Information

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- Title :
  A Portable and Cost-effective Configuration of Strap-down INS/GPS for General-purpose Use

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Abstract

In this paper we suggest a new configuration of strap-down INS/GPS (Inertial Navigation System/Global Positioning System) integrated navigation system suitable for general-purpose use. The goal of our study is to develop a low-cost, small and light strap-down INS/GPS that have good precision as much as possible. We build a prototype system based on the configuration and do a test. The result shows it has precision enough for controlling or monitoring general moving objects.

The motivation of our study is derived from today ' s demands for controlling or monitoring moving objects such as vehicles, robots and so on. Strap-down INS/GPS systems have much potential to be served in these applications because they give precise state values: position, velocity and attitude of the moving objects. However, there are rare cases where existing INS/GPS implementations are employed on the objects. This is because most of them are intended for precision top priority uses such as aircrafts and spacecrafts and they are unsuitable for other purposes in their portability and cost efficiency. They use big, heavy and expensive dedicated components.

Therefore we propose the new strap-down INS/GPS configuration. The configuration is based on decentralized INS/GPS integration, so-called " loose coupling " , with Kalman filtering. It is characterized by two features. The first feature is to use MEMS (microelectromechanical system) inertial sensors and a civil-use GPS receiver as INS/GPS components. Each sensor with low Signal/Noise (S/N) ratio does not have precision enough for navigation but is low-cost, small and light. The other feature is quaternion modeling. It is noted that applying extended Kalman filtering (EKF) to non-linear system models that have low S/N ratio inputs often causes divergence because linearized models in the EKF does not reflect correctly real models. To decrease possibility of divergence, we simplify the models mathematically to reduce the error between described models and real models. In the system model we express position and attitude in quaternion to eliminate singular points. Additionally, in the error model for EKF, we use multiplicative quaternion as error residues to keep unity of quaternion.

In order to examine the effectiveness of our configuration, we built a prototype system and did an experiment. The system consists of tri-axes MEMS accelerometers and tri-axes MEMS gyros and an L1-wave GPS receiver module, and has a USB interface to a data acquisition PC. Our developed prototype system is far smaller, lighter and more inexpensive than existing ones. Moreover, the experiment for comparing the prototype with GAIA, a high-precision INS/GPS instrument developed by Japan Aerospace Exploration Agency (JAXA), is performed in flight of an experimental aircraft MuPAL-alpha of JAXA. The result shows that the difference of the attitude values outputted from the two systems is no more than ten degrees. The experiment demonstrates our developed prototype system achieves our goal.