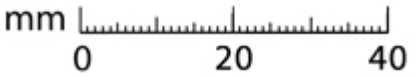
TN-I0019
Technical Note

3DM-GX3® -25



Coning and Sculling

Overview

The 3DM-GX3® -25 allows the user to enable or disable coning and sculling compensation. This technical note provides a narrative on the subject of coning and sculling.

Coning

In older inertial navigation systems, gyroscopes and accelerometers were mounted on a gimbaled mechanical plate. As the vehicle rotated, the gimbals continuously maintained the plate in an horizontal position so that the gyroscopes and accelerometers did not rotate. In newer inertial navigation systems, so-called 'strapdown systems', the gyroscopes and accelerometers are fixed to the vehicle and rotate as the vehicle rotates. When you time integrate angular rate and acceleration to get angle and velocity in these newer strapdown systems, the time integration is severely non-linear. Because of this phenomena, you have to do integration in tiny little steps really fast if you have high speed motion occurring. In particular if you have rotation about more than one axis, you have to do the integration really fast to avoid errors from creeping in.

Now let's say that you are a user that wants to do time integration as part of your own Kalman filter algorithm. You want the 3DM-GX3® -25 to provide you with angular rates and accelerations and as we said above, you have to do the integration in tiny little steps really fast, which means you have to get that data at a really high sample rate, say 1000 Hz. Let's also say that you really don't want to deal with the data that fast because it puts a heavy burden on your processor. This causes a conflicting requirement. On the one hand you want the ability to get accurate results which implies you need to get high speed data, but on the other hand you don't really want to deal with this flood of data coming in to be integrated.

So what is coning? Well, we still have a ways to go in our discussion. The real question is 'what is delta theta?' Delta theta is a quantity that can be output from the 3DM-GX3® -25 that is similar to angular rate, but already has some of the integration done. The high speed integration is being done on the 3DM-GX3® -25, its output is in the form of delta theta, and delta theta is very much analogous to angular rate. Delta theta can be used in a very similar way, and because the high speed integration is done on-board to produce the delta theta quantity, your processor is relieved of this burden. You can now take delta theta quantities at a lower rate, say 100 Hz instead of 1000 Hz. You still have to do an integration process, but at much reduced complexity. The difference between angular rate as a straight-up quantity vs. delta theta is that the delta theta quantity has already captured the non-linearity using the 3DM-GX3® -25's 1000 Hz integration speed. The resultant delta theta quantity can be taken into your processor at 100 Hz while still retaining its accuracy.

So what is coning? Coning is a name of the characteristic errors that you get when you don't do the integration fast enough. It's called coning because the worst case for developing this kind of error is when the axis of rotation itself prescribes a cone in space cyclically. In other words, the rotation axis itself revolves and sweeps out a cone in space and if it does that at high speed, let's say as a result of a 500 Hz vibration-like motion, and you don't do the integration fast enough, you get this characteristic kind of error creeping in. The coning compensation done on the 3DM-GX3® -25 insures you don't get that kind of error.

Sculling

Sculling on the other hand is basically analogous to coning but it has to do with the accelerometers instead of the gyroscopes. Coning relates specifically to an error in your angle measurement and so fundamentally it is coming from gyro data. On the other hand, sculling happens when you have a cyclic linear acceleration in combination with cyclic rotation. We call this sculling because it results in an apparent but erroneous velocity and the characteristic motion that gives you this erroneous velocity looks like the sculling type of oar where the oar sweeps back and forth. Without compensation, this would come out in the delta velocity quantity and the output would have that corruption built into it. For example, if you have very fast motion, especially a vibration-like oscillating motion at the same time that you have a slow sampling rate, you will be in trouble without the sculling compensation provided by the 3DM-GX3® -25.

Further Details

You will find these delta theta quantities further described in the 3DM-GX3® -25 Data Communication Protocol manual http://www.microstrain.com/pdf/3DM-GX3 Data Communications Protocol.pdf. Please review the sections entitled *DeltaAngle & DeltaVelocity* on page 14, *DeltaVel* on page 41 and *DeltaAng* on page 42. Please review Coning and Sculling matters in the sections entitled *Sampling Settings* on page 29, *Internal Architecture* on page 34, and *Data Output Rate* on page 35.

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