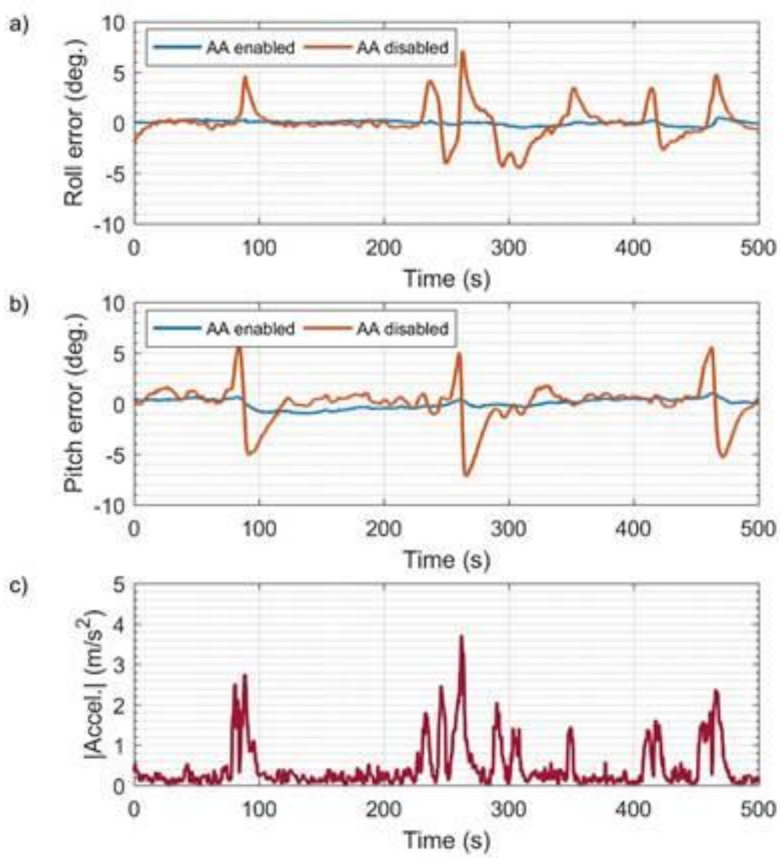
Auto-Adaptive Dynamic Roll & Pitch Performance

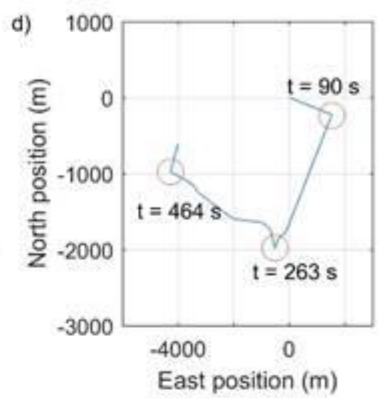
How the Auto-Adaptive EKF improves roll/pitch accuracy in the real world

Introduction

One of the most enigmatic specifications for an inertial device, whether it is a GNSS/INS, AHRS, or VRU, is the roll-pitch accuracy. The difficulty with this specification is that it can be quite good when measured in an environment that is moving at constant velocity (like zero) and quite terrible in any other environment. Of course, most manufacturers state the constant velocity measurement because it is easy to measure and easy to verify. However, what you really want to know is, “what is the dynamic accuracy in my application?” This is not such an easy question to answer because no one except you know the exact dynamics of your application. There are some standards, but they are not always relevant. For purposes of this discussion, we will simply show you the graphical results of our own real world test of driving around in a car and you can extrapolate from there.

Standard Fusion vs. Auto-Adaptive





Error with respect to the reference in a) the roll angle and b) the pitch angle. The magnitude of the lateral acceleration as measured by the reference unit is shown in c). Portions of the trajectory corresponding to higher lateral acceleration are indicated in d). Maximum pitch and roll deviation with AA enabled are ± 0.5 deg. and ± 1.0 deg. respectively, versus ± 7.1 deg. and ± 7.2 deg. respectively with AA disabled.

Figure 1

LORD MicroStrain®
SENSING SYSTEMS

This example illustrates the roll-pitch errors displayed by a “simple” AHRS filter (using standard method of gravity corrections) and the errors when utilizing the new auto-adaptive feature in the EKF of our fifth generation devices (3DM-GX5, 3DM-CV5, etc). Without diving too deeply into the detail, the graphs in *figure 1* show a car traveling over a 6-mile course with typical straightaways and occasional sharp turns. We ran two 3DM-GX5-25 AHRS side by side – one with auto-adaptive off and one with auto-adaptive on. The reference used was a Novatel SPAN GPS/INS. We plotted the pitch-roll errors for each device and showed the corresponding acceleration vector magnitude in the third graph.

It is clear from *figure 1* that using auto-adaptive dramatically improves pitch and roll accuracy in dynamic conditions. This is because the auto-adaptive filter continuously monitors and adapts to the acceleration conditions and only uses the acceleration vector as a gravity reference when it appears that the lateral accelerations are zero and the magnitude of the gravity vector is within the bounds of what is expected. In other words, it only gets a gravity “fix” when the acceleration vector truly represents the gravitational vector.

Roll Errors	Conventional	Auto-Adaptive
RMS	±1.7°	±0.21°
Peak	±7.1°	±0.5°
Peak:RMS	4:1	2.5:1

Table 1

As shown in table 1, the RMS roll error is an impressive ±0.21°. This is actual in-run error. More importantly, the peak error never exceeds ±0.5°. The auto-adaptive feature constrains the peak errors to a much lower multiple of the RMS errors. As shown in table 1, the ratio of Peak to RMS errors for roll are 4:1 for conventional filtering and 2.5:1 for auto adaptive. Note also that the non-AA peak is 14 times larger than the AA peak. Similarly, the non-AA RMS value is 8.5 times larger than the AA RMS value.

Adaptive filtering was introduced with the fourth generation of LORD MicroStrain devices such as the 3DM-GX4, however, the adaptive thresholds on the GX4 are fixed and determined by the user. This legacy option is still available on the 3DM-GX5, but with its greater processing capabilities, the GX5, CV5, and all other fifth generation devices are able to offer the auto-adaptive option. There is no tuning required, which makes the new auto-adaptive filtering option more flexible, reliable, and easy to use.

Summary

This is a single example but it is representative of the potential improvement in attitude accuracies that may be realized using our fifth generation GNSS/INS, AHRS or VRU using the auto-adaptive EKF technology. It demonstrates that the dynamic (real-world) roll-pitch accuracy of an AHRS or VRU can approach the accuracy of a GNSS/INS, making them suitable replacements for GNSS/INS in some applications.

LORD Corporation
MicroStrain® Sensing Systems
459 Hurricane Lane,
Suite 102
Williston, VT 05495 USA
www.microstrain.com
ph: 800-449-3878
fax: 802-863-4093
sensing_support@lord.com
sensing_sales@lord.com

LORD MicroStrain® SENSING SYSTEMS