GeoEasy 3 Step by Step Tutorial

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> ***Note***
>
> This training material does not extend to the use of the program in every detail, further information can be found in other documentation files.

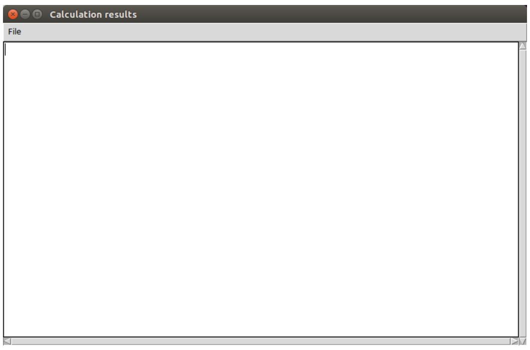
The installation kit contains a *demodata* directory. In this guide the data files from the *demodata* directory will be used.

Images in this tutorial are generated on an Ubuntu box. Window layouts on different operating systems may look different.

After starting GeoEasy a small windows appears near to the upper left corner of your monitor. It is the main window with a menu and a rotating Earth. If the rotation stopped the software is busy, user have to wait.

Main window

Another window is opened for the calculation results. It has dual function besides the results it has some logging role.



Calculation results window

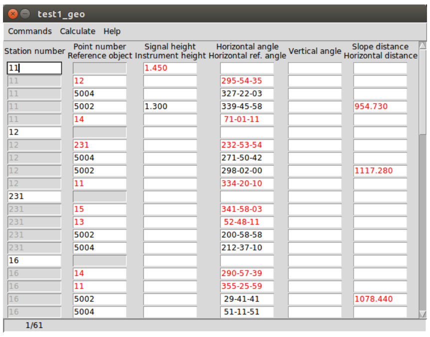
Loading sample data set

In the main window select **File/Load...** from the menu. Navigate to the *demodata* folder and select *test1.geo*. A log message appears in the *Calculation results* window, that data have been loaded.

View and edit field-books

The loaded field-books can be opened in a window. Select **Edit/Observation** from the menu of the main window. In a cascading menu the name of the loaded data sets popup, in this case only *test1* is visible, select it. Field-book data are displayed in the default mask type.

> ***Note***
>
> The mask name is used for dialog boxes containing tabular data. This comes from the display masks which were used on old Leica instruments.



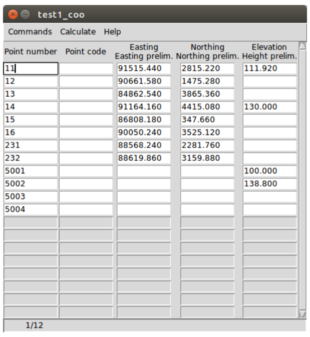
Fieldbook data

Data are arranged in a table, a row contains station or observed point data. Column header can contain more labels (e.g. Signal height and Instrument height). The color of the values in the cells can be different, if more header lines are present, for example signal heights are black, instrument heights are red. Colors can be customized in the **File/Colors...** menu from the main window.

You can move in the table using the right side scroll bar, up and down arrow keys, mouse wheel (Windows only), TAB/PgUp/PgDn/Ctrl-PgUp/Ctrl-PgDn keys. You can edit the content of the active field, inside the field Home/End/Backspace/Delete/Insert keys can be used. If the edited value is not valid (e.g. non-numeric value in the distance field) an error message appear and you can not leave the field until the field value is invalid.

View and edit coordinate lists

The loaded coordinate lists can also be opened in a window. Select **Edit/Coordinates** from the menu of the main window. In a cascading menu the name of the loaded data sets popup, in this case only *test1* is visible, select it. Coordinate data are displayed in the default mask type. Points are ordered in the table by point IDs.



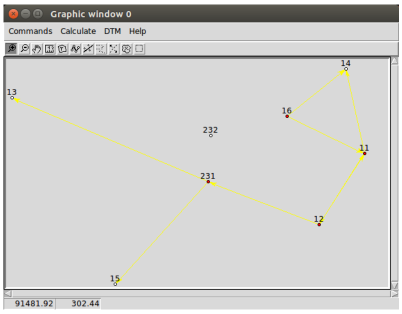
Coordinate data

Data are arranged in a table, a row contains coordinates of a point. Column header can contain more labels (e.g. Easting and Easting prelim.) The color of the values in the cells can be different, eastings are black, preliminary eastings are red. Colors can be customized in the **File/Colors...** menu from the main window.

