Digital Compass Calibration

Most new smartphones contain electronic magnetometer, gyroscope, and accelerometer chips that, either individually or when combined, provide orientation information about the device. These electronic components vary in quality and are subject to a number of limitations. For example, magnetometers can be strongly influenced by the magnetized iron, steel or other permanent magnets in the device (the hard iron effect), as well as being influenced by external magnetic material in the natural and built environment. Gyroscopes often suffer from gyro-drift – an error caused by the accumulation of the unique bias present in each gyroscope. We can counteract these limitations by attempting to calibrate the sensors, or using a combination of their output data to provide an improved result.

However, some smartphones perform more consistently than others. This variation between devices can be caused by:

- differences in phone hardware and firmware
- differences in the built-in noise filtering and sampling frequency
- the different sensor combinations (sensor fusion) or compensation algorithms

There are also differences between the mobile operating systems and how they allow developers to access and manipulate the sensors available on each device.

We are reluctant to recommend specific devices to run FieldMove Clino, however there are significant variations in the quality of the components that are currently being used by the various manufacturers, and we feel strongly that we should make users aware of some of our recent findings.

Calibration for iPhones

The iPhone 4S, 5 and 5C contain good quality components and the compass readings are generally accurate to +/-1 degree – better than can be achieved with a traditional hand-held Brunton or Silva compass. Unfortunately the magnetometer/gyroscope/accelerometer combination in the iPhone 5s is of lower quality and the compass is only accurate to +/-5 degrees. This is a known issue which has been widely documented online and in the press. Apple have produced a firmware fix for this issue but we have not yet had the opportunity to test the device with the installed update. To calibrate, Apple phones display a black screen with a small red ball that must be rotated within the confines of a graduated circle. The compass clinometer within FieldMove Clino will not become active until this operation has been performed.
Calibration for Android™ Phones

We have observed much larger variations in the measured data recorded using Android phones which we suspect is largely down to the quality of the hardware components inside the device. If you are running FieldMove Clino on an Android phone then we would strongly recommend that follow the advice below. It is essential to calibrate the magnetometer/gyroscope/accelerometer combination in your phone before starting to measure data. The iPhone has a built-in calibration operation. Unfortunately, many Android phones do not display a similar visual feature for calibrating the internal components. We recommend that you follow the instructions set out in the manufacturer’s guide, which might include rotating the phone several times in the x-y-z planes. There are also some helpful videos on YouTube relating to compass calibration for certain models of Android phone.

We have found that some Android phones do not correctly report inclination. This is obvious when a phone is on a flat horizontal surface, yet FieldMove Clino still reports a dip. We believe this is due to components in the device not being seated properly, as we have tested other devices of the same make and model and not observed any problems. To counteract this, we have added an accelerometer calibration option in the app settings. In all cases, calibration resulted in devices correctly reporting inclination. To get the most out of your smartphone we recommend that you collect data with the device in a variety of orientations and compare this against a traditional hand-held compass clinometer to work out the best orientation to collect data in. Many Android phones work better when held against the rock in landscape mode (long-axis horizontal) rather than in portrait mode (long-axis vertical). When measuring lineations, some Android phones will only record sensible measurements of plunge azimuth in one orientation - when the device is held with the top of the screen pointing down- or up-plunge depending on the manufacturer. This does not seem to apply to the iPhone (all models) with good data being recorded irrespective of the orientation of the phone.

These questions may help you:

- Does the phone have reasonable consistency with itself in all orientations and situations?
- Does the phone have reasonable consistency with a control analogue compass clinometer in all orientations and situations?
- Are there any orientations (e.g. device long-axis vertical or horizontal) that provide more consistent and accurate results? If so, make sure to collect data only in these orientations.
As with an analogue compass, be aware of sources of interference. This can come from magnets, ferrous metals, electronic devices, another analogue compass or electronic device, watch or phone case (watch out for magnetic clasps).

..and finally

We have found that there are tremendous advantages to using FieldMove Clino on a well-calibrated smartphone. Most users will have experience with traditional analogue devices, where often a single reading is taken at each station with the assumption that each of these readings will have a high level of both precision and accuracy. This assumption is normally wrong. We always recommend taking several readings at each location, which can then be treated statistically to provide both improved accuracy and an understanding of measurement error. We have designed FieldMove Clino to make data collection quick and easy, facilitating the collection of large, statistically valid data sets. Our stereonet functionality in the FieldMove Clino Pro in-app purchase enables users to perform some basic statistical analysis of structural data in the field. More advanced analysis can also be carried out within Move – see www.mve.com for more information.