Optimizing of ANFIS for estimating INS error during GPS outages.

ABSTRACT

Global positioning system (GPS) has been extensively used for land vehicle navigation systems. However, GPS is incapable of providing permanent and reliable navigation solutions in the presence of signal evaporation or blockage. On the other hand, navigation systems, in particular, inertial navigation systems (INSs), have become important components in different military and civil applications due to the recent advent of micro-electro-mechanical systems (MEMS). Both INS and GPS systems are often paired together to provide a reliable navigation solution by integrating the long-term GPS accuracy with the short-term INS accuracy. This article presents an alternative method to integrate GPS and INS systems and provide a robust navigation solution. This alternative approach to Kalman filtering (KF) utilizes artificial intelligence based on adaptive neuro-fuzzy inference system (ANFIS) to fuse data from both systems and estimate position and velocity errors. The KF is usually criticized for working only under predefined models and for its observability problem of hidden state variables, sensor error models, immunity to noise, sensor dependency, and linearization dependency. The training and updating of ANFIS parameters is one of the main problems. Therefore, the challenges encountered implementing an ANFIS module in real time have been overcome using particle swarm optimization (PSO) to optimize the ANFIS learning parameters since PSO involves less complexity and has fast convergence. The proposed alternative method uses GPS with INS data and PSO to update the intelligent PANFIS navigator using GPS/INS error as a fitness function to be minimized. Three methods of optimization have been tested and compared to estimate the INS error. Finally, the performance of the proposed alternative method has been examined using real field test data of MEMS grade INS integrated with GPS for different GPS outage periods. The results obtained outperform KF, particularly during long GPS signal blockage.

Keyword: Adaptive neuro-fuzzy inference system; Global positioning system; Inertial navigation system; Particle; Swarm optimization.