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Station Based Polynomial Modeling of the local ionospheric Vertical Total Electron Content (VTEC) using Particle Filter

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In this study, particle filter (PF) which is mainly based on the Monte Carlo simulation technique has been carried out for polynomial modeling of the local ionospheric conditions above the selected ground based stations.

Less sensitivity to the errors caused by linearization of models and the effect of unknown or unmodeled components in the system model is one of the advantages of the particle filter as compared to the Kalman filter which is commonly used as a recursive filtering method in VTEC modeling. Besides, probability distribution of the system models is not necessarily required to be Gaussian. In this work third order polynomial function has been incorporated into the particle filter implementation to represent the local VTEC distribution. Coefficients of the polynomial model presenting the ionospheric parameters and the receiver inter frequency biases are the unknowns forming the state vector which has been estimated epoch-wise for each ground station. To consider the time varying characteristics of the regional VTEC distribution, dynamics of the state vector parameters changing permanently have been modeled using the first order Gauss-Markov process. In the processing of the particle filtering, multi-variety probability distribution of the state vector through the time has been approximated by means of randomly selected samples and their associated weights. A known drawback of the particle filtering is that the increasing number of the state vector parameters results in an inefficient filter performance and requires more samples to represent the probability distribution of the state vector. Considering the total number of unknown parameters for all ground stations, estimation of these parameters which were inserted into a single state vector has caused the particle filter to produce inefficient results. To solve this problem, the PF implementation has been carried out separately for each ground station at current time epochs. After estimation of unknown parameters, Ionospheric VTEC map covering the predefined region has been produced by interpolation. VTEC values at a grid node of the map have been computed based on the four closest ground stations by means of inverse distance squared weighted average. The GPS data which is acquired from ground based stations have been made available from the International GNSS Service (IGS) and the Reference Frame Sub-commission for Europe (EUREF). Raw GPS observations have been preprocessed to detect cycle slips and to form geometry-free linear combinations of observables for each continuous arc. Then the obtained pseudoranges have been smoothed with the carrier to code leveling method.

Finally, the performance of the particle filter to investigate the local characteristics of the ionospheric Vertical Total Electron Content (VTEC) has been evaluated and the result has been compared with the result of a standard Kalman filter.

Keywords: ionosphere, GPS , Particle filer, VTEC modeling