NS 535: Driver Assist Systems to Support Snowplow Operations: Literature Search
Monday, July 09, 2018

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Resources searched: ASCE Library, MnDOT Library Catalog, Transport Database, Research in Progress, Web

Summary: Results are compiled from the databases named above. Links are provided for full-text, if applicable, or to the full record citation. I completed my searches using the following terminology: driver assist system, driver support system, lane boundary, lane guide, GPS, global positioning system, snowplow, snow plow, instrument panel, dashboard, and indicator. The results are divided into most relevant and less relevant

Most Relevant Results

Title A high accuracy vehicle positioning system implemented in a lane assistance system when GPS is unavailable / prepared by Edmund Arpin V, Craig Shankwitz, Max Donath.

Summary The use of lane assistance systems can reduce the stress levels experienced by drivers and allow for better lane keeping in narrow, bus-dedicated lanes. In 2008, the Intelligent Vehicles (IV) Lab at the University of Minnesota developed such a system for this purpose. The IV Lab lane-assist system uses dual frequency differential GPS (DGPS) for high accuracy position information. This position information is used in conjunction with a geospatial database containing the road geometry and lane boundary positions required for a lane-assistance system. In urban environments, where tall buildings, overpasses, and other obstructions to the sky are present, DGPS suffers from inaccuracies and outages. This report proposes a method for replacing DGPS sensing with a high accuracy vehicle positioning system which fuses data from RFID (Radio Frequency IDentification) and LiDAR (Light Detection and Ranging) curb detection.

A Vehicle Positioning System (VPS) was originally developed by the IV Lab to provide the lane level ("which lane on the road") position of a vehicle with respect to a known reference (i.e., a mile marker or start of roadway) by the use of encoded position information in RFID tags on the roadway, read by the vehicle. The lateral position resolution of VPS is constrained to one lane width, which is insufficient for lane-assistant systems. Thus, in-lane level ("where in the lane") lateral position estimation was supplemented by a LiDAR unit that generates an accurate position of the vehicle with respect to the curb, which is cross referenced with a map database that provides the distance from the lane center to the curb, thus providing the vehicle’s lateral offset from the lane center. On-board odometry is used to maintain accurate longitudinal position in between tag reads.

By fusing the information from the VPS, LiDAR, and on-board odometry, high accuracy, "where in lane" level vehicle positioning can be maintained from this enhanced VPS during DGPS outages.
Field Testing of the Snowplow Driver Assistance System
This task will evaluate a global positioning system (GPS) based Driver Assistance System (DAS) for 2 snowplows and 1 snowblower. This task is a follow up to task 2167 that ended on 8/30/2015. This task will complete the field testing of the DAS that was not finished in task 2167. The DAS has been installed on two snowplows and one snowblower that are used on the Donner Pass section of I-80. The system provides a high accuracy GPS map of the roadway that is displayed on a heads-up monitor. The monitor also displays vehicles picked up by forward looking radar installed on the front of the snowplow. Included are vibrating seats that let the driver know when the operator has traveled out of the lane. This system has the potential to be a valuable tool for snowplow operators during low visibility conditions.

Project
- Status: Active
- Sponsor Organizations:
  - California Department of Transportation
    Sacramento, CA  United States  95819
- Project Managers:
  - Baumeister, Larry
- Performing Organizations:
  - Regents of the University of California, Davis
    Davis, CA  United States  95616
- Principal Investigators:
  - Ravani, Bahram
- Start Date: 20151001
- Expected Completion Date: 20170523
- Actual Completion Date: 0

Title
- Evaluation of GPS-based Mountain Pass Road Opening for Tioga Pass.

