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MODELING OF SENSOR ERROR EQUATIONS FOR GPS/INS HYBRID SYSTEMS

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Abstract. *In this paper, we develop identification methods for IMU (Inertial Measurement Unit) sensor error models in the GPS/INS hybrid systems. GPS provides high-accuracy position, velocity. The main factor limiting the use of GPS is the requirement for line-of-sight between the receiver antenna and the satellites. On the other hand, an Inertial Navigation System (INS) provides position, velocity and attitude autonomously at a rate of several tens of Hz. However, its errors are accumulated owing to drift of IMU. In order to overcome the inherent drawbacks of each system, integrated GPS/INS systems have been developed. In this paper, for more accurate positioning, we develop the identification methods for IMU sensor error models in the hybrid navigation system.*

In the hybrid navigation for keeping accurate positioning, GPS/IMU coupled methods and filtering techniques have being investigated for past two decades. IMU sensor errors models (bias, scale factor and noise) are assumed as stochastic models such as Gauss Markov (GM) model. For most navigation-grade IMU such as ring laser gyro (RLG), 1st order Gauss-Markov models are usually used for the hybrid navigation. This is also true for low-cost IMU sensors such as fiber optical gyro (FOG) and micro electro mechanical systems (MEMS) although sometimes a random walk process is utilized instead. In this paper, we discuss IMU stochastic error modeling applying autoregressive (AR) models of orders higher than one [2]. Namely, the IMU sensor errors are modeled as the high-order vector autoregressive (VAR) models. The best order of AR models is determined by Akaike's information criterion [1]. First, we discuss nonlinear filtering construct and In-Motion alignment methods to estimate the initial attitude and heading of INS. Next, we examine sensor error model and sensor error state equation. Based on the above method, we show the experimental results under considering the static situation. The sensor error models applying VAR models execute the decreasing of error factor of AR coefficient by considering of axis correlation.
Keywords: Sensor error model, VAR, GPS/INS hybrid system, MEMS

1. **Introduction.** The INS numerically integrates accelerations and angular rate to determine the mobile object's velocity, position and attitude relative to a known starting point. These navigation states must be initialized at the starting point. Figure 1 shows the architecture of strapdown INS with major computational components.

The INS information such as position, velocity and attitude that are obtained by Inertial Navigation composed of a gyro and an accelerometer. It is necessary to transform the sensor data output in the body frame into the local-level frame. And position and velocity are calculated by double integral. Therefore, it is important to estimate sensor error vectors δa_k, $\delta\omega_k$ of the navigation system.

$$a_k = a_k^t + a_k^g + \delta a_k \tag{1}$$

$$\omega_k = \omega_k^t + \delta\omega_k \tag{2}$$