Field values can be edited in the same way as in field-books. The default mask for field-books and coordinate lists can be configured in the *geo_easy.msk* file (*geoMaskDefault* and *cooMaskDefault* variables)

Graphic window

Points having horizontal coordinates from all loaded data sets are displayed in graphic window. Select **Window/New graphic window** from the menu of the main window or press F11 key to open a new graphic window.



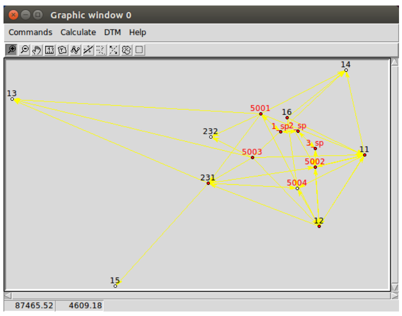
Graphic window

Enlarge the size of the graphic window, drag the corner of the window by the mouse and press F3 to zoom to extent. Point symbols, IDs and observations are visible in the graphic window. Red filled circles are stations but not oriented yet.

Preliminary coordinates

Let's calculate preliminary coordinates for those points which have no coordinates so far. Select **Calculate/Preliminary coordinates** from the menu of any window. You'll get a message, that there are no elevations for some points. Several points will be added to the graphic window and the coordinate list. They have red point IDs to mark preliminary coordinates. Preliminary orientations and elevations are also calculated.

Press F5 button to turn off detail points, having a less crowded view in the graphic window (or **Commands/Detail points** from the menu of the graphic window).



Graphic window detail points turned out

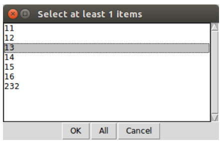
> ***Note***
>
> Detail points are selected by the program using the following rules. A detail point has a numeric ID and has only one polar observation and was not station.

Calculations

The calculation results are listed in the *Calculation results* window, if you have closed it, open it **Window/Log window** from the menu of the main window. Calculation results are stored in a log file (*geo_easy.log* in the user's home directory), so you can review them later. There are calculations for a single point and multiple points. Single point calculations are available from the popup menu, right click on the point in the graphic window or in the row of the point in the coordinate list window or in the field-book window. Multi point calculations are available from the *Calculation** menu of any window.

Whole circle bearing and distance

Let's calculate the whole circle bearing and distance between points 231 and 13. Click on the point *231* with the right mouse button in the graphic window and select **Bearing/Distance** from the popup menu. A selection list is displayed with the point IDs having coordinates. You can select one or more point to calculate bearing and distance. Select *13* from the list. The calculation result is visible in the *Calculation results* window and in the status bar of the graphic window.



Point selection box

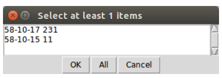
```
2017.11.26 09:22 - Bearing/Distance
Point num  Point num  Bearing   Distance Slope dis Zenith angle
231        13         293-08-21 4029.889
```

The slope distance and the zenith angle are calculated only if the elevations of the points are known.

> ***Note***
>
> You can use the right mouse button in the field-book or coordinate list windows, too. Right click on the point ID and select **Calculate**, a cascading menu appears with the possible calculations for the point. If you select the menu item with the point ID an info box will be displayed about the point.

Orientation on a station

Let's calculate orientation for station *12*. Click on the point *12* with the right mouse button in the graphic window. Select **Orientation** from the popup window. A list with the back-sight directions are displayed, orientation angle in the first column and point ID in the second.



Backsight selection

Select both points (231, 11), use Shift or/and Ctrl keys to select more lines. If you would like to select all rows, click on the *All* button.

A weighted average will be calculated for the mean orientation angle, the weights are the distances. The calculation results are shown in the *Calculation results* window.

```
2017.11.26 09:47 - Orientation - 12
Point num  Code Direction    Bearing   Orient ang   Distance   e" e"max   E(m)
231             232-53-54   291-04-11    58-10-17   2243.319    0   16    0.010
11              334-20-10    32-30-25    58-10-15   1588.873   -1   19   -0.010
Average orientation angle                58-10-16
```

The *e"* column contains the difference from the mean, *e"(max)* is the allowable maximal difference (depending on distance), *E(m)* is the linear difference at the back-sight point.

