GNSS USER INTEGRITY ASSESSMENT IN DIFFERENT ENVIRONMENTS USING A FISHEYE CAMERA SYSTEM

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Keywords

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Abstract

PNT users more and more tend to exploit multiple sensor data to aid Global Navigation Satellite Systems (GNSS) in challenging environmental conditions. The use of camera systems in this field is getting more attention. These sensors represent an added-value by classifying the surroundings of any user in order to analyse whether an observed satellite signal is either line-of-sight (LOS) (i.e. direct path) or non-line-of-sight (NLOS) (i.e. different from the nominal). This classification can be used, among others, to characterize, weight or exclude observations in the process of acquiring position, velocity, and timing (PVT) solutions. This application may be used in, for example, the field of autonomous driving vehicles.

This study, however, focusses on the use a fisheye camera system to assess the availability and reliability of GNSS in challenging environmental scenarios, and therefore characterize the effect of such conditions at user level. To classify satellites as LOS or NLOS, the recorded fisheye camera image needs to be segmented into sky and non-sky regions. Different image segmentation algorithms are assessed which can be roughly classified into image histogram based segmentation techniques and image gradient segmentation techniques. To ensure robustness of segmentation, the different algorithms are benchmarked using a set of reference images for which the segmentation is known a-priori. This set of reference images contains a number of different environments (urban canyon, dense vegetation, and open sky) as well as a number of different weather conditions (sunny, cloudy, and dusk). Although, the image histogram based segmentation is generally able to observe more features, the marker based watershed algorithm (using the image gradient) performs better, especially in sunny conditions (i.e. in which the pixel intensity strongly varies in the sky segment).

The calibration required for the correct mapping of the satellites onto the image is further improved with respect to existing methods. This is accomplished using a genetic algorithm selecting an optimum set of calibration images considering, among others, good coverage of the field-of-view of the camera as well as the image re-projection error. This approach is validated using a static test in which the CN_0 for the classified satellites (NLOS or LOS) is assessed.

In addition, the classification of the satellites (provided by the image segmentation algorithm) can be used to filter the observations in the process of obtaining a PVT solution. The resulting positioning improvement is used to validate the correct image segmentation of a complete set of test campaign results.

Using the aforementioned approach, the camera footage of test campaigns in Haarlem (dense vegetation), Rotterdam (urban canyon), and Amsterdam (urban)

in the Netherlands are analysed. The classification of the available satellites as either LOS or NLOS gives an estimation on the reliability of GNSS in these different environments. The reliability and availability of GNSS directly relates to the attainable positioning accuracy, among others through the effect on the geometric dilution of precision (GDOP). Therefore, these types of testing can be, for example, used to assign regions in which GNSS augmentation services might be desired.

Affiliations

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