Introduction

As the number of pedestrian back-up incidents increase, the need for systems to assist drivers in safely backing up their vehicles becomes more pronounced. Hundreds of injuries and death reports occur every year due to vehicles backing over pedestrians [1]. Each week, at least two children are killed and another 50 are hurt in backover accidents [5]. Most accidents involve the elderly, who are unable to move quickly to avoid collision, and small children that are unaware of danger. The many casualties incurred by these accidents make it apparent that finding an ideal system to assist drivers in safely backing up their vehicles is not only important, but greatly needed. The objective of the backup system is to provide the driver with information about the environment surrounding his vehicle, and take intervention when necessary.

System Overview

Ultimately this system aims to provide drivers with a safe backing experience. The driver is given a comprehensive view of the rear of the vehicle, as well as internal and external alerts and warnings when collision is imminent. Information is provided on the vehicle's infotainment screen through data collected by rear camera and ultrasound sensors. Audio and visual warnings will be provided internally and externally as to alert both the driver and any pedestrians of potential danger. When necessary, the system will take action to mitigate a collision. Speed restrictions will be placed on the vehicle when operation in the pedestrian backup system mode. Intervention will be taken by the system to stop the car when the calculated risk of collision is immediate, however, the driver is ultimately able to override features of the system.

Functional Requirements

The functional requirements for the hardware and software of the pedestrian backup system are as follows:

System Hardware Components & Integration
1. Vehicle contains 1 rear-view camera located on the Car's bumper.
2. Vehicle contains 3 rear ultrasonic sensors integrated in the rear bumper with a scanning range of 70 meters that measures the distance from any object.
3. Vehicle contains a media infotainment system.
4. Vehicle contains LED lights on the rear-view mirror, and right and left exterior mirrors.
5. Vehicle contains button on dashboard to override pedestrian backup system.
6. System is engaged to breaks, accelerator, override button, camera, ultrasound sensors, audio, and light ECUs, and the infotainment system, and does not conflict with other software components of the car.
System Activation

7. Gear position sensor detects the position of the gear and sends the data to the ECU. Upon detection of the vehicle in reverse, the system is activated.
8. When the system is activated, the camera and ultrasonic sensors are turned on and begin collecting data.
9. When the system is activated, the system display occupies the infotainment system and covers the previous screen/activity. Any radio/CD/Bluetooth/AUX audio that is playing is muted.
10. When activated, the system restricts the vehicle to a maximum of 10mph at all times.

Object Detection

11. The rear-view camera continuously collects data that is used as input for object detection algorithms to detect people and static objects.
12. The ultrasonic sensors on the back of the vehicle continuously obtain distance measurements between the car and any detected objects.
13. The driving path of the vehicle is calculated based upon position, angle and steering input of the vehicle using data from the camera and ultrasound sensors.
14. The infotainment system displays an outline of the vehicle's driving path. Objects detected outside of the driving path are displayed in white, while non-human objects detected within the driving path are displayed in orange, and humans in red. All objects are displayed in the infotainment system with relative proximity.

Mitigation & Intervention

15. When any object is initially detected in the driving path of the vehicle, an audio alert will be made notifying the driver that an object(s) has been detected in the driving path.
16. When an object is detected in the driving path within 90cm of the vehicle, the lights upon the rear-view and exterior mirrors will light up red.
17. When an object is detected in the driving path within 90cm of the vehicle, an audible beeping will occur through the vehicle's speakers.
18. When an object is detected in the driving path within 90cm of the vehicle, the vehicle's rear hazard warning lights will flash.
19. When an object is detected in the driving path within 90cm of the vehicle, the vehicle will be restricted to a maximum of 5mph.
20. As the distance of 90cm between the vehicle and detected object within the driving path decrease, the vehicle's rear-view and exterior mirrors will begin to flash with increasing frequency, and the audible beeping will also increase in frequency.
21. If the distance between the detected object within the driving path and the vehicle reaches 30cm, the system will stop the vehicle by activating the braking system and disengaging the gas pedal. Additionally, an audio alert will notify the driver of the action.

System Exit

22. If the user presses the override button, the system will operate without providing any intervention - meaning, every aspect of the system will maintain except for the speed limitation and breaking provided by the system.
23. Gear position sensor detects the position of the gear and sends the data to the ECU. Upon detection of the vehicle out of reverse, the system exits.
24. Upon system exit, the infotainment system resumes the previous screen/activity and any previous audio radio/CD/Bluetooth/AUX is resumed.
25. Upon system exit, the ultrasound sensors, camera sensors stop fetching data and are turned off.
26. Upon system exit, the rear-view mirror and external mirror LEDs are turned off and any audio warnings cease.
27. Upon system exit, the vehicle is no longer restricted to a maximum of 10mph.

Non Functional Requirements

The non functional requirements for the hardware and software of the pedestrian backup system are as follows:

1. An efficient object detection algorithm should be used to save computation time and memory.
2. An object detection algorithm effective in distinguishing humans should be used.
3. A high definition camera should be used.
4. More cameras can be provided dependant upon budget.
5. The infotainment screen should be of high resolution.
6. The display on the infotainment screen should show all data in real time.
7. Checksums should be used to ensure all data transfer.
8. The number of ultrasound sensors should be able to capture data at the back of the vehicle and around the rear tires and back sides of the vehicle.
9. System should address security threats to the pedestrian backing system through the infotainment system.
10. The system's hardware components should be affordable (affordable as defined by the manufacturer)
11. The system should be able to detect objects no matter the weather conditions.

System Invariants

1. Prevent exiting of the system by anything other than a shift out of reverse or push of the override button.
References


http://www.msnbc.msn.com/id/19353735/ns/health-childrens_health/t/lives-shattered-drivewaybackover-accidents/#.TxWrQxw8tog