Note that the fill color of the point marker of point *12* became green, oriented station. The orientation angles and the mean are stored in the field-book, too. Select the orientation mask from the **Commands/Mask...** in the field-book window to see them.

Orientation for all points

You can calculate orientations for all station in a single step, select **Calculate/Orientations** from the menu of any window. Results are written to the *Calculation results* window. If the difference from the mean is too large a warning is displayed. The three other unoriented stations are also oriented.

```
2017.11.26 10:05 - Orientation - 11
Point num  Code Direction    Bearing   Orient ang   Distance   e" e"max   E(m)
12              295-54-35   212-30-25   276-35-50   1588.873    1   19    0.010
14               71-01-11   347-36-58   276-35-47   1637.971   -1   18   -0.010
Average orientation angle               276-35-48
```

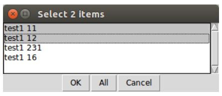
```
2017.11.26 10:05 - Orientation - 231
Point num  Code Direction    Bearing   Orient ang   Distance   e" e"max   E(m)
15              341-58-03   222-18-10   240-20-07   2615.063   -1   14   -0.023
13               52-48-11   293-08-21   240-20-10   4029.889    1   11    0.023
Average orientation angle               240-20-08
```

```
2017.11.26 10:05 - Orientation - 16
Point num  Code Direction    Bearing   Orient ang   Distance   e" e"max   E(m)
14              290-57-39    51-22-38   120-24-59   1425.779   -2   20   -0.016
11              355-25-59   115-51-02   120-25-03   1628.118    2   18    0.016
Average orientation angle               120-25-01
```

> ***Note***
>
> Orientation angles are stored in the field-book, you can see them if you select *orientation* template (mask). The calculated orientation angles will overwrite the previous values.

Intersection

Let's calculate the coordinates of point *5004* using intersection. Four directions were measured from point *11, 12, 231* and *16* to *5004*. Stations have to be oriented to be used in intersection. Right mouse button click on point *5004* in the graphic window and select **Intersection** from the popup menu. A list of possible intersection directions are displayed in the selection window. The field-book name and the point numbers are shown in the list (if more field-books are loaded, stations from any field-book can be used). Select two directions *11* and *12* (best intersection angle).



Intersection point selection

There are two columns in the list window. The first column refers to the data set name, the second column contains point numbers.

> ***Note***
>
> This selection dialog is used at several places in the user interface. Check the header of the selection window, how many lines should be selected.

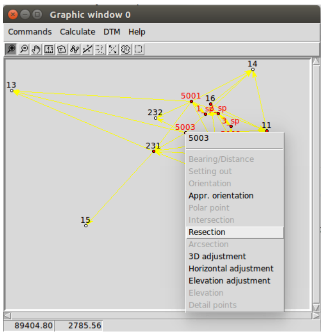
```
2017.11.26 10:23 - Intersection
Point num  Code                 E            N     Bearing
11                         91515.440     2815.220   243-57-51
12                         90661.580     1475.280   330-00-58
5004                       90246.207     2195.193
```

Note the color of point number is changed in the graphic window from red to black after calculation done.

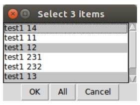
> ***Note***
>
> You can repeat the intersection calculation selecting different directions. The last calculated coordinates are stored only in the coordinate list. Previous coordinates will be overwritten.

Resection

Let's calculate the coordinates of point *5003* in demo data set using resection. There are six possible directions for resection. Let's find the best geometry, 120 degree between directions at 5003. Point 12, 13 and 14 look optimal. Right mouse button click on point *5003* in the graphic window and select **Resection** from the popup menu. A list of possible resection directions are displayed in the selection window. The field-book name and the point numbers are shown in the list.



Resection from the popup menu



Resection point selection

2018.01.20 11:26 - Resection

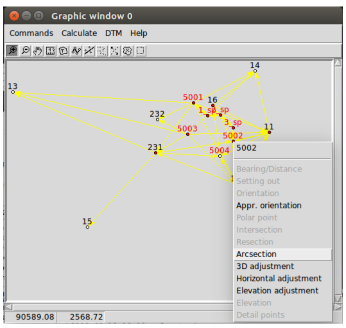
Point num	Code	E	N	Direction	Angle
14		91164.160	4415.080	99-10-24	88-42-37
12		90661.580	1475.280	187-53-01	147-41-20
13		84862.540	3865.360	335-34-21	
5003		89398.550	2775.210		

Note

You can repeat the resection calculation selecting different direction. The last calculated coordinates are stored only in the coordinate list. Previous coordinates will be overwritten.