Source
- 2015/7/31. 56p

URL

Abstract
- This report documents the research project "Evaluation of GPS-based Mountain Pass Road Opening for Tioga Pass." The primary goal of this project was to address porting of the GPS-based Mountain Pass Road Opening (MPRO) rotary plow Driver Assistance System (DAS) design and implementation from SR 108 to SR 120, and evaluate the system's performance in this new environment. Caltrans has eight mountain passes that are closed in the fall and opened each spring. Opening these passes is a difficult and dangerous job with few visual indicators or landmarks to guide experienced snowplow operators. Existing techniques include probing the snow pack with poles,
path staking, and active embedded cable systems, which all have associated drawbacks. MPRO uses an infrastructure-free approach that uses the Global Positioning System (GPS) to provide a real-time in-cab mountain pass road opening system for rotary plow driver assistance. Under previous research, the Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center developed MPRO to be portable, easy to install, and shareable among multiple vehicles. The MPRO system was originally developed for use on Sonora Pass (SR 108), and was tested there over five road opening seasons. The current project investigated porting the MPRO system to Tioga Pass (SR 120) and testing the system for one road opening season. The key task in porting the system, in addition to the physical installation of the hardware, was the development of a base map to support the GPS-based location of the vehicle. In the current project, a new approach was used based on Mobile Terrestrial Laser Scanning (MTLS). This approach allowed rapid generation of a highly accurate base map for use in the MPRO system. Testing on SR 120 was successful, demonstrating the portability of the MPRO system.

**Publication Year**
2015

**Title**
Evaluation of the University of Minnesota GPS Snowplow Driver Assistance Program.

**Source**
2015/8/30. 107p

**URL**

**Abstract**
The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center at the University of California-Davis, in conjunction with Caltrans Division of Research, Innovation and System Information (DRISI), identified advanced snowplow driver assistance system (DAS) technology that can significantly enhance the safety and efficiency of snow removal operations in certain parts of Interstate 80 in the Sierra mountains in northern California. The DAS was previously developed at the University of Minnesota and used by the Alaska Department of Transportation (DOT). This research evaluated the DAS as implemented for California operations and provided technical support for DAS implementation. The research included collaboration with the University of Minnesota and MTS System Corporation to instrument two snowplows and one snow blower with DAS to support scientific testing and evaluation. A Global Navigation Satellite System (GNSS) base station was established at Kingvale maintenance station in support of the DAS operation. The DAS GNSS receivers' performance was evaluated. The DAS radar unit experienced icing during heavy snowstorms. Significant effort and time was spent in developing and testing radar icing mitigation solutions. A viable solution was developed and tested near the end of the research. Limited preliminary snowplow operator feedback was collected due to lack of snow storms for DAS operational testing and evaluation with the radar icing problem fully resolved. Due to the lack of snow storms in the research period, and the time spent developing radar icing mitigation solutions, more time is required for testing and evaluation to completely establish whether the DAS would be an effective tool to reduce snowplow operator's exposure to collision and road departure risks in the poor...
visibility conditions encountered in California, and, if effective, in what ways the system can be adopted by Caltrans.

**Title**
A *Snowplow* Driver Assistance System Based on Magnetic, Radar and *GPS*.

**Source**

**Abstract**
This paper proposes a *snowplow* driver assistance system (SDAS) based on magnetic, radar and *GPS*. The SDAS functions include lane position indication, lane departure warning, road dangerous position warning and obstacle warning. The embedded magnetic reference marker system can indicate lateral position and supply the early-warning signal for the lane departure. Meanwhile, the location-based service (LBS) technology based on the *GPS* and digital maps can provide the road dangerous position warning service for the driver. In order to make up for the human eye under the low visibility conditions, we use millimeter wave radar to detect vehicles and other inorganic objects buried or obscured by snow. Millimeter wave radar has the good ability to measure the accurate distance to an object and is robust in bad weather, but the common detection results in a large number of false alarms in practice. In order to reduce the false alarms, we propose a new detection method. Extensive experimental results show that this method is efficient in detecting obstacles. The SDAS has been applied in the Northern China and can be introduced to other provinces.

**Title**
Alaska Department of Transportation & Public Facilities Intelligent Specialty Vehicle System Pilot Program Report.

