Effective DistoX with TopoDroid

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Abstract

Cave surveying has dramatically changed with the advent of DistoX. However, an improper use of the DistoX can lead to gross mistakes in surveys. This work reviews examples of bad usage of the DistoX and the functions provided by TopoDroid to avoid them.

Keywords:

DistoX, TopoDroid, cave-surveying, calibration

DistoX

DistoX is an integrated electronis instrument for cave surveying. It has been designed and developed by B. Heeb, who created a board for the Leica Disto, that allows the simultaneous measurement of distance, azimuth and inclination, with a precision suitable for underground surveying. The measured values are stored on board and are transmitted via bluetooth when a device is connected to the DistoX.

It was presented at the Int. Congress of Speleololgy in Vercoors in 2008 (Heeb 2008). It was an immediate success among cavers because Heeb provided also PocketTopo. POcketTopo is a Windows program that connects to the DistoX, receives the data, and help the user to organize them (eg. assigning stations), and let him sketch plan and profile views with the midline reference. It was the first complete "paperless" solution for in-cave surveying tasks.

Fig. 1. DistoX (left) and DistoX2 (right)

The first DistoX, based on the Leica model Disto A3 (Heeb 2009), consisted of an add-on board that was inserted inside the device and connected to the original board already present. The production of this board ended early 2011 because an essential electronic component went out of market.

In the following years Heeb worked towards a new model which eventually appeared at the end of 2013. The DistoX2 is based on the Leica model Disto X310. It consists of a board that replaces one of the two original boards inside the device (Heeb 2014). This model is an evolution of the first one and has several additional function. The most important one being the possibility to update the firmware on the board via bluetooth. This means that one can easily update his/her DistoX to the latest software version. (In the first model a firmware update required a special PC program, and a connection to the board).

Before DistoX there have been other attempts to build integrated electronic instruments for underground surveying, some for azimuth and inclination only. The main problem was the calibration of the accelerometric and magnetic sensors, to account for the differences in the responses of the sensors and imprecisions in the work of mounting them on the board. Heeb solved the problem for the DistoX using repeated measurements at different angles of roll around various directions of the laser {Heeb 2010). The calibration transformation is approximated at first order with a linear transformation (a non-linear term was later added in), and the computation of the coefficients of the transformation is carried out by PocketTopo using a suitable set of raw sensor data. Then the calibration coefficients are uploaded to the DistoX. On taking shots, the DistoX applies the transformation to the raw sensor data. It then stores and transmits azimuth and inclination data along with the distance.

A well-calibrated DistoX can have a precision of 0.2 degrees, and even 0.1 degrees using a calibration rig, with tripod. Therefore surveys of BCRA/UIS grade 6 could be possible with the DistoX.

In practice the situation is not that good. The ready availability of the DistoX and the apparent simplicity of its use can lead a caver to do surveys with plenty of data, but no attention to the details of the cave. At the extreme we have "only-data" surveys, where the sketch is done later at home, on memory, relying on the data for the accuracy, with the result that the survey lacks most of the features of the cave, and is often limited to the bare outline of the walls.

Here are a few bad-practices of cave surveying with DistoX that I found among cave surveyors:
- a calibration badly done
- using a DistoX with a calibration that is too old
- inattention to magnetic influences
- leg taken with a single shot
- splay shot taken at random, due to inexperience in surveying and map drafting
- no immediate check of the data

Calibrating the DistoX is not difficult, but some care is needed. A calibration is bad if it is done in an environment where the magnetic field is not uniform (for example in a building) , or with shots taken at short distances (which implies large angle variations), or not using fixed points, or not all directions are covered (Heeb suggests 14 directions at the vertices and the center of the faces of a cube).

An old calibration may be no longer reliable because the internal fields of the device can change with the time due to the exposure to some external intense magnetic fields. There is no sharp rule about how long a calibration remains good. The best practice is to do a calibration check just before every surveying trip (see below).

The objects that have most influence on the DistoX are the batteries. Therefore it must be used at a distance from the batteries on the helmet. Also glasses, wrist watch, caving gear, iron anchors and carabiners affects the DistoX, as well as the drill.

PocketTopo expects that the legs are measured three times at least. This improve the quality of the data (with the average), it also reduces the chances of a bad measurement (for example aimed beyond the target or before it). If a bad aiming has a 20% change, doing that three (independent) times in a row has a probability of 1%.