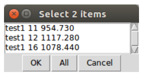
Arcsection

Let's calculate the coordinates of point *5002* using arcsection. There are three measured distances from *5002* to *11*, *12* and *16*. Right mouse button click on point *5003* in the graphic window and select **Arcsection** from the popup menu. A list of possible arcsection directions are displayed in the selection window. The field-book name and the point numbers are shown in the list.



Arcsection from the popup menu

Let's use the distance from point 11 and 12.



Arcsection point selection

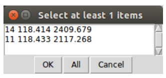
```
2018.01.20 12:01 - Arcsection
Point num  Code              E           N        Distance
11                       91515.440    2815.220     954.730
12                       90661.580    1475.280    1117.280
5002                     90587.628    2590.110
```

> ### *Note*
>
> Using arcsection there are two solution (two intersections of the two circles). If there are more observations for the point to be calculated, GeoEasy can choose the right solution as this case a third distance. Otherwise the user have to select from the two possible solutions.

> ### *Note*
>
> You can repeat the arcsection calculation selecting different distances. The last calculated coordinates are stored only in the coordinate list. Previous coordinates will be overwritten.

Elevation calculation

Let's calculate the elevation of point 5003. Right mouse button click on point *5003* in the graphic window and select **Elevation** from the popup menu. A list of possible elevation calculations are displayed in the selection window. The point name, the elevation and the distance are shown in the list.



Elevation point selection

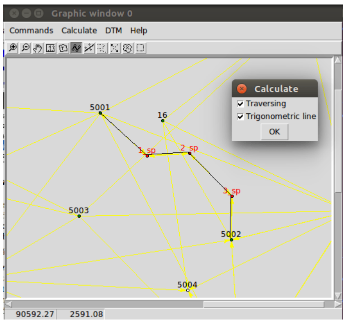
Let's select both rows. The elevation will be calculated as a weighted average. The weight is inverse proportional of the distance square.

```
2018.01.20 20:30 - Elevation
Point num  Code             Height      Distance
14                         118.414      2409.679
11                         118.433      2117.268

5003                       118.425
```

> ### *Note*
>
> You can repeat the elevation calculation selecting different points. The last calculated elevation is stored only in the coordinate list. Previous elevation will be overwritten.

Traverse and trigonometric line

There is a traversing line with three internal points (1_sp, 2_sp, 3_sp) between point *5001* and *5002*. Let's use the 6th toolbar icon to specify the traversing line. Click on the first point (*5001*) and the three internal points using the traversing tool and double click on the last point (*5002*). A black line is draw as you click on points.



Traversing line selection

This is an open traversing with orientation on both known endpoints. A small dialog is shown where you can select the calculation task. Traversing to calculate horizontal coordinates and/or Trigonometric line to calculate elevations.

```
2018.01.20 21:11 - Traversing Open, two orientation
            bearing    bw dist
Point        angle     distance  (dE)     (dN)       dE         dN
           correction  fw dist    corrections      Easting     Northing
              0-00-00        -
5001        132-34-52
           -  0-00-05                             89562.512   3587.544
            132-34-47        -
1_sp        134-23-17  498.890  367.351 -337.557    367.369   -337.521
           -  0-00-05        -    0.018    0.035  89929.881   3250.023
             86-57-59        -
2_sp        228-16-31  330.610  330.147   17.496    330.159     17.520
           -  0-00-05        -    0.012    0.023  90260.040   3267.542
            135-14-25        -
3_sp        225-08-37  468.460  329.859 -332.637    329.876   -332.604
           -  0-00-06        -    0.017    0.033  90589.916   2934.938
            180-22-56        -
5002        359-37-10  344.860   -2.301 -344.852     -2.288   -344.828
           -  0-00-06        -    0.012    0.024  90587.628   2590.110

              0-00-00                              1025.116   -997.434
           1080-00-27 1642.820 1025.056 -997.550
            720-00-00
           -  0-00-27             0.060    0.116
```

```
                                            0.130

Error limits                     Angle (sec)   Distance (cm)
Main, precise traversing             50        30
Precise traversing                   65        38
Main traversing                      67        51
Traversing                           85        63
Rural main traversing                87        71
Rural traversing                    105        89
```

```
2018.01.20 21:11 - Trigonometrical line
                                           Height differences
Point    Distance    Forward Backward   Mean  Correction Elevation

5001                                                     100.000
            498.879   23.947        -   23.947   -0.010
1_sp                                                     123.938
            330.623    0.307        -    0.307   -0.004
2_sp                                                     124.240
            468.449   12.661        -   12.661   -0.008
3_sp                                                     136.893
            344.836    1.926        -    1.926   -0.005
5002                                                     138.815

           1642.787                     38.842   -0.027   38.815

Error limit:   0.118
```

