this correspondence problem. However, as the size of the scene itself grows, additional cameras are needed to provide adequate coverage. This creates another problem known as pedestrian re-identification. This is a much more challenging problem because of the lack of hard temporal (frame to frame) constraints when matching across non overlapping fields of view in a camera network. However, the ultimate goal of any surveillance system is not to track and reacquire targets, but to understand the scene and provide a more effective interface to the operator. Central to this goal is the ability to search the camera network for a person of interest. This is effectively the same as pedestrian re-identification without any temporal constraints. This problem of pedestrian recognition is the main subject of this paper.

IV. MOTION BASED OBJECT DETECTION:

In this paper we propose a motion-based approach to simplify the detection of moving objects in order to improve available methods and make them more efficient. We interpret the image sequence containing the moving object (e.g. a vehicle or a crossing pedestrian) as a three-dimensional signal

V. SITUATION ANALYSIS, DECISION AND VEHICLE CONTROL:

Situation analysis and vehicle control are the components of a driver assistance system that generate a machine-level understanding of the current situation (based on the aforementioned sensor information) and take appropriate actions.

Decision is the core module of the assistance system, because it associates the function with the driver's behaviour. Due to the high injury risk of a pedestrian in an accident, collision avoidance is the primary objective of the function. To identify the best way of supporting the driver, it is necessary to know the driver's current driving intention.

VI. IMPLEMENTATION:

In this paper we concentrate about pedestrian recognition and motion based object detection. We use 6-D vision and also we add some additional features in order to reduce accidents. Here, 4-IR sensors are used. (Front-1, back-1, side-2). The block diagram of the proposed system is given in figure 2.

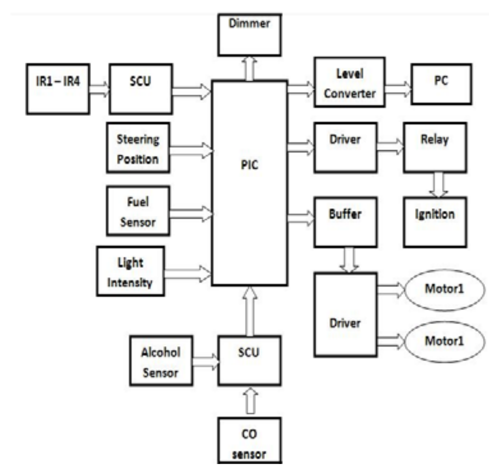

Figure 2: Block diagram of the proposed system

If the sensor senses any object or pedestrian, first it will give the beep sound to warn the driver and automatically it decelerates the speed for driver's safety and finally the vehicle will apply automatic braking or evasive steering based on the sensing condition. The conditions handled in this system are as follows:

A. EVASIVE STEERING:

Suppose if the left sensor (right sensor) any object or pedestrians it gives beep sound and the speed of the vehicle are reduced then the car takes right (left) and moves a certain distance and finally it comes to the original lane position. This is possible when left sensor senses any object, the left motor will move forward and the right motor will off and then both the motor will move forward at a certain distance (till it covers the length of the obstacle) after that left motor will off and the right motor will move forward. The sensor in the side of the vehicle is used to determine the length of the obstacle. The car is steered till the length of the vehicle. During steering there will be a gap between the car and the obstacle so there is no possibilities to hit obstacle.

B.BRAKING:

If both left and right sensors detect any object or if left (right) and back sensors detects any objects, it gives beep sound and decelerates the speed and then automatic braking will be applied. During braking the deceleration of speed is not only for driver's safety but also to reduce the fuel consumption.

C. ALCOHOL SENSOR:

In this we set certain threshold value if it exceeds that the person who consumed alcohol will not be able to start the car. Here Alcohol sensor is also used as a Gas sensor because leaking of gas also causes accidents.

D. CARBON MONOXIDE (CO) SENSOR:

It senses and displays the emission level of the smoke. In real car it is possible to use filter (Gas Molecular Precipitator) which converts CO or CO_2 into O_2 .so there is no pollution.

E. LIGHT DIMMER:

In this we are using light dependent resistor. If there is any opponent vehicle or in presence of street lights, the light intensity of the vehicle is reduced. If the surrounding is darkness, the intensity is more.

F.FUEL SENSOR:

In the proposed system, the fuel sensor is implemented which is used to indicate the fuel level to driver.

VII. CONCLUSION:

This paper has presented a novel active pedestrian safety system that combines sensing, situation analysis, decision making, and vehicle control. We demonstrated that the benefit of adding 6D-Vision to a baseline PedRec (Track) system is that lateral moving pedestrians (2 m/s) can earlier be detected; furthermore, velocity estimation is more accurate. On two scenarios, which require a split-second decision between no action, automatic braking, and automatic evasion, the system made, in all runs (more than 40), the correct decision. After deceleration of speed, the system will perform automatic braking or steering. In future, we intend to incorporate a filter called glass molecular precipitator which is used to convert carbon monoxide into oxygen. So that the pollution can be avoided. Despite the strong performance on the test track, additional challenges remain before this system can reliably be deployed in real urban traffic.

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