ABSTRACT

The performance of car navigation systems depends on the absolute location information provided by Global Navigation Satellite Systems like GPS. Whilst multiple techniques exist for the estimation of a vehicle location, most provide only relative information which is then used to reduce inaccuracies encountered in GPS receivers. Nevertheless, GPS estimations remain the most used and reliable source of absolute location information. The use of stored digital road networks as a priori information together with communications and localisation technologies is opening multiple opportunities for mobile ‘location aware’ applications.

This paper describes a novel; metrics based method for the evaluation of GPS receivers in real traffic conditions. For this purpose, the trajectory of the test vehicle is measured in real-time at a high accuracy using a tactical level inertial measurement unit, a surveying grade GPS and odometry. The results are exploited as the ground truth with respect to which the location estimations acquired concurrently by several GPS receivers are compared. To avoid any EMC issues, all GPS receivers use the same antenna. With this experimental setup, it was now possible to compare their response with regard to the ground truth. Statistics on error spreads under various test conditions can be generated and thus quantitative rather than qualitative results obtained. To facilitate their interpretation, it is necessary to include information on the environment traversed by the vehicle, the context, for this reason results were plotted on satellite images using the Google Earth software.

In these conditions, a systematic series of tests runs were done, these were structured according to the availability of line of sight signals from the constellation of GPS satellites, on the vehicle onboard GPS receivers. These tests were classified into use cases according to the level of occlusion encountered. These include rural, peri-urban and urban areas as well as special cases like urban canyons and tunnels. A complete set of results will be presented together with their statistical analysis and interpretation.

The experiments have shown that estimations differ greatly from manufacturer to manufacturer in all conditions except when vehicles are driven in open scenarios. That is, the location estimations are different following the assumption embedded in the receiver software, e.g. as the vehicle enters a tunnel, one GPS receiver will stop generating estimations, others will presume the vehicle moves at a constant speed and in a straight line, whilst others will perform estimations on the multipath signals received. Other than the precision problem, it was observed that some receivers showed a kind of overshoot response as the vehicle moves at speed on a curve, the location estimates will be laterally and longitudinally away from the ground truth. The same response is obtained at roundabouts. It was also found that different behaviours exist as the vehicle enters or exits a tunnel.

Urban Canyons are scenarios where most difficulties exist; all the tested GPS struggled to attain good estimations, hence the need to use other observations to improve estimation precision and continuity. It is found that all GPS receivers respond differently, as such, if these are changed, extensive tuning and testing will be necessary on the car navigation systems and applications, to take into account the different responses.

Figures 1 and 2 present a sample of the type or results that the paper will include, location estimates and statistics.
Sample Publications

Figure 1. GPS positions’ drifts at high dynamic trajectories in wooded area (ground truth in yellow).

Figure 2. Error distribution for a GPS receiver on the trajectory shown in Figure 1.