Optimization-based Inertial Motion Tracking in the Presence of Uncertainties

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Inertial motion tracking focuses on estimating the relative position and orientation (pose) of a moving object. To this end, inertial sensors (3D accelerometers and 3D gyroscopes) are placed on the object of interest. For systems with a high degree of freedom, such as humans, multiple sensors can be placed on different moving segments resulting in a sensor network. Constrained sensor networks are subject to correlations between sensor measurements and their uncertainties which can be exploited fur applications such as human motion tracking.
Each sensor's pose can be estimated by integrating the gyroscope data and double integrating the accelerometer data in time. For ideal sensors, this would allow us to estimate the pose correctly. Unfortunately, such sensors do not exist, and each sensor is subject to different error sources which lead to a drifting estimate over time.
To obtain highly accurate state estimates, it is crucial to model the uncertainty of the sensors, as well as those of aiding sources and make use of the system constraints. In combination with reliable identification of sensor and system parameters such as scale factors of the inertial sensors or the displacement between different sensors, a good tracking performance can be achieved.
In this talk, we give an overview of the methods we use to tackle uncertainties in our optimization-based estimation framework for inertial motion tracking. Besides showing the importance of uncertainty modeling, we present different methods for the propagation of the arrival cost and the computation of state uncertainties. Finally, we show how an optimization-based estimator can recover from an imperfect and therefore uncertain calibration of sensor and system parameters in a real-time motion tracking scenario. The results show improved performance in comparison to traditional Kalman filtering.

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