ABSTRACT

The main driving force to integrate these two navigation systems as an integrated GPS/INS system in different architectural forms to provide robust positioning. The complementary advantages of GPS and INS have been extracted. The loosely coupled and tightly coupled GPS/INS systems have been in existence for more than two decades and performed reasonably well, nevertheless, the tracking performance was still a problem to be addressed in non-benign environments such as dynamic scenarios, indoor environments, urban areas, under foliages etc., where the GPS tracking loops lose lock due to the weak signals, subjected to excessive dynamics or completely blocked.

The strong force for this research, therefore, was to address these limitations with ultra-tight integration architecture of GPS/Pseudolite/INS system using Kalman filter. The main research contributions are written in brief:

1. The performance of the tracking loops in dynamic scenarios were analysed in detail with both conventional and ultra-tight software receivers. The stochastic modelling of the INS-derived Doppler is of the most important in improving the merits of ultra-tight integration, and therefore, two popular stochastic techniques—Gauss Markov (GM) and Autoregressive (AR), were investigated to model the Doppler
signal. The simulation result illustrated that the AR method will provide better accuracies and is more efficient. The algorithms to determine the AR parameters (order and coefficients) were also provided.

2. The different mathematical relationships were derived in detail to explain and understanding of the ultra-tightly integrated system. The Kalman filter design and its implementation were also provided. The required simulations were conducted to study the performance of the filter, and the results confirm the underlying assumptions in the theoretical analyses and the mathematical derivations. Covariance analysis was also performed to study the convergence and stability effects of the filter.

3. It was proposed to increase the sampling rate of the INS-derived Doppler by an Interpolator, designed by signal processing techniques. Two optimal techniques were investigated – Polyphase and Cascaded Integrator Comb (CIC), to efficiently realise the interpolator transfer function. The results show that CIC was more efficient than polyphase in accuracy and real-time implementations.

4. The ultra-tight integration of Pseudolites (PL) and INS was analysed for an indoor environment. The ‘Pseudolites-only’ and ‘Pseudolite/INS’ modes were compared for acquisition and tracking performances. The impact of the inertial
signals aiding was also studied. Improvement of the overall tracking performance was obtained by the addition of the inertial signals with the baseband loops (acquisition and tracking). An overall effect of the pseudolite signal propagation is also shown.

5. The proposed algorithms and design of the ultra-tightly integrated systems were evaluated by proper Simulations. A comparison was also done between GPS/PL/INS and GPS/INS integrated systems to study the potential advantages of the pseudolite integration. The results confirm that the developed mathematical models and Algorithms are correct.