RESEARCH NOTES
TRAFFIC OPERATIONS RESEARCH
Task Order 4232
September 2006

Magnetometer/GPS/INS Demo 2003 Support and Mitigation of GPS Signal Blockage Research

Why This Research Was Undertaken

Future highways and highway maintenance systems will benefit from accurate vehicle navigation systems. Accurate navigation systems would increase the safety of emergency vehicles or highway maintenance equipment operating in low visibility conditions due to snow or fog. Accurate navigation systems would increase the efficiency of spring snow clearing operations along highways not maintained over the winter. Advanced driver warning systems require information about the vehicle position relative to a highway lane. Automated passenger, transit, or heavy vehicles require accurate roadway relative position, velocity, and orientation information. This research effort was undertaken to produce a reliable and cost effective navigation system meeting the accuracy requirements of these applications without requiring changes to the highway infrastructure.

What Was Done?

At the initiation of Task Order 4232, a working differential carrier phase GPS aided INS had been demonstrated to meet the accuracy, but not reliability requirements for advanced highway applications. It was known based on theoretical and experimental analysis that the navigation error would increase in situations where signals at least four GPS satellites could not be received. A previous research project demonstrated theoretically and experimentally that this issue could be addressed by aiding the INS with magnetometer measurements; however, the magnetometer aiding approach requires changes to the highway infrastructure. The present project investigated the use of alternative aiding signals that do not require changes to the highway infrastructure. New theoretical algorithms were developed to utilize the alternative signals both for INS aiding and for aiding of the integer resolution process. These algorithms were demonstrated using roadway elevation. Roadway elevation is easily and freely available. Use of roadway elevation does not require any changes to the roadway or any additional sensors. Reliable performance was demonstrated on passenger buses at the Crows Landing Facility. In addition, multiple differential GPS aided INS prototypes were constructed. One of these is now located at the PATH facility to facilitate future collaboration and testing at PATH.

What Can Be Concluded From The Research?

Aided inertial navigation systems offer a cost effective navigation approach for advance highway systems. The ubiquitous aiding signal is differential carrier phase GPS. DCPGPS aided INS can reliably produce the vehicle state with position accurate to 2.5 cm, when at least 4 satellite signals are being received. When signal from four satellites is not available (e.g., near trees, mountains, or tunnels), other aiding signals such as magnetometer or pseudolites would be required. Magnetometer aiding has been demonstrated. Pseudolite aiding is a current research objective. Note that other than the magnetometer approach, none of the approaches require changes to the highway infrastructure. Note also that magnetometer or pseudolite aiding is only required in the vicinity of the obstacles blocking the GPS signals.

What Do the Researchers Recommend?

Under separate funding, this technology is being evaluated for use on highway maintenance equipment. The approach is expected to succeed at this application, possible needing pseudolite or

magnetometer augmentation along limited stretches of highway. It would also be interesting to study the utility of this technology for automated highway surveying. Many applications require access to decimeter level accuracy highway databases. This technology offers a cost effective method to acquire the required data.

Implementation Strategies

Portions of this research are ready for or being commercialized. For example, Applanix (http://www.applanix.com/) now markets the POS LV Applanix developed this product independent of the UCR research, but it implements a differential carrier phase GPS aided INS similar to the one that UCR first demonstrated in 1997. This illustrates that there is commercial potential for and interest in the research that we are performing. First demonstrations through academic research often motivate future commercial products. Commercially available products are a necessary precondition to implementation of this research by CALTRANS because commercial entities are more capable than universities for supplying the required level of product support. Currently, there are no commercially available systems that utilize additional aiding signals, as feasibly demonstrated in the current project. However, commercial entities are evaluating the market potential. In the past, we have teamed with Leica. This month we plan to meet with Navcom. A main question for the commercial entities is whether the potential market is sufficient to warrant product development. Therefore we are in a 'chicken and egg' scenario where commercially available products will not become available unless the potential size of the transit market is clarified to potential commercial entities. Transportation authorities could help to clarify this potential market size.

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