ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institut für Automatik

NR.1
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Issue Date**:**

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.

Tasks

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

Working with the FHNW students, 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:

Based on the results of the first task, a first version of the estimation software should be developed and implemented on an appropriate platform. Most likely this can be done on a PC using Labview or Matlab to acquire and process the incoming data streams and to perform the calculations required. A definition should be made for what sensor values will be passed from the FHNW groundstation to the PC which will perform the calculations as well as what form of output will be given. 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. It can either be used for the state propagation of the INS algorithm directly or apply another Kalman filter in an outer loop to estimate the trajectory.

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Testing and Validation:

Working with FHNW students and staff, the estimator should be tested in the loop and its output used in some preliminary stabilizing and tracking controllers. The implementation of the controllers themselves will be the responsibility of the project supervisors but the estimator should provide a robust estimate of kite position, velocity and orientation so that the appropriate control actions can be calculated. The performance goals to be achieved are:

- Kite stabilized at zenith for > 1 min.
- Figures of eight flown at constant line length for > 1 min.

Procedures

Time schedule

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Oral presentation Date

Signatures

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