**Source**
2007/3/26. 13p (1 Figs.)

**URL**

**Abstract**
The Intelligent Specialty Vehicle System (ISVS) is equipped with Precision Global Positioning System (*PGPS*) technology which is delivered in the form of Real Time Kinematics (RTK) to the vehicle from a single dedicated *GPS* base station. The vehicle mounted system has integrated collision avoidance radar technology designed to provide the driver a means to maintain desired lane position and avoid collisions with obstacles during periods of low visibility. The *PGPS* provides position information to the vehicle which can be as accurate as 3 cm. Distance from the *PGPS* determines the final accuracy, the further the ISVS is from the *PGPS*, the lower the accuracy. This project is motivated by the fact that specialty vehicles often must operate under inclement weather conditions. The driver assistive system improves safety for the specialty vehicle operator by providing the necessary cues for lane keeping and collision avoidance normally unavailable during poor visibility conditions. The driver assistive
system, when placed in snow and ice control vehicles, improves safety by facilitating all-weather road services which keep roads open and passable for other emergency vehicles and the general motoring public. A snow blower and snowplow are the primary vehicles of the ISVS project for the Alaska Department of Transportation and Public Facilities (ADOT&PF). The project implemented, operated and evaluated all necessary infrastructure components, in-vehicle sensing technology, in-vehicle processing including algorithms, and driver-vehicle interfaces. Testing of these systems took place on state highways using state vehicles under all conditions including low-visibility conditions such as snow, blowing snow, ice fog, and night.

Publication Year 2007
Title DRIVER ASSISTIVE SYSTEM FOR SNOWPLOWS.
Source Part of the Intelligent Vehicle Initiative.
URL http://www.lrrb.org/PDF/200313.pdf
Abstract A comprehensive driver assistive system which utilizes dual frequency, carrier phase real time kinematic differential global positioning system, high accuracy digital geospatial databases, advanced automotive radar, and a driver interface with visual, haptic, and audible components has been used to assist specialty vehicle operators perform their tasks under these low visibility conditions. The system is able to provide a driver with high fidelity representations of the local geospatial landscape through a custom designed Head Up Display (HUD). Lane boundaries, turn lanes, intersections, mailboxes, and other elements of the geospatial landscape, including those sensed by automotive radar, are projected onto the HUD in the proper perspective. This allows a driver to safely guide his or her vehicle in low to zero visibility conditions in a desired lane while avoiding collisions. Four areas of research, are described herein: driver assistive displays, the integration of a geospatial database for improved radar processing, snowplow dynamics for slippery conditions, and a virtual bumper based collision avoidance/gang plowing system. Results from this research have vastly improved the performance and reliability of the driver assistive system.

Publication Year 2003
Title Analysis of single frequency, carrier phase based GPS positioning performance and sensor aiding requirements / prepared by Demoz Gebre-Egziabher, Hamid Mokhtarzadeh.

Least Relevant Results
Summary
The work described in this report outlines the design and testing of a low-cost, single frequency, carrier phase positioning system. Furthermore, aiding sensor accuracy requirements are analyzed to improve the robustness of the carrier phase system after emerging from signal outages. The applications of interest are ones with safety-of-life implications such as driver assist systems.

Electronic Version
Report -

Summary -

http://hdl.handle.net/11299/144017

CTS research reports website -
- http://www.cts.umn.edu/Publications/ResearchReports/

Title
The Impact of an In-Vehicle Display on Glance Distribution in Partially Automated Driving in an On-Road Experiment.

Source
Transportation Research Part F: Traffic Psychology and Behaviour. 2018/1. 52 pp 40-50 (Refs.)

URL
http://dx.doi.org/10.1016/j.trf.2017.11.012

Abstract
One of the major challenges of designing an HMI for partially automated vehicles is the trade-off between a sufficient level of system information and avoidance of distracting the driver. This study aimed to investigate drivers' glance behavior as an indicator of distraction when vehicle guidance is partially automated. Therefore, an on-road experiment was conducted comparing two versions of an in-vehicle display (during partially automated driving) and no display (during manual driving) on a heavy congested highway segment. The distribution of drivers' total glance durations on the HMI showed that visual attention was shifted away from monitoring the central road scene towards looking at the in-vehicle display to a considerable extent. However, an analysis of the distribution of single glance durations supports the view that using partial automation and a respective HMI does not lead to a critical increase in distraction. Driving with a simplified version of the HMI had the potential to reduce glance duration on and thus potential distraction of the in-vehicle display.

Publication Year
2018