Note

Orientations on all stations were calculated previously. Orientation have to be calculated before traversing calculation.

You can start traversing calculation from the **Calculation/Traversing** menu. That case the traversing points are selected from lists.

Detail points

Some polar detail points were measured from the traversing points. Let's calculate the coordinates for those points. The fastest way to get the coordinates of detail points is to select **Calculation/New detail points** from the menu. It will calculate orientation angle automatically if necessary.

```
2018.01.28 13:30 - New detail points
                                                        Oriented   Horizontal
Point num  Code       E          N           H   Station   direction  distance
101              89817.597  3124.363   125.301 1_sp      221-46-38  168.468
102              89888.171  3112.673   126.819 1_sp      196-52-41  143.505
103              90043.330  3181.366   126.988 1_sp      121-09-42  132.631
201              90257.647  3134.405   124.353 2_sp      181-00-54  133.142
202              90112.941  3206.373   120.740 2_sp      247-25-17  159.272
```

```
301                 90543.529  2842.469   139.235 3_sp     206-38-02  103.440
302                 90467.005  2904.622   137.424 3_sp     256-08-41  126.578
303                 90443.170  2958.505   139.836 3_sp     279-07-35  148.611
```

Note

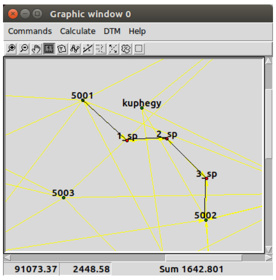
You can recalculate all detail points after editing the observation data using **Calculate/All detailpoints**, you may need to recalculate orientation, too. You can recalculate station by station, right click in the graphic window on a station and select **Detail points** from the popup menu.

Calculation distances and areas

The sum of the horizontal distances between points having coordinates can be calculated in the graphic window using the ruler tool from the toolbar (4th icon). Click on the point marker of the first point and the further points. Finally double click on the last point. A report is sent to *Calculation results* window.

```
2018.02.24 09:11 - Distance calculation
Point num          E            N            Length
5001           89562.447     3587.503
1_sp           89929.837     3249.997       498.885
2_sp           90260.005     3267.527       330.633
3_sp           90589.899     2934.934       468.453
5002           90587.624     2590.112       344.830

Sum                                        1642.801
```

The sum of the distances is shown in the status line of the graphic window, too.



Distance calculation

The next icon, right to the distance calculation is the area calculation. It works similar to the distance calculation. Click on the points of the polygon and double click on the last point (you needn't to click on the first point finally). The calculation result are reported in the *Calculation result* window.

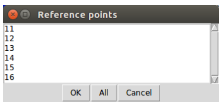
```
2018.02.24 09:18 - Area calculation
Point num          E            N            Length
5003           89398.545     2775.181
5001           89562.447     3587.503       828.693
1_sp           89929.837     3249.997       498.885
2_sp           90260.005     3267.527       330.633
3_sp           90589.899     2934.934       468.453
```

```
5002          90587.624     2590.112      344.830
5003          89398.545     2775.181     1203.396

Area                                   680295.78817
Perimeter                                3674.889
```

> ***Note***
>
> The distance and area calculation is available from the **Calculation** menu. That case the points are selected from lists.

