Robust Kalman Filtering Techniques Applied to Train Positioning

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Position and speed are two essential variables in a vehicle application. Various levels of precision and integrity are required, depending on the objectives. For instance, from a security point of view, i.e., to avoid collisions, providing a confidence interval prevails upon precision.

State estimation techniques are a natural way to estimate these variables by blending measurements and process modelling. One can quote Kalman filtering based on GPS (Global Positioning System) and INS (Inertial Navigation System) [5], particle filtering for positioning, navigation and tracking applications [1], [2] or nonlinear filtering in maritime applications [3], [4]. However, all these techniques require an accurate model. To handle model uncertainties, robust filters have been proposed [6], which bound the l_2 norm of the operator from the input disturbances and initial estimation errors to the estimation errors, provided the model uncertainties have a bounded H_∞ norm.

In this study, a classical Kalman filter and a robust filter are designed and compared in the context of train positioning. These filters are based on a one-dimensional kinematic model, and several sensors providing position, velocity and/or acceleration measurements at asynchronous discrete times. These sensors include odometers, radars and accelerometers. Measurements have been recorded in real-life experiments and put together in a database.

Accelerometers require a special attention as their measurements are influenced by the track gradient. The steeper the slope, the more the accelerometer output is biased by the gravity acceleration. In a real configuration, only one accelerometer is available. In order to handle the erroneous sensor output, a slightly modified version of the robust filtering algorithm described by Mangoubi [6] is developed, which takes asynchronous data into account.

References

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