To take good splays one must know what to shoot, and this is something that one acquires drawing sketches in the cave, and drafting cave maps. Unfortunately, we sometimes have to survey with people who do not have this experience, so either they take too few splays (usually LRUD), or take splays randomly. There is little to do about this except train cavers and provide surveying courses.

Finally the immediate check of the shots on the spot is necessary to identify possible data error and correct them on the spot while still surveying. The distance can be measured wrong due to a missed target or interference with water drops. The angles can be wrong because of magnetic influences. In the worst case a DistoX failure can happen. With the first model the accelerometric sensor could get stuck, although on rare occasions. The second model has two sensors to alleviate the problem.

In conclusion DistoX is a very powerful device for underground surveying, but, without some background education and care, it can be easily used badly, so that the surveys that are produced are worse than they would be if Suuntos instruments were used (Piccini 2015).

TopoDroid

TopoDroid is an Android app for cave surveying, and in particular for cave surveying with the DistoX (Corvi 2015). TopoDroid development was started in 2011, and the app is on Google Play since April 2014. It has been downloaded by over 29800 users (Dec. 2017), although the number of "stable" installs can be estimated as about 2700.

TopoDroid has several functions to help the in-cave surveying task. Here we consider only those that give practical help with DistoX
- calibration
- estimate of the "precision"
- calibration check
- shot management
- anomalous data
- survey precision
- loop mis-closure
- survey under magnetic anomalies
- DistoX quick reference

TopoDroid implements the same calibration algorithm used in PocketTopo. It differs in the way the result is presented to the user. It also has a few additional auxiliary functions.

Fig. 2. Calibration report

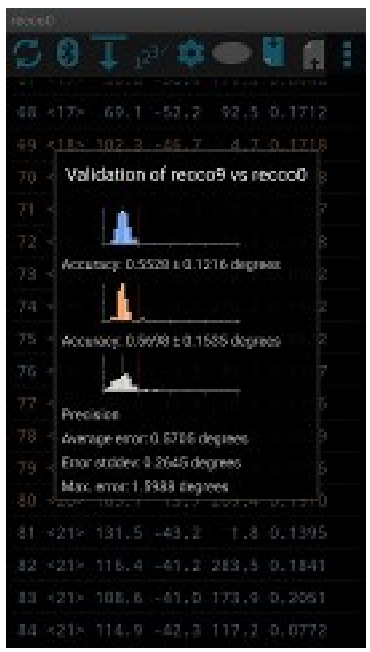

Fig. 3. Calibration validation

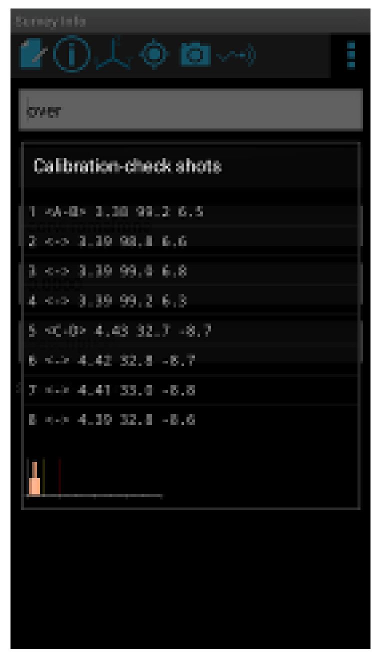

Fig. 4. Calibration check

The residual error on the calibration shot is shown in degrees. TopoDroid reports the maximum and the average errors, and the standard deviation (in degrees). Furthermore, a graphical histogram of the error distribution is displayed, and gives a quick glance at the quality of the calibration [Fig. 2].

TopoDroid can display the angular distribution of the directions of the calibration shots. This is a tool to check whether enough shots have been taken over all directions.
Finally TopoDroid has a function to remote control the DistoX. This allows to take calibration shots commanding the DistoX from TopoDroid, thus avoiding the small movements caused by pressing the DistoX button.

The calibration evaluation is the comparison of two independent calibrations (possibly done one after the other) [Fig. 3]. For each calibration the program computes the errors of the shots (with respect to the average value of the shot group) using the coefficients of the other calibration, and displays them graphically. It also computes the differences between the corrections of two calibration for each shot and displays them graphically. This last result is an estimate of the precision of the calibration, because it is the variations of the data.

