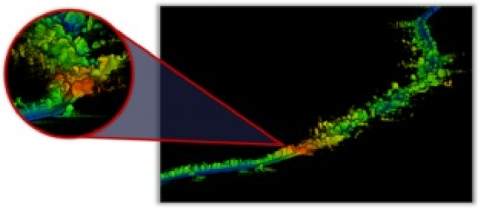
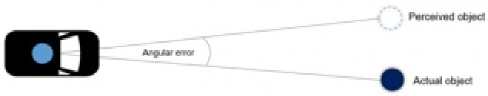
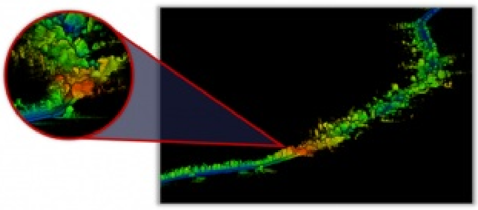
How to Get the Best Precision and Point Cloud Accuracy







We rarely stop to appreciate just how complex modern surveying technology is. Surveyors use the most advanced physics, with decades of experience, in every component. Consequently, in such complex systems, there are many sources of error. Luckily however, we can talk about these quite broadly to better understand the accuracy of our surveying. This article will discuss further some important points for obtaining survey and point cloud accuracy from a surveyor's perspective.

IMU accuracy

An IMU (inertial measurement unit) measures the intrinsic movement to which it is subjected. Typically using gyroscopic instruments and accelerometers the IMU will determine its acceleration and changes in its orientation. For surveyors therefore, an IMU is extremely important. This is because surveying typically is the observation of objects at a distance from oneself for the greatest convenience but the further away an object is, the less accurately its position can be known. Consider the diagram below; for all measurements there is an intrinsic error including in the angle changes measured by the IMU.

Taking a small angle approximation, the error in an objects position is simply the angular error x distance to the object. This means that a tiny angular error can easily lead to a very large discrepancy in a surveyed object's position by being at a long range. A typical IMU for surveying such as the OxTS NAV650 IMU might have an accuracy of half a degree.

The IMU is also very important for navigation purposes. Intrinsically, the IMU measures motion. This means that surveyors can use it as a rudimentary navigation device to track how the IMU is moving. Therefore it is possible to use a high grade IMU to output the essential orientation information but also the information of where the IMU is located. However, all instruments exhibit a random walk or a drift in their measurements that will negatively affect point cloud accuracy. Therefore, an IMU alone will quickly drift away from its true position as it measures motion and does not localize position.

Position error in a survey due to orientation uncertainty.

GNSS Localization

A GNSS (global navigation satellite system) system localises its position on the Earth using the constellations of satellites in orbit. Using the highly accurate timing information from these satellite signals, a GNSS receiver is able to determine its position to within much less than a meter on the Earth's surface. By using a second receiver, often referred to as a base station, corrections can be calculated for how the signals from the satellites have been distorted in the atmosphere and this can increase the accuracy of the device to even a centimetre.

There are other systems that can be used for localizing position but most of them are limited to big infrastructure environments to act as a substitute when GNSS signals cannot be received, for now, there is no real competitor to GNSS in outdoors environments. GNSS gives highly accurate and precise absolute positioning on the Earth whereas many substitutes can only deliver relative positioning without the aid of GNSS itself.

GNSS Constellations

There are four main constellations of GNSS satellites in use today. For a long time the Russian and US constellations, GLONASS and GPS, have been ubiquitously used but the European and Chinese constellations, Galileo and Beidou, are becoming increasingly widespread also (there are others also, for example QZSS). In general, accuracies using these individual constellations are similar, but a GNSS system can make the best use of all available data by using multiple, or all four, of these constellations combined. In the image shown below, you can see the trajectory of an INS system. The trajectory of a GPS only (blue) position trace and a GPS and GLONASS (red) trace is shown. As the vehicle has passed by some obstructive trees and buildings the satellite signals have been lost and position drift has occurred. In post-processing this is seen by a sudden jump in the position of the blue line, and it appears to be moving in the wrong lane. However, in the red line we see no such jump but a smooth trajectory in the correct place. This is because GNSS systems need a minimum number of satellites in order to provide optimal results. The more satellites, or the more constellations, the more reliable the position output will be especially in poor GNSS environments such as a city or town. Nowadays systems such as the OxTS xNAV650 are moving towards offering all four of these constellations as standard for the most reliable solution.

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Point cloud coloured by OxTSâ€™ uncertainty estimation.