Abstract

An average of 45,000 vehicle-related fatalities occur per year in the United States. The U.S. Department of Transportation has declared a crisis. Collision avoidance systems for commercial transportation have the potential to reduce these fatalities, but are slow to be adopted. This project builds on the top-tier student competition team at the California Polytechnic State University for large trucks by integrating several different low-cost sensors. These sensors have been selected for testing and development for this system: ultrasonic, sonic phase doppler, and magnetic. The sensors have advantages and shortcomings that don’t allow them to work in a standalone system. Each sensor type is evaluated to determine the limitations of each sensor type to overcome the limitations of the others. These sensors have been selected to work in the real world and blend into a truck. In addition, the information from different sensors can be utilized to determine object type, track targets, and assign target threat levels.

Objectives

• Identify low-cost alternative sensors and model their behavior
• Develop an algorithm that combines sensor strengths and limits sensor shortcomings
• Identify false positives, false negatives, and sensor limitations
• Ensure the system responds in real time

Sensors

A thorough literature review was completed to identify the state of the art sensors and their applications in today’s crash avoidance systems. Although the following list is not exhaustive, the following sensors were selected as low-cost alternative sensors for this project: magnetic, resistive force, and wave sensors.

Magnetic-resistive Sensor

- Honeywell HMC2003 three-axis magnetic sensor
- Three perpendicular magnetic-resistive sensing elements
- Magnetic field range: ±1 Gauss
- Resolution: 4 bit
- Self-powered by vehicle’s magnetic field

Ultrasonic Sensor

- Vibrationally coupled transducers: M proximity EZ series ultrasonic sensors
- Geometrically spaced sound waves
- Sample time: 0.2 ms
- Range: 20 ft
- 24 GHz radar
- Radar frequency
- Range: 710 ft

Magnetic Sensor

- Model: MaxSonar® - EZ series resistive magnetic sensor
- Magnetic field range: ±2 Gauss
- Model can be used to set numeric values for various object types.
- Magnetic sensor 3D modeling

Magnetic Sensor 3D Modeling

A mathematical model was created to understand the behavior of the magnetic signature as a vehicle passes the sensor. This model includes the effects of magnetic field strength, vehicle orientation, and number of acting dipoles. The model can be used to set numeric values for various object types. The graphs shown above represent the capabilities of individual sensors. Although ultrasonic sensors allow for rapid detection and vehicle tracking, while multiple magnetic sensors placed in fixed locations can follow for relative velocity calculations, such a sensor fusion becomes possible with the use of an intelligent algorithm.

Magnetic Sensor Results

All vehicle classes have inherent magnetic signatures that can cause localized changes in magnetic fields. A small passive magnetic sensor can detect magnetic signatures or footprints produced by all vehicles have their own magnetic signature based on their class, mass, number of wheels, and orientation. The magnetic sensor can detect magnetic fields and frequency allow for positive detection of moving vehicles and even differentiate magnetic signatures of different vehicle types. Below are the magnetic signatures for a typical heavy truck and a typical car.

Sensor Integration for Low Cost Truck Collision Avoidance

Charles Birdsong Ph.D., Peter Schuster Ph.D., Hemanth Porumamilla Ph.D., Stephane Roussel, Mario Garcia, Joey Marino

California Polytechnic State University, San Luis Obispo, CA 93407

Sensor Coverage Area

The focus of this sensor system is to prevent rear impact crashes and helps avoid blind spot detection. The sensor coverage for these crash modes require use of both short and long range sensors. In this study, both short-range and magnetic sensors provide lateral blind spot detection while the radar monitors the rear.

Sensor Analysis

A thorough test plan was carried out to validate that magnetic sensors can provide an active role in the crash avoidance system. A single magnetic sensor was set up on the lateral side of a test vehicle and used to detect magnetic signatures with vehicles.

Preliminary Combined Sensor Data

A full-scale test was carried out to validate that magnetic sensors can provide an active role in the crash avoidance system. The magnetic sensor used to detect moving objects and vehicle type. In addition, the radar provided information on vehicle velocity and direction.

Magnetic Sensor Results

A full-scale test was carried out to validate that magnetic sensors can provide an active role in the crash avoidance system. The magnetic sensor used to detect moving objects and vehicle type. In addition, the radar provided information on vehicle velocity and direction.

Fig. 1 Scale Testing

A full-scale test was carried out to validate that magnetic sensors can provide an active role in the crash avoidance system. The magnetic sensor used to detect moving objects and vehicle type. In addition, the radar provided information on vehicle velocity and direction.

Future Work

• Investigate traffic flow assessment
• Fire service, almanac, and probability functions
• Radar sensor integration
• Incorporate wireless capabilities
• Utilize automated passive sensing

Acknowledgments

The authors would like to acknowledge the following entities: Mechanical Engineering, Transportation Research Board for providing funding for this research project and for enabling this project. We would also like to acknowledge Jim Misener (California PATH) and Chris Garo (California University) for their valuable time spent in the development stage of this project. Bruce Hansen (Michael Dusi Trucking) for allowing us to use his company’s 60 foot long trailer. The technical writing and editorial work was provided by Travis Lapp, Chuck Keeler (Cal Poly Tech Writing) for his assistance with revisions.