Calibration of an inertial measurement unit

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***Abstract*—This paper presents a way to calibrate different inertial measurement sensors. In particular we present the calibration of an accelerometer and a gyroscope using least square. A model of the sensors is presented based on the main errors that MEMS devices present, a calibration method is proposed for the static parameters of the model. Finally a temperature adjust is made.**

I. Introduction

The development of the Microelectromechanical Systems(MEMS) technology has allowed to manufacture many low-cost chip-sensors, such as accelerometers, gyroscopes and magnetometeres. Those chips have been adopted in many applications, for instance Inertial Navigation Systems (INS) [**?**]. However this sensors have many error sources, thus they must be calibrated before being used and they should be re-calibrated peridoically for any precission application. The different sources of error will be analysed in more detail in section II and the implications of those errors will be derived.

The calibration proposed in this paper is tested on a 3-axis accelerometer ADXL345 of Analog Devices and a 3-axis gyroscope ITG-3200 of InvenSense, yet the model developed and the methodology can be used in other devices because the model is based on comun characteristics of MEMS sensors. The sensors named before are included in a Inertial Measurment Unit(IMU): The Mongoose(figure **??**).

The first step of the calibration is to obtain the static parameters of the devices for the ambience temperautre. This step is based on knowing the exact orientation of the IMU for the calibration of both sensors and the exact angular speed for the gyroscope calibration. Other related works waive this requirement [1] and [2] and uses the fact that in any position angular speed(for the gyroscope calibration) and gravity vector (for the accelerometer calibration) are constant.

It can be observed(figure **??**) that the measures given by this sensors are not independant of the temperature. Many devices that uses MEMS sensors need to work properly in a wide temperature range. In other cases, the temperature in operation of the system is different(for instance due to Joule Effect of the wires near the sensors) than the ambiance temperature in which the sensor was calibrated. Therefore a temperature adjust must be made.

II. Model of the sensors

As it was stated before, there exist many error sources in MEMS devices. In [1] two of this sources are mentioned: the nonlinear response of the sensors and the non-orthogonality of the axis of the sensor. In addition we can observe also that it exist an electric noise in the measures (figure **??**) and a dependance of the temperature.

In the datasheets of the considered sensors([3] and [4]) the effect of nonlinearityis negligible since it represents the $\pm 0.5.\%$ of the full scale for the accelerometer and the $\pm 0.2\%$ for the gyroscope. Therefore we will not discuss any further on this issue.

In figure **??** we can observe that the electrical noise of the devices is typically 2 bits, this error (acording the datashets [3] and [4])correspond to $7.8mg$ and $0.14°/s$.

A. Accelerometer

B. Gyroscope

III. Calibration method proposed

A. Static Parameter Calibration

1) Temperature adjust:

IV. Results and analysis

V. Conclusion

References

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[4] "Itg-3200 datasheet," tech. rep., Inven Sense, 2010.