When to use "Capture Gyro Bias"

Guideline on when to do a gyro bias capture on LORD Sensing Systems inertial devices

Introduction

The MEMs gyros used on the LORD Sensing Systems GX, CX, RQ, and GQ series of Inertial sensors are very high quality automotive grade gyros that have excellent temperature, linearity, and bias stability characteristics. They have very low noise and are stable over a wide range of dynamic conditions. Like all MEMs gyros, however, there are conditions that can cause the zero-bias value to change.

Sources of Gyro Zero-Bias Changes

The main sources of gyro bias change are as follows:

1. **Aging**: MEMs Gyros tend to drift over long periods of time due to mechanical changes that are related to various mechanisms: gradual relaxation of fabrication stresses, slow changes in gas pressure and composition inside the hermetically sealed package, gradual stabilization of residual chemical composition in adhesives, etc. These effects are partially eliminated by accelerated aging techniques such as thermal cycling. All LORD Sensing Systems inertial products are thermal cycled over a minimum of 8 hours as a part of the temperature compensation and calibration process and this, in effect, acts as an initial accelerated aging process. However it does not entirely eliminate aging effects.
2. **Shock**: Gyros can undergo subtle permanent mechanical changes if exposed to a shock event (any acceleration > 100g or rotation rate > 10,000 degrees/second).
3. **Thermal Stress**: Gyros can undergo subtle permanent mechanical changes if exposed extreme high or low temperatures for a prolonged periods (exposed to >> 85°C or << 40°C for > 10 minutes).
4. **Thermal Cycling**: Gyros can undergo subtle temporary mechanical changes if exposed to extreme thermal cycling (-40°C to 85°C with a ramp rate of 3°/minute for example). These changes tend to relax over time in a pattern that looks like rapid aging.

Bias Tracking

Some of these bias changing sources, like aging and temperature cycling, are unavoidable but can be compensated for by tracking the gyro bias using what is essentially a high-pass filter built into the EKF. This feature is a user selectable option on all our models with EKF outputs.

Bias tracking alone, however, is not adequate for some applications as it has two requirements to work well. First, it requires a convergence period after the filter is reset. The filter has to have enough data samples from all its sensors to converge on a bias value that is "good", that is, a bias value that has a low uncertainty value. The amount of time required for this convergence is determined empirically by the user as it varies depending on the dynamics of the application. In a desktop test, the convergence time is generally less than 30 seconds.

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Second, symmetrical bias tracking on all three axis requires physical motion that provides signals on all axis. In applications where a device is stationary for a long period, it is difficult to track the bias of the vertical axis because there is no signal that can verify that the vertical axis rotation rate is zero.

Gyro Bias Capture

For applications that need to have the zero bias be as accurate as possible immediately on startup or cannot tolerate the convergence period of bias tracking or applications that have long stationary periods and need an accurate heading that cannot tolerate the normal drift characteristics of the gyros over time, the "capture gyro bias" function may be used to re-zero the bias. A bias capture may also be required if the bias has a relatively large change due to events such as a shock or thermal stress. If the bias change introduced by these events is too high, the bias tracking may not be able to converge to a value that can fully compensate without doing a gyro bias capture.

Recommended Gyro Bias Capture Guidelines

For applications that are able to utilize the gyro-bias tracking feature, do a gyro bias capture:

1. Once after installation of the inertial device in the end product, or after re-installation in the end product if the device is removed for any reason.
2. Once if the device is exposed to any of the following events:
   a. Shock (dropped or struck or any event exceeding 100g)
   b. Extreme over-ranging event (rotation rate exceeds 10,000 degrees/second)
   c. Extreme temperature event (exposed to >> 85°C or << -40°C for > 10 minutes)
3. Once after a waiting period of two days if the device is thermal cycled at high ramp rates (-40°C to 85°C with a ramp rate of 3°/minute for example)

For applications that are *NOT* able to utilize the gyro-bias tracking feature, do a gyro bias capture:

1. Once after installation of the inertial device in the end product, or after re-installation in the end product if the device is removed for any reason.
2. Monthly for the first three months.
3. Annually after the first three months.
4. Once if the device is exposed to any of the following events:
   a. Shock (dropped or struck or any event exceeding 100g)
   b. Extreme over-ranging event (rotation rate exceeds 10,000 degrees/second)
   c. Extreme temperature event (exposed to >> 85°C or << -40°C for > 10 minutes)
5. Twice if the device is thermal cycled at high ramp rates (-40°C to 85°C with a ramp rate of 3°/minute for example). Once after a waiting period of two days and again after an additional two days.

Any of these guidelines may be adjusted up or down by the user depending on the requirements for their application. Some may find an initial bias capture to be sufficient; others may want to do a regularly scheduled bias capture to maintain the absolutely best initial bias possible.

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