Dynamic Disturbances

Dynamic disturbances are defined for this discussion as disturbances in acceleration or magnetic that are time dependent. Examples include periodic vibration measured on the accelerometer, or temporary deflection of the magnetic field, caused by the presence of a magnetic object placed near the sensor.

With the default tuning parameters installed on the VN-100, any disturbance in either the measured acceleration or magnetic field will cause errors in the calculated orientation. There are essentially two ways in which the user can tune the VN-100 to increase performance in the presence of measured disturbances. Which of the two methods is best for your application depends upon whether or not you know ahead of time when the disturbance will occur.
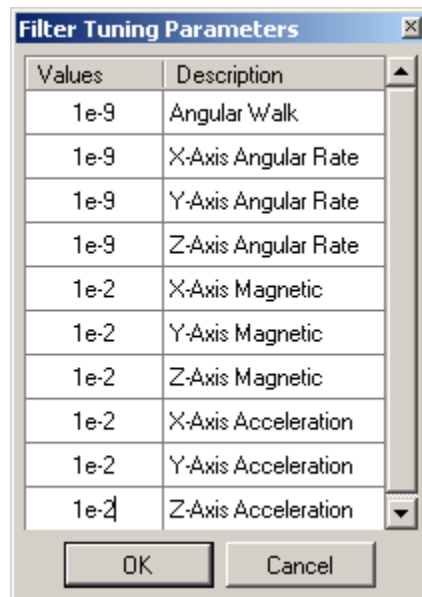
Case 1 – Known Disturbance

There are times when the user will know ahead of time when a disturbance will occur. The case where the sensor is placed near an electric motor that is used occasionally is an example of a case where the user would know ahead of time that a disturbance was about to occur. In this case when the motor is turned on, assume that both the measured acceleration and magnetic fields are significantly disturbed by the operation of the electric motor. If the user knows ahead of time when the motor is going to turn on, then his best option for tuning the performance of the VN-100 would be to set the filter tuning parameters just prior to operating the motor, and also right after the motor is turned off.

Case 1 - Prior to turning the motor ON

Just before turning the motor on you will want to set the tuning parameters so that more trust is placed in the gyros and significantly less in the accelerometer and magnetometer. Example parameters are shown below.

Figure 1 - Motor ON Parameters

As soon as the motor is turned off, then the tuning parameters can be set back to their original values. This will allow the filter to re-gain trust in the magnetometer and accelerometer and keep the errors in the gyro drift bounded.

Case 2 – Unknown Disturbance

There are also cases where the user does not know ahead of time when a disturbance will occur. To account for these disturbances the Filter Active Tuning Parameters were added to the VN-100 (see Section 6.24 of the User Manual). Essentially these parameters offer a real-time mechanism for decreasing the confidence in the sensor measurements, based upon a comparison of the length of the vector measurements to their known reference lengths. Both the measured acceleration and the magnetic field are vector measurements, and these vectors have a known reference length. For instance the acceleration vector should always read ~9.8 m/s^2 (gravity) in static conditions. If the sensor is reading an acceleration that is smaller or larger than this length, then it is likely measuring an additional acceleration that is being added to gravity to result in a measured acceleration that has a magnitude different than 9.8. The magnetic vector measurements also have a known magnitude, and in the case where a hard/soft iron calibration is performed correctly, the magnitude of this vector should not change as a function of attitude.

The active tuning registers have two parameters for each sensor. The first parameter is a gain. This gain is multiplied by the difference in the measured and known vector lengths to get an additional amount of uncertainty that will be added to the filter tuning parameters at each time step. In the event that the measured vector is the same magnitude as the reference vector, then zero is added to the uncertainty of the sensor. In the event that the measured vector is 0.1 in length larger than the reference vector, and the gain is set to 0.5, then 0.05 is added to the filter tuning parameters for that sensor. Since the

filter tuning parameter numbers are variances and their magnitudes are quite small, it doesn't take that large of a number to be added to the tuning parameter for the filter to completely disregard the measurement. In most cases, an amount of 0.01 or greater will completely eliminate the confidence the filter has in that sensor for that time step. The second active tuning parameter is the memory. The memory just sets how long the filter will wait before trusting the sensor after a bad measurement. A value of around 0.99 will give about 1-2 second memory and zero gives no memory.