Before starting a survey it is a good practice to do a check of the calibration to make sure that the DistoX is well calibrated. To do this one takes four shots A-B rotating the DistoX around the laser axis, and four shots B-A in a similar way. The data are then checked to see if there is any mismatch. TopoDroid has a function to mark a leg as "calibration-check" and to visually show the agreement of the data [Fig. 4].

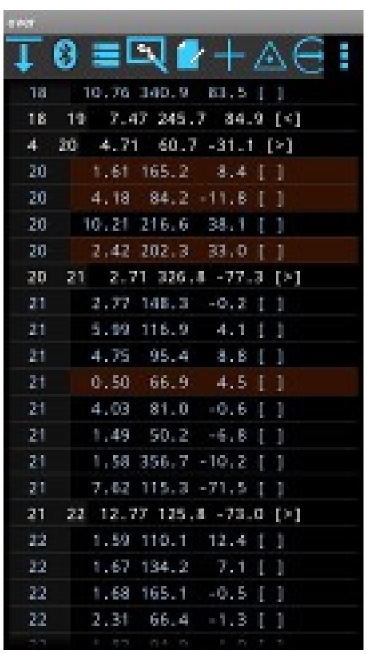

Fig. 5. Anomalous data

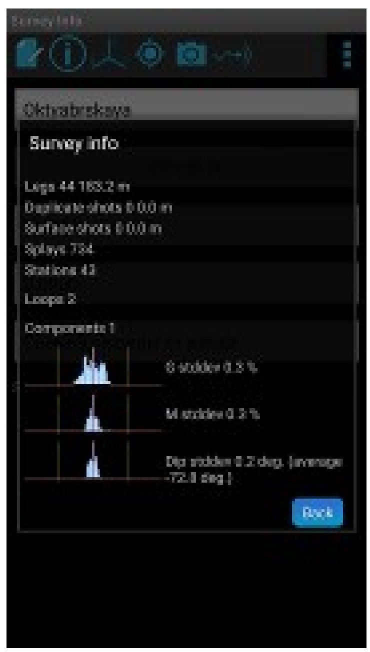

Fig. 6. Survey quality

TopoDroid can assign the stations automatically, and it recognizes repeated shots as a leg, and the others as splays, just like PocketTopo. The program has several choices of policies for the station assignment, and the user should pick the one that suits his surveying habits. The names of the stations can contain any character except spaces.

In particular TopoDroid has a station naming policy suitable for surveying under magnetic anomalies. In this case the azimuth of all the shots at a station is corrected with a local at-station declination which is computed comparing the fore leg to the station and the corresponding backsight leg (Halleck 2005).

Besides distance, azimuth and inclination the DistoX transmits also the intensities of the gravity and magnetic fields, and the magnetic dip angle. TopoDroid uses this information to signal possible anomalies, ie, shots for which one of the values differs too much from the respecive average. Possible anomalies are denoted with a red backgound in the shot list and with a red color in the sketch.

The quality (precision) of the survey is analized through the analisys of the distribution of these quantities around their mean values [Fig. 6].

TopoDroid automatically hides shots that are above a specifed length (overshots). These are not thrown away and can be recovered. Very short legs are highlighted with orange background.

Loop closure compensation is bad because it hides errors, and TopoDroid does not do it by default. It is better to leave loops open (last station different from the first station) and identify the misclosure graphically observing the plan and projected profile views. If the loops are closed (last station equal to first station) the closure errors are reported in the survey statistics.

Finally among the in-app help pages of TopoDroid there is a quick guide to the commands of both DistoX and DistoX2. These devices have many commands and it is likely that one remembers only the most used ones. If by chance one presses the wrong buttions and turns the DistoX in a strange mode, it is necesary to go and look up the commands to bring it back to the normal state.

TopoDroid has also other functions for the DistoX. In particular the memory dump and the firmware upgrade. The memory dump is used to recover the survey data from the DistoX memory, in emergency situations, when the data transferred to the Android or the Palm get lost. TopoDroid contains the firmwares for the DistoX2, and the DistoX can be upgraded (or downgraded) with TopoDroid.

In conclusion TopoDroid is there to help the cave surveyor getting precise and accurate data with the DistoX efficiently. However it cannot do the topography in place of the cave surveyor. Both DistoX and TopoDroid are merely instruments for the underground topography, and no instrument is a replacement for knowledge and experience.

References

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