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EFFECTS OF INCLINOMETER ERROR ON STAR SENSOR POSITION ACCYURACY

Abstract

Recently attempts to find a solution to compensate for Global Positioning System (GPS) deficiencies has increased due to various requirements from civil and military applications. These deficiencies include mainly intentional or unintentional loss or manipulation of signals which leads to loss of precise position information. Several replacements for GPS have been introduced so far but one of the potential candidates is utilization of star sensors. For position determination using star sensor, the information of orientation, exact time of capturing the star image and deviation from local vertical are required. Orientation is determined by default application of available star sensors. Image capturing time can be provided from onboard timing systems which can vary from GPS to atomic clock. Deviation from local vertical can be determined using a set of inclinometers or Inertial Measurement Unit including gyroscope. Accuracy of resulting system depends on these three main elements as well. Bright point position affects the accuracy of transfer matrix between Inertial and Body reference frame. Time accuracy affects the transfer matrix between Greenwich and Inertial reference frame. Accuracy of inclinometer effects transfer matrix between local horizontal plane and Body frame which has an important role on overall position determination accuracy. In this paper effect of inclination measurement accuracy on position results are analyzed using Monte-Carlo simulations. For this purpose 200 random positions are simulated. Camera boresight in each position is pointed to sky in equal steps between -30 to +30 degree zenith angle. The only source of error is placed on inclinometer accuracy in measuring the stable platform inclination from horizon. In each position 1000 images with random error on inclinometer are examined. No additional error such as bright point position or time is applied to examine the nominal performance of position determination. Using sequential transfer matrix method, attitude matrix along with timing information and transfer matrix between local horizontal plane and body frame are combined to derive the same position that is initially simulated. Results demonstrate that position determination using star sensor shows its highest accuracy while aligned in the opposite direction of local vertical or zenith. Net error increases while deviating from zenith depending on inclinometer resolution. This study demonstrates that 0.001 degree nominal accuracy is acceptable within aforementioned range of zenith deflection. Therefore depending on hardware overall precision, more common inclinometers can be selected to reduce the fixed price.