Nonlinear State Estimation with Missing Observations Based on Mathematical Programming

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The contribution deals with two problems in the state estimation – a bounded uncertainty and missing measurement data – which frequently occur in many practical application. An algorithm for the state estimation of a non-linear discrete-time state-space model with bounded uncertainty (SU model) is proposed here that copes with situations when some data for identification are missing. An estimation of the state and measurement noise bounds is included into the proposed algorithm.

The Bayesian approach is used and maximum a posteriori probability estimates (MAP) are evaluated. As the model uncertainties are supposed to have a bounded support, the searched estimates lie within an area that is described by the system of inequalities. In consequence, the problem of MAP estimation becomes the problem of nonlinear mathematical programming (NLP). The estimation with missing measurements data reduces to the omission of corresponding inequalities in NLP formulation.

The proposed estimation algorithm is applied to the off-line estimation of a moving vehicle position. The position is measured by global positioning system (GPS) but outages occur in the measurements. During these outages, the actual position is estimated using data from the inertial measurement sensors as velocity and yaw rate. A model of the moving vehicle is constructed using kinematics laws. This model can be applied on an arbitrary type of ground vehicle.

The contribution also discusses a setting of initial conditions for the estimation process. To prevent numerical instability of the algorithm based on NLP, a starting point of the optimization has to be set appropriately. Here, we propose its setting in the following way. We construct simplified model of moving vehicle whose states coincide with states of the proposed non-linear SU model. The obtained linear uniform state-space model is estimated and resulting state estimate is set as a starting point for the subsequent NLP.

The proposed algorithm is an alternative to the standardly used Kalman filter based algorithms. It is simple to perform and it need no demanding initial setting. Introduced model uses readily available data.

References

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