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Uncertainty Estimation for Kinematic Laser Tracker Measurements

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ABSTRACT

Laser trackers are widely used to measure kinematic tasks such as tracking robot movements.
Common methods to evaluate the uncertainty in the kinematic measurement include approximations specified by the manufacturers, various analytical adjustment methods and the Kalman filter. In this paper a new, real-time technique is proposed, which estimates the 4D-path uncertainty of an arbitrary path in space. This method can be applied to processes, which include various types of kinematic behaviour, constant velocity, variable acceleration or variable turn rates.
Both the Kalman filter and the proposed approach rely on Bayesian filtering, but the new approach also applies a hybrid system estimator to deal with the different kinematic characteristics of a process. The Interacting Multiple Model (IMM) filter and the Residual Mean Interacting Multiple Model (RMIMM) filter are both separately employed as hybrid system estimators, in conjunction with a bank of Bayesian filters. In order to include the influence of kinematic behaviour within the measurement model, an existing static model has been augmented. Application of the Monte Carlo method results in a reliable estimator of uncertainty in the measurement model.
The new approach is compared with the Kalman filter and a manufacturer's approximations. The comparison was made using data obtained by tracking an industrial robot's tool centre point (TCP) with a Leica laser tracker AT901. The predefined trajectory describes the edges of cube and semi-circles on its sides. It shows that the new approach is more appropriate to analysing kinematic processes than the Kalman filter, as it reduces overshoots and decreases the estimated variance. In comparison with the manufacturer's approximations, the new approach takes account of kinematic behaviour, with an improved description of the real measurement process and a reduction in estimated variance. This approach is therefore well-suited to the analysis of kinematic processes with unknown changes in kinematic behaviour.

KEYWORDS: Laser tracker, kinematic measurement, hybrid system estimator IMM / RMIMM, uncertainty estimation, Bayesian filtering