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Using Vehicle-to-Vehicle Positioning to Improve the Driving Experience

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Introduction

Vehicle-to-vehicle (V2V) navigation has been an ongoing field of study in the vehicle industry, as the demand for intelligent transportation systems increases. Knowing the relative location of other vehicles could potentially allow for incorporation of safety features such as vehicle detection in blind spots, detection of slow cars ahead, and/or collision avoidance, for example. For this to be realized, however, the relative position needs to be determined with a sufficiently high level of accuracy and reliability.

Figure 1: Typical Driving Environments in the Calgary Area (Alves et al, 2010)

Testing Procedures

Drivers today experience a variety of environments; most of which cause difficulties in positioning with GPS alone. To simulate standard driving conditions, a road test was conducted in February of 2010, in the northwest section of Calgary, Alberta.

Figure 3: Road Test in Open Sky Scenario

Observation combinations used:

- GPS Only Solution
- GPS and Ultra Wide Band Solution
- GPS and Bearing Solution
- GPS, Ultra Wide Band, and Bearing Solution

Figure 4: Road Test in Industrial Scenario

Additionally, different sensor combinations were tested in various environments to illustrate the benefits and shortcomings of each additional data source in realistic scenarios, such as:

Open Sky (Ideal): An area that has an unobstructed view of the sky, as seen in Figure 3. All satellites visible to the specified location will be able to provide observations.

Industrial (Average): An area where a portion of the visible sky is blocked by a man-made structures, as seen in Figure 4. Some satellites may be unable to provide quality observations as a result of this obstruction.

Residential/Foliage (Average to Harsh): An area where the visible sky is partially obscured by vegetation and natural objects, as seen in Figure 5. Again, some satellites may be unable to provide quality observations depending on the density of the area in question.

Figure 5: Road Test in Residential Scenario

Conclusion

The results obtained from the above testing procedure and analysis illustrate how UWB and bearing measurements can significantly improve positioning accuracy and reliability, particularly in environments where GPS availability is poor. Ultimately, these findings are useful for the development of future V2V technology that will allow users to better navigate their world in a confident and safe manner.

Problem Definition

Until most recently, GPS has served as the primary source of information for positioning systems, but GPS alone cannot deliver the performance levels desired for positioning of moving vehicles in all situations. The absence of an accurate GPS solution is a result of limited satellite availability, and by incorporation of additional measurement methods, a more consistent positioning solution can be obtained. To this end, two additional sensors, namely Ultra Wide Band (UWB) radios and bearing (direction) sensors, have been integrated with GPS to achieve more accurate and reliable V2V performance and to do so more often.

The main objective of this research project was to augment existing GPS-only relative positioning software with UWB and bearing data, and to assess the improvement in performance that can be realized.

Figure 2: GPS and UWB Equipment Setup on Test Vehicle

Results

An analysis of the data collected from the road test showed significant improvement in the positioning solution of the vehicles. To better understand the augmentation improvements, the positioning errors were split into two directional movements: across track (perpendicular to motion of vehicle) and along track (parallel to motion of vehicle). For simplicity, the results are shown for one vehicle.