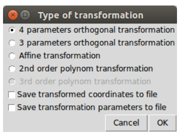
Coordinate transformation

During a GeoEasy session all points have to be in the same coordinate reference system (CRS). Coordinates can be converted between two CRSs if there are common points in the two system. Two GeoEasy data sets have to be used. The source data set is opened and select **Calculation/Coordinate transformation** from the menu. The target data set have to be selected next. Select *test1_trafo.geo* from the *demodata* folder. A list of the common points width horizontal coordinates in the two data sets is shown.



Common points for transformation

Select all points and press OK button. In the next dialog box the transformation type can be selected.



Transformation options

Pressing the OK button the transformation parameters are calculated using the least squares method. In the *Calculation results* window three blocks of information is displayed.

```
2018.02.24 12:09 - 4 parameters orthogonal transformation test1 -> test_trafo
E = 561684.477 + e * 0.999997669 - n * -0.000003434
N = 246411.178 + e * -0.000003434 + n * 0.999997669

  Scale = 0.99999767 Rotation = -  0-00-01

  Point num      e           n           E            N          dE       dN       dist
  11        91515.440   2815.220   653199.720   249226.070   -0.007    0.007    0.010
  12        90661.580   1475.280   652345.850   247886.150    0.001   -0.007    0.007
  13        84862.540   3865.360   646546.830   250276.240    0.002   -0.003    0.004
  14        91164.160   4415.080   652848.440   250825.940   -0.001   -0.006    0.006
  15        86808.180    347.660   648492.460   246758.540   -0.004   -0.001    0.005
  16        90050.240   3525.120   651734.510   249935.970    0.009    0.010    0.014
```

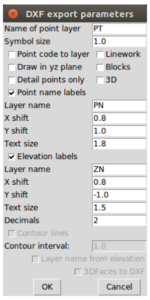
```
RMS= 0.008

Point num     e           n           E            N
231       88568.240   2281.760   650252.518   248692.628
232       88619.860   3159.880   650304.141   249570.746
```

In the first block the formula of the transformation is given. The second block contains the coordinates of common points and the errors. In the third block the transformed coordinates are given, those points can be found here which have coordinates in the source data set but not in the target data set.

> ***Note***
>
> If the transformation parameters are known use the **Commands/Transformation** or **Commands/Transformation, parameters from file** from the menu of the coordinate list window.

Save to DXF file

The points with horizontal coordinates from all loaded data sets can be exported into a DXF file. Select **Commands/DXF output** from the menu of the graphic window. In the displayed dialog box several options can be set for the DXF file.



DXF options

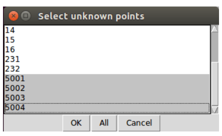
The point symbol (AutoCAD point entities), the point ID and the elevation can be exported to the output. The last block is available if a DTM is loaded.

Horizontal network adjustment

Let's calculate the coordinates of points 5001, 5002, 5003 and 5004 using all available observations from points. GeoEasy uses GNU Gama for the network adjustment.

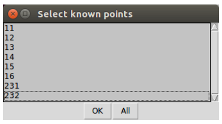
Before adjustment calculation the a priori standard deviations should be set in the **Calculation parameters** dialog. 3 arc seconds for directions and 3 mm + 3 ppm for distances.

From the **Calculate** menu select **Horizontal network adjustment**. From the first point list select the unknown points (which coordinates are changed during adjustment). This list contains all point having preliminary or final coordinates.



Unknown points

From the second point list select the fixed points (if no fixed points selected then free network will be calculated). This list contains point with final coordinates.



Fixed points

The result of the adjustment is shown in the Calculation results window. During the adjustment statistical tests are calculated to detect blunders but blunders are not eliminated automatically.

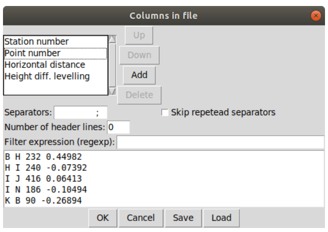
Leveling network adjustment

Leveling data can be loaded from GSI field-books created by digital leveling instruments (for example Leica DNA03 or NA3000 instruments). Manual input of height differences is also possible.

Let's start with an ASCII file (field-book) which contains start and endpoint, distance, height difference.

