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Automation of Inertial Sensor Reference Tests

The Institute of Flight System Dynamics at the Technical University of Munich is devoted to analyzing and modifying the dynamic characteristics of aerial platforms. This includes research groups on simulation, trajectory optimization, avionics and safety critical systems as well as navigation and sensors.

To support its research, the institute runs a laboratory infrastructure that incorporates, amongst other devices, a three-axis motion simulator ACUTRONIC AC3340.



The AC3340, placed on an isolated test pad, enables the institute to conduct research on a wide range of navigation and sensor related subjects, including:

- Characterization of inertial sensors for novel navigation algorithms
- Development of novel calibration techniques for inertial sensors
- Testing of inertial and integrated navigation systems

The development of novel calibration and test techniques require generally accepted reference tests as a benchmark.

The IEEE Gyro and Accelerometer Panel provides standard specifications and test procedures for all common inertial sensor technologies.

To perform these standardized tests in a repeatable and effective way, a MATLAB-based framework for test automation has been created.

For simple handling, the developed tool provides a graphical user interface that guides the user through the sensor configuration and allows the compilation of the desired test procedures to an automated batch test (see Figure 1).

During the test procedures, the GUI displays information about the current status and progress, as well as potential instructions for the user. After the tests are successfully performed, a detailed PDF-report and analysis is automatically generated. The report holds all the results, as well as the important test parameters (rates, orientations, test durations).

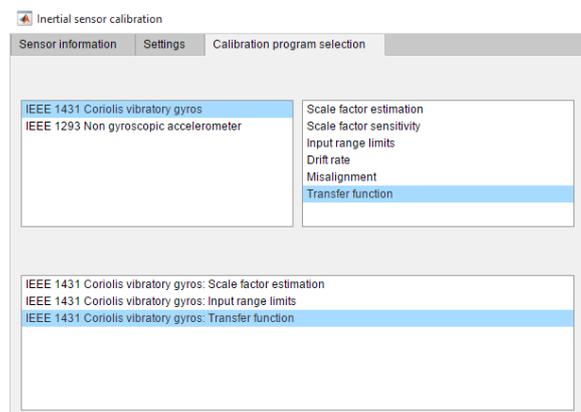


Figure 1: GUI of the test automation tool



The developed tool commands the rate table to perform different motion profiles, as defined by the IEEE procedures. Here, the advantages of a three axes rate table have been utilized to minimize the operator's interaction, e.g. remounting of the sensor.

The rate table is controlled directly from the MATLAB environment by interfacing the ACUTROL 3000e by:

- *ACUTRONIC Command Language (ACL)* for static poses as well as the
- *UDP Realtime Network Interface* for complex profiles

In general, accelerometers can be calibrated using the local gravity as a known reference input. With the AC3340, the sensor is put to a series of different orientations with respect to the local gravity vector (see Figure 2). Using a three-axis rate table no remounting of the sensor is required. The recorded output from the different positions is then used to identify the parameters of a mathematical model for the sensor.

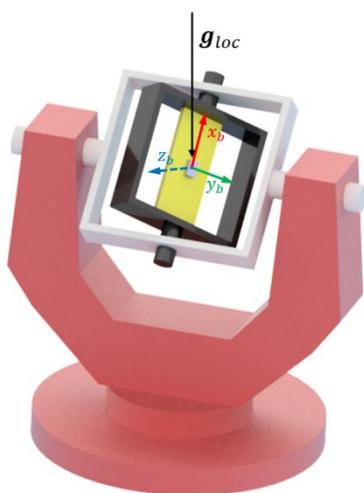


Figure 2: Orientation of the sensor with respect to gravity

Similarly, for the gyroscope calibration, the sensor is rotated at a series of constant rates about its own axes. Comparing the gyroscope output for the different motions with the known rates of the simulator, characteristic errors can be found. Figure 3 exemplarily demonstrates the estimation of the gyroscope's scale factor.

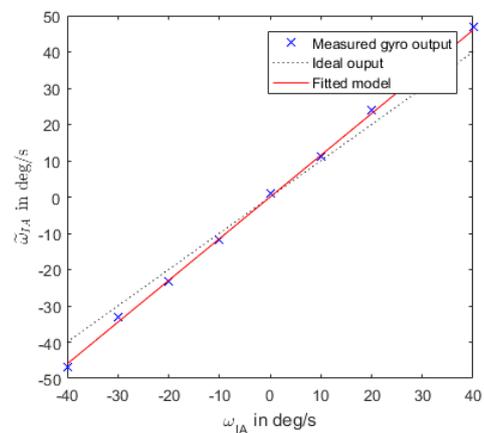


Figure 3: Gyro scale factor estimation

Again, the availability of three independent rate table axes reduces the number of manual remountings to a minimum. Still, some tests, for example g-sensitivity tests, require the operator to remount the sensor in a different orientation.

In addition to the IEEE standard calibration procedures, a series of different other characterization tests has been implemented.

Using the real-time interface of the AC3340, it is possible to perform complex arbitrary motions. This is used to determine the frequency response of e.g. Coriolis vibratory gyroscopes, by applying a sine sweep rotation (oscillation with increasing frequency) to the sensor.

The frequency response of the gyroscope is then estimated from the recorded rate of the simulator and the gyro output of the performed motion (see Figure 4).

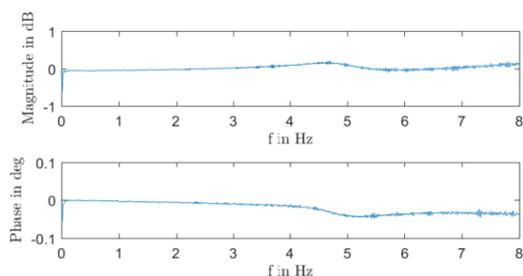


Figure 4: Part of Bode plot for a gyroscope's frequency response

Further implemented tests include range testing, noise characterization, and long-term analysis of the sensor errors.

The automation tool provides an open framework that allows simple extension and integration of additional test procedures.

In combination with the AC3340 three-axis rate table, the developed tool boosts research on inertial technology by automating routine test procedures and thus leaving more time for research.

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