Positioning Errors for Industrial Scenario

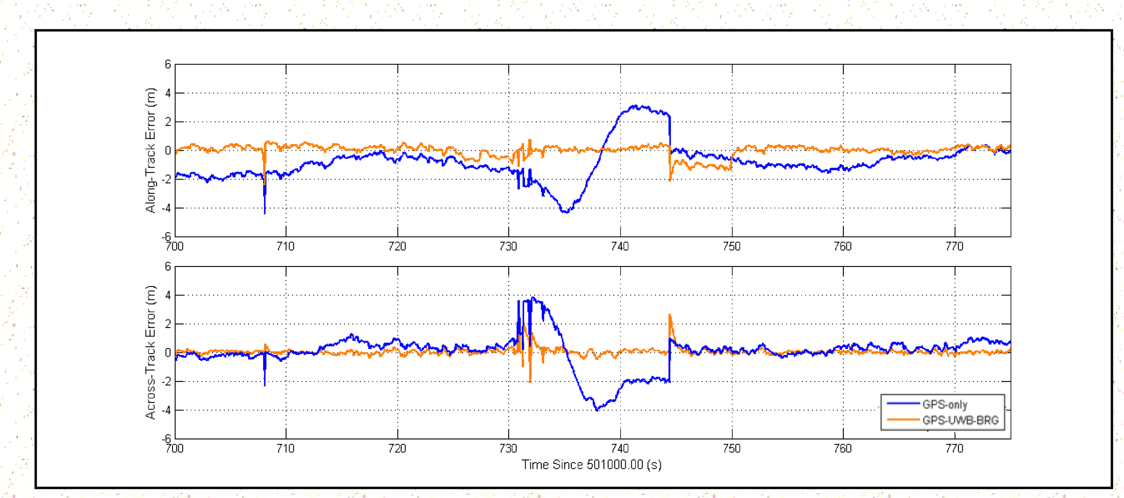

Figure 6: Along and Across Track Errors in Industrial Scenario

Figure 6 shows the along and across track errors during the urban canyon scenario. In this environment, several errors affect the positioning solution as one satellite is removed due to obstruction by the Children's Hospital, and the building itself reflects signals of interest (multipath). The orange line indicates the GPS-UWB-Bearing solution, and clearly indicates the most accurate solution with the least variability. In fact, the positioning error in the along track direction decreases from a mean value of 0.82m (GPS-Only) to 0.12m.

Figure 7 shows the along and across track errors during the residential scenario, with significant foliage cover. As can be seen in the plot, around GPS time 502860 (1860 on the plot) there is a data outage in the GPS–only solution (blue line) causing fairly large errors in positioning for about 10 seconds. The GPS-UWB-Bearing solution (orange line) indicates that the errors are not only smaller, but the recovery time is about 4 seconds. By using all available observations, the mean positioning error in the across track direction improves from –4.27m (GPS-Only solution) to -0.33m.

Positioning Errors for Residential Scenario

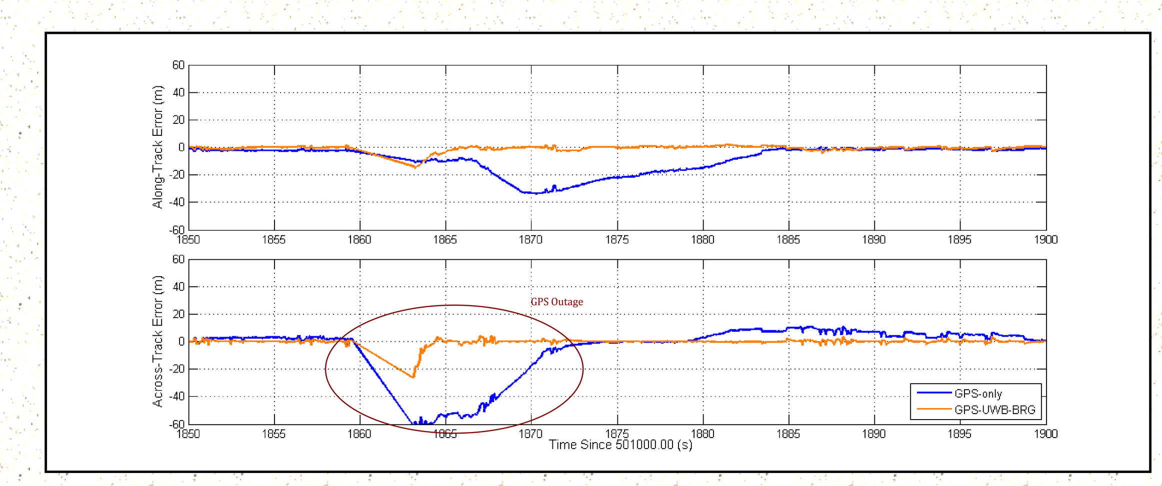

Figure 7: Along and Across Track Errors in Residential/Foliage Scenario

In this manner, during GPS signal outages, the additional observations present in the positioning solution allow for a reliable solution to still be obtainable.

References and Acknowledgements

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