Grey Relational Analysis-Aided H_∞ Filtering for GPS Navigation

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ABSTRACT

Kalman filter, while employed in the GPS receiver as the navigational state estimator, provides optimal solution if the noise statistics for both the measurement and the system process are completely known. In Kalman filter designs, the divergence due to modeling errors is critical. Poor knowledge of the models may seriously degrade the Kalman filter performance, and even provoke the filter divergence. If the input data does not reflect the real model, the KF estimates may not be reliable. The case that theoretical behavior of a filter and its actual behavior do not agree may lead to divergence problems. In system design, H_∞ filter can be employed to ensure that the energy gain from the disturbances to the estimation error will not exceed a pre-specified level. The philosophy of such type of filter is designed based on the approach of linear quadratic (LQ) game theory, which is sometimes called a *minimax* filter due to the fact that it minimizes the worst-case performance under noise uncertainties. Results based on H_∞ filtering approach may provide better performance than those based on standard Kalman filtering when the noises are non-Gaussian, or when the statistical knowledge of noise is poor. The more the uncertainty of noise knowledge is, the worse the solution of the Kalman filter becomes.

In this paper, tuning of the prescribed level of noise attenuation (γ) of the H_∞ filter is performed through the grey relation. The system with partial unknown structure, parameters, and characteristics is called a grey system. The grey system theory can be employed to improve the navigation accuracy performance without sufficient information or with highly nonlinear property. The grey relational analysis (GRA) uses information from the grey system to dynamically compare each factor quantitatively. This approach is based on the level of similarity and variability among all factors to establish their relation. The relational analysis suggests one approach to make prediction and decision, and generate reports that make suggestions for tuning the parameter. It also provides data to support quantification and comparison analysis. The GRA-aided H_∞ filtering for GPS navigation processing is conducted and the resulting performance is discussed.

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