Mitigation of G-Dependent Gyro Errors through Vision Aiding

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ABSTRACT

Accurate positioning of first responders, electronic monitoring, and military personnel is often critical in GNSS denied environments. In such environments, Inertial Navigation Systems (INS) are typically the preferred tool to be used for navigation. When large accelerations (e.g. > 1g) are experienced by the gyro, mass imbalances due to manufacturing, result in acceleration sensitive errors. The error is commonly called the g-dependent bias and can impact the MEMS rate gyros to 100 degrees / hour / g when uncompensated. In order to sustain an accurate navigation solution for long durations, the gyroscope g-dependent bias has to be measured and mitigated. Ideally, this calibration is done in situ, rather than in a factory.

The angular rate obtained using visual information is independent of the errors affecting the gyroscope. Man-made environments are commonly full of straight and parallel lines found in orthogonal directions. Perspective projection mapping transforms the three-dimensional scene into two-dimensional images. The process maintains the straight lines but modifies their parallelism resulting in an apparent intersection point of the lines. This point is called the vanishing point. Lines in three orthogonal directions constitute three vanishing points. The vanishing point locations are dependent on the camera rotation, but not of the translation. By monitoring the motion of the vanishing point locations in consecutive images, the roll, yaw and pitch angular rates may be obtained. The angular rates may then be used to calibrate the gyroscope during navigation and mitigate the effect of the g-dependent bias as well as the gyro bias.

The performance of the visual-aided INS based navigation approach is evaluated. A camera is attached to a body and helmet of a user going through typical high acceleration situations and the gyroscope errors are mitigated with the method explained above. The visual-aiding correction of the g-dependent errors is anticipated to significantly improve the positioning accuracy.

KEYWORDS: Visual-aiding, vanishing point, g-dependent bias, gyroscope, calibration.