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KALMAN FILTER ADAPTATION ON UNDERLYING VOLTERRA'S PRINCIPLE – ESTIMATABLE MODELING APPROACH TO NATURALLY COMPLEX SYSTEMS –

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Abstract. *Being intended for in situ adaptation of self-location processes by using GPS, a mathematical model of pointing residual is considered from the view point of electro-chemical complexity in the ionosphere. As the empirical basis of the investigation, first, two kinds of experimental data are analyzed: atmospherics observed by the EXOS-D satellite and the GPS residual. Results of finite Fourier series analysis of the electron density and the positioning residual exhibit a common drift term of the same time scale. Integrating these experimental results with geophysical knowledge on electro-chemical processes, a structural model is presented for describing ionosphere dynamics in terms of competitive growth of electrons and positively charged particles. Next, the random behavior of the time evolution of the populations of electrons and charged particles is formalized by stochastic differentials satisfying the Volterra's principle in a stochastic sense. By associating the population of the electrons with the observation of the GPS residual, the Kalman filter is designed for generating population estimates of charged particles which in turn, provides the level of electron density. In implementing the filter dynamics, the state dependence of process noise is renormalized in terms of the state estimate itself. The validity of this renormalization is demonstrated in the sense of estimatability; associated filter dynamics can afford to generate positive population estimate throughout risky intervals in which the state estimate approaches to zero. By invoking the Volterra's principle as the criterion of model consistency, finally, an adaptation scheme is introduced to filter dynamics. Through experimental studies, the adaptation scheme was verified to restore the ionospheric term of the positioning residual Simultaneously, experimental results demonstrate that the modeling process can be completed before receiving two full frames of a GPS navigation message.*

Keywords: Nonlinear signal processing, Ionosphere dynamics, Volterra's principle, Kalman filter, Estimatable model

1. **Introductory Remarks.** The Kalman filter established within a linear Gauss-Markov framework has been applied to extended classes of practical complex systems. In the exploration of 'extended' filtering beyond the horizon of the linearity combined with 'white' randomness, signals to be processed are assumed to be generated within the space of stochastic systems slightly deviated from 'original' states. However, it is not easy to have *a priori* evaluation on the equivalence of the solutions to shifted systems with target signals