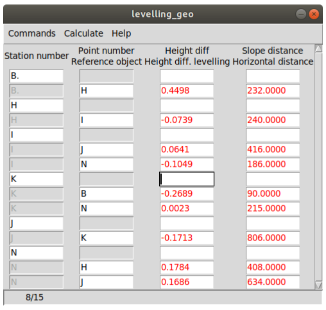
```
B H 232 0.44982
H I 240 -0.07392
I J 416 0.06413
I N 186 -0.10494
K B 90 -0.26894
K N 215 0.00234
J K 806 -0.17131
N H 408 0.17836
N J 634 0.1686

Field-book (leveling.dmp)
```

Let's load this field-book into GeoEasy. Select **File/Load** from the menu of the main window. Select *Fieldbook (*.dmp, *.DMP)* type. The leveling.dmp file is in the demodata sub-directory of GeoEasy installation folder. Select the file and click on Open button. A dialog will be displayed where fields of the input file can be set. Remove the unnecessary fields (*Horizontal angle, Vertical angle, lope distance, signal height,instrument height*) and add *horizontal distance* and *Height diff. leveling*. Don't forget to add *space* to the separators.



Loading leveling.dmp

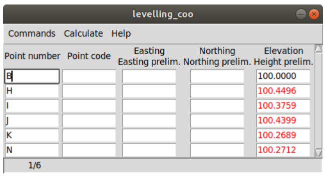
Open the field-book (**Edit/Observations**) and change the mask (**Commands/Mask...**) to *leveling*. You can see nine observations.



Observations in leveling mask

These observations were made by digital leveling instrument with a standard deviation of 0.3 mm/km. Change calculation parameters (**File/Calculation parameters...**), *Decimals in results* should be changed to 4. Check also *Standard deviation for leveling [mm/km]*, it should be 0.3.

We shall adjust this small leveling network. There are no elevations in the field-book, so first set the elevation of point *B* to 100.000. After it let's calculate preliminary elevations (**Calculations/Preliminary coordinates**)

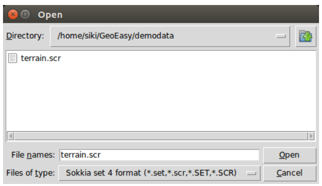


Preliminary elevations

Now we can start leveling network adjustment (**Calculate/Leveling network adjustment**). Select all point as unknown. In the calculation result window a long result list is displayed and the coordinates in the coordinate list are updated.

Digital terrain model

GeoEasy is capable to create TIN based Digital Terrain Models from the points in the loaded data sets or from a DXF file. *Triangle* open source project is used to generate triangles. There is a small electric field book in the demo data set called *terrain.scr*. Load the *scr* file using the **File/Load...** menu of the main window.



Loading field book

There are 77 points in the coordinate list, let's open a graphic window to see the points and turn off the the yellow observation lines and point name labels using the **Commands/Observations F4** and **Commands/Point names** from the menu of the graphic window.

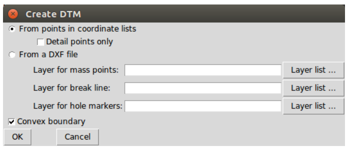
Note

In the calculation results window you can see a table with collimation and index errors. If the observations were made in two faces, the average of face left and face right will be stored in the field-book.

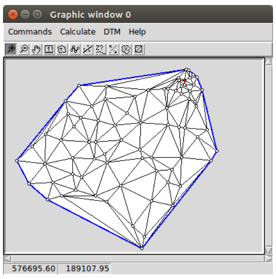
Note

The colors used in the graphics window can be changed using **File/Colors...** from the menu of the main window.

Let's start to create a TIN, select **DTM/Create...** from the menu of the graphic window and press OK button in the *Create DTM* dialog and select directory and name for the DTM in the *Save as* dialog.

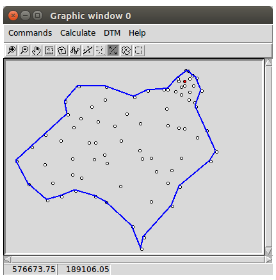


DTM creation



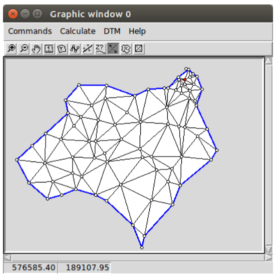
TIN in the graphic window

The convex hole of the points is filled by triangles which have minimal sum of perimeters. At the side of the model there are narrow triangles. These can be avoided by defining a non-convex boundary for the model. Unload the TIN by **DTM/Close** from the menu of graphic window. Using the Break line tool from the toolbar draw the boundary of the model.