Example case – Unknown magnetic disturbance

Here is an experiment that you can try to get a feel for how the active tuning works. First, find a small magnet or steel object. A pocket knife or refrigerator magnet will work fine. Place the VN-100 on a table, load up Sensor Explorer, and perform a factory reset. Then set the sensor to the following settings:

Baud Rate: **115200**

Output Frequency: **50 Hz**

Data Output: **Quaternion, Magnetic, Acceleration, and Angular Rates**
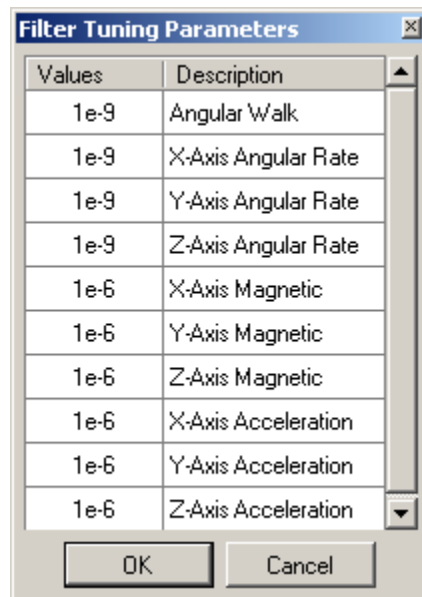
All four graphs should now be operational on the right half of Sensor Explorer.

With the device stationary on the table, perform a Tare command by clicking the Yellow star icon on the menu bar. Wait about 5-10 seconds for the solution to stabilize, then try moving the magnet close to the sensor. If your object is indeed magnetic, you will notice a disturbance in the orientation solution of the VN-100. Move the magnet back and forth and rotate it around the sensor to get a feel for its effect.

Set the Filter Tuning Parameters

Now let's tune the filter and see how the performance changes. First, we will need to increase the confidence in the gyros so that they can help the filter ride through the times when the disturbances are occurring. To do this go to Commands -> Set Filter Tuning and set the parameters to the following values:
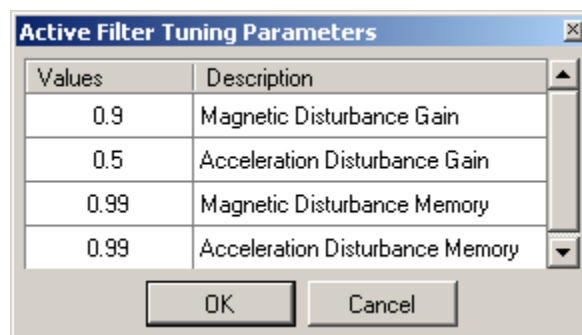
Figure 2 - Filter Tuning Parameters

Now move the magnet close to the sensor and get a feel for its new performance. You will notice that although there are still errors in the calculated orientation, they are much smaller than the previous case. This increased performance is due to the increased confidence placed in the gyros.

Active Tuning Parameters

Now let's turn on the active tuning. Go to Commands -> Set Active Filter Tuning and set the parameters to the following:

Figure 3 - Active Tuning Parameters

Now move your magnet again close to the VN-100 and observe its performance. If the settings were configured correctly you should observe very little effect on the calculated orientation. While you are waving your magnet close to the sensor watch the bottom right graph (the magnetometer output) and observe the strength of the disturbance. Then look at the top right graph to determine the amount of disturbance in the calculated orientation solution.

Conclusion

This simple experiment should give you a feel for how the active tuning parameters work. Now that you know how to set them, spend some time experimenting with the values to learn how they affect the performance.