ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institut für Automatik

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Termination Date:

Sensor Fusion / State Estimation for a Kite Power Plant

Description

Working within the context of the SwissKitePower project,

- Develop and implement a data fusion algorithm that provides a real-time estimation of the kite's position, velocity and orientation using the output from multiple sensors.
- Perform laboratory and field tests to validate and quantify the performance boundaries of the estimator.
- Document the results in a report and presentation.

Related Work

Sensor Selection and preliminary testing:

Researchers at FHNW and ETH have already selected and procured a number of sensors and performed preliminary tests. These sensors include:

- Xsens – Commercial GPS + IMU with extended Kalman filter implemented in on-board DSP.
  http://www.xsens.com/en/general/mti-g

- ArduPilot – Open source GPS + IMU system with DCM (direction cosine matrix) calculation implemented in on-board microprocessor.
  http://diydrones.com/profiles/blogs/ardupilot-mega-home-page

- X-IMU – Early commercial IMU with integrated storage and Bluetooth, some sensor fusion implemented on-board.
  http://www.x-io.co.uk/node/9

In addition, the following sensors have been ordered and will be implemented and tested on the FHNW groundstation during the next set of bachelor thesis projects:

- Line angle sensors from TWK - Both the vertical and horizontal angles and angular rates of change of the kite line

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will be measured using the following sensors. When combined with the length of the line, an estimation of kite position and velocity are possible. http://www.twk.de/data/pdf/11278fe0.pdf

- Differential GPS system – A DGPS from Novatel has been ordered which consists of two receivers, one which will go on the kite and another on the ground which measures and transmits the correction information. http://www.novatel.com/assets/Documents/Papers/OEMStar.pdf

These systems should be tested and the results analyzed to determine the best suitable combination of sensors for the system. Additional sensors, such as the PixIMU from ETH and the new version of the ArduIMU can also be tested and potentially used in the system. First testing can be made using a centrifuge, which is available at FHNW to understand how the various GPSs and IMU's perform under high g-loads and dynamic conditions. Preliminary tests of this nature have been performed and their results documented in a report which is available.

State Estimator Development:

A first version of the estimation software should be developed and implemented on an appropriate platform. A definition should be made what incoming data the estimator uses and what data it has as output. It is possible that not all sensors are available and the algorithm has to be able to deal with different sensor setups. This should be defined during an initialization phase. Different state estimation algorithms should be implemented and tested. Care should be taken how to evaluate the performance of the different algorithms. As a start the conclusion of the Master Thesis of Héjj Andreás "Kalman-filter based position and attitude estimation algorithms for an Inertial Measurement Unit" can be used. From there on it has to be investigated how we can use the model information of the kite system to improve the state estimation.

Tasks

- Compare XSens integrated Kalman filter with other implementation
- How does the sensor behave with GPS outage (~30-40s)
- Does a constrained model for a kite improve

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performance compared to a free point mass model or does it even make things worse since it does not match the real system.

- Is there a difference in performance of the different IMU's?

To get a real ground thruth a Vicon system can be used to collect data but with the drawback of no GPS signal. However, the GPS could be simulated using biased Vicon measurements at a certain rate. An experimental setup has to be found to let the sensors move in a similar way as with the kites and be able to test various algorithms.
The model for the Kalman filter would be different as for the kite but the setup should stay the same.

Procedures

Sensor Platform Evaluation
A centrifuge experiment is going to be set up at FHNW in order to test the different IMU's under different g-loads. The data will be recorded on SD-cards. The pxHawk and xIMU have an integrated microSD slot, the data from the commercial xSense MTI-G is sent to the pxHawk over a serial connection and logged there. Synchronization of the different platforms will be done by using GPS time on the pxHawk and setting the same time on the xIMU via a Computer. The results will be evaluated and compared considering the expected conditions in a kite.

Sensor Data Fusion
Based on the Master Thesis of Andreas Heji an Extended Kalmann Filter is going to be developed, that estimates the position, velocity and orientation of a pendulum. Several different versions are going to be considered, using different restrictions on the movement of a pendulum.
The filter will be evaluated in an indoor experiment using a Vicon system that provides an exact ground truth. The missing GPS signal is going to be simulated using the Vicon position output and adding artificial noise.
The filters application on the state estimation for a flying kite is going to be discussed as extensively as possible.

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Time schedule

March	Literatur, Einarbeiten, Kalman Filter verstehen	make Sensor Platforms work & prepare Experiment; Simple Kalman Filter Implementation in Matlab	Centrifuge Experiment @ FHNW
April	Experiment Auswerten	Anpassung / Verbesserung der Kalman Filter Implementation; ev. Mehrere Versionen	Prepare Vicon Tests
Mai	Vicon Experiment durchfuehren und auswerten; Write Report	Finalize Report	Deadline: 1.6.12

Oral presentation Date

Signatures

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STUDENT Fabian Hilti & Roman Patscheider