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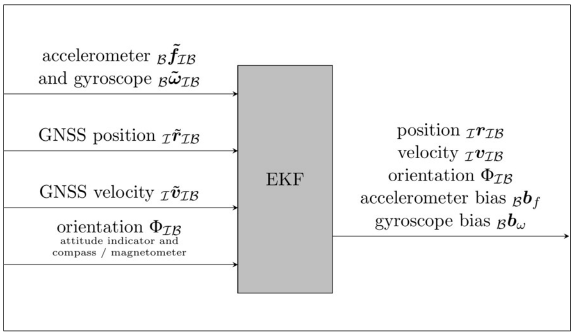
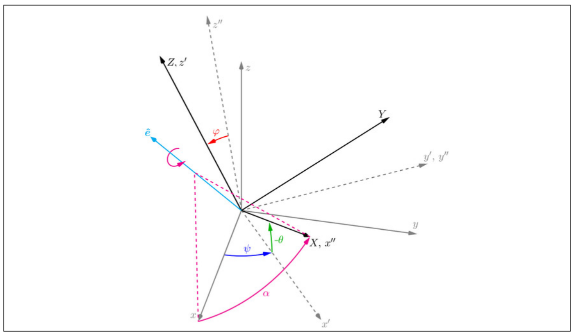
Subject Area	Sensor, Actuator and Communication Systems

Helicopter Tracking

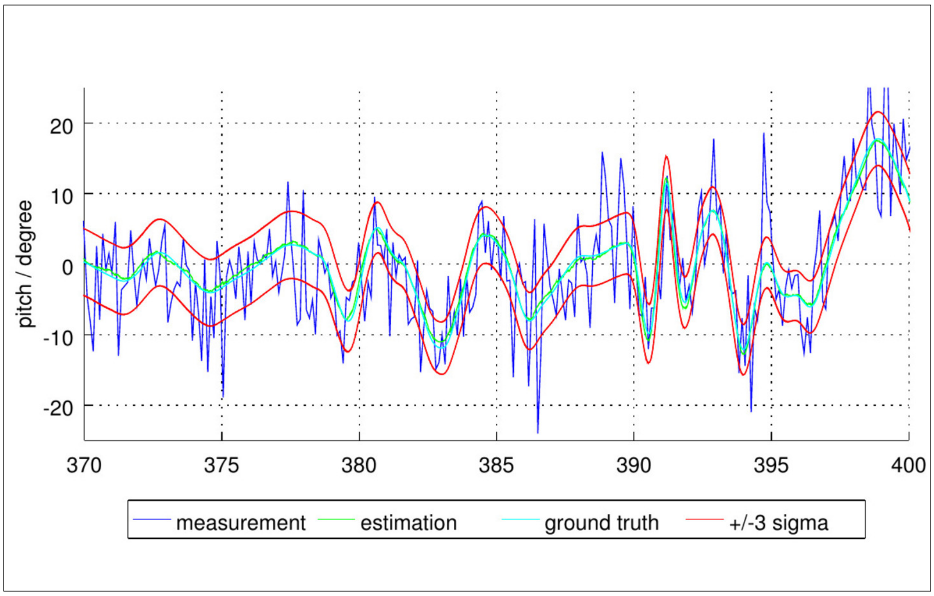
Orientation, Position and Velocity Estimation using a Kalman Filter



Combining the sensor data on the left to the estimated states on the right. Each arrow denotes a clock domain.



The orientation of the body frame (X,Y and Z) described as a rotation sequence (x-y'-z'') and by a single rotation.



Orientation (only pitch) of the helicopter tracked by the extended Kalman filter. The estimated trajectory (green) is quite good compared to the raw measurement (blue).

Introduction: The institute of communication systems at university of applied sciences Rapperswil is developing a simulation platform. To simulate the acceleration and rotation acting on the pilot of an aircraft or an arbitrary vehicle, the pilot sits on a moving platform. The next step is to validate and improve the rather complex helicopter simulation. Hence, the instrument inputs, orientation, position, etc. during real helicopter flights must be measured accurately.

Objective: Assuming there are different sensors providing position, orientation, acceleration and angular velocity measurements, the extended Kalman filter offers to combine these measurements elegantly. The Kalman filter also enables to deal with asynchronous measurements at different sampling rates. Thus the advantages of different sensors can be combined, e.g. the high sampling rate of an IMU providing a quite noisy acceleration and drifting angular velocity and the absolute position measurement of a rather slow GNSS sensor.

Procedure / Result: The purpose of this report is to briefly introduce the prerequisited mathematics and to summarize the equations to implement an extended Kalman filter. In particular, it is considered how to deal with orientations in 3D space in a Kalman filter or other optimization algorithms. In addition, some implementation specific details are discussed regarding the implementation of a Kalman filter dealing with asynchronous measurements. Based on a recently introduced Kalman filter the equations and matrices to track the orientation, position and velocity of a helicopter are summarize and implemented in Octave and Matlab. The implementation is tested with data from the flight simulator and additional synthetic noise.