Non-convex boundary for TIN

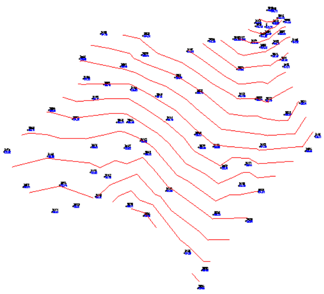
Select again the **DTM/Create...** from the menu and unselect convex boundary checkbox. Triangles are created inside the closed polyline.



Non-convex boundary for TIN

> ### *Note*
>
> Break lines can be added, those can be open polylines. If convex boundary is unchecked at least one closed polyline must be added to the model.

Let's add contours to our model, **DTM/Contours** from the menu. Input 1 (meter) for contour interval. Finally export contours to an AutoCAD DXF file using **Commands/DXF output**.



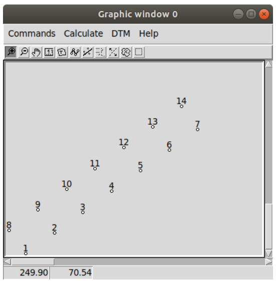
Contours in LibreCAD

> ### *Note*
>
> TINs are stored in three ASCII files (.pnt for points, .dtm for triangles and .pol for break lines).

Regression calculation

Regression calculation can be used to find best fitting geometrical shape to the coordinates of points. Least square adjustment is used to find the parameters of the best fitting geometry. The *reg.geo* data set in the demodata folder will be used in this chapter. Load the data set to try regression algorithms.

Regression line



Crane track points

Observations were made along a crane track. Points from 1 to 7 are on the right rail and points from 8 to 14 on the left rail. Let's first fit a 2D line on the right side rail, **Calculate/Regression calculation/2D Line** from the menu.

```
2019.03.30 13:59 - 2D Line
N = +0.71863307 * E -100.619
Angle from east:  35-42-08
Correlation coefficient: 1.000

Point num           E             N            dE           dN            dist
1                223.563       60.040       -0.001        0.001         0.001
2                231.684       65.879        0.001       -0.001         0.001
3                239.801       71.714        0.002       -0.002         0.003
4                247.926       77.543       -0.003        0.004         0.005
5                256.046       83.388        0.002       -0.002         0.003
6                264.161       89.211       -0.002        0.003         0.004
7                272.285       95.058        0.002       -0.002         0.003

RMS=0.003
```

The results are printed in the *Calculation results* window. Beside the equation of the line the direction and correlation are also calculated. From the table of the point-line distances (*dist*) can be read.

This case we had better to fit two parallel lines using **Calculate/Regression calculation/Parallel 2D lines**. From the first point list select the points on right side rail (1-7) and press OK. From the second point list select points on left side rails (8-14).

```
2019.03.30 14:05 - Parallel 2D lines
N = +0.71870599 * E -100.637
N = +0.71870599 * E -90.785
Angle from east:  35-42-18
Horizontal distance: 8.000
Correlation coefficient: 1.000

Point num           E             N            dE           dN            dist
1                223.563       60.040        0.000       -0.000         0.001
2                231.684       65.879        0.001       -0.002         0.002
3                239.801       71.714        0.002       -0.003         0.003
4                247.926       77.543       -0.003        0.004         0.005
5                256.046       83.388        0.001       -0.002         0.002
6                264.161       89.211       -0.003        0.004         0.005
7                272.285       95.058        0.001       -0.001         0.001
8                218.896       66.533       -0.002        0.003         0.003
9                227.017       72.376        0.001       -0.002         0.002
```

```
10                235.137      78.206      -0.002       0.002       0.003
11                243.254      84.045       0.001      -0.001       0.001
12                251.374      89.883       0.002      -0.002       0.003
13                259.496      95.715      -0.001       0.001       0.001
14                267.611     101.550       0.001      -0.001       0.001

RMS=0.004
```

Regression plane

On a diaphragm wall points were scanned by a robotic total station, points from *Scan0676* to *Scan0915*. Let's check if the wall is vertical using **Calculate/Regression calculation/Vertical plane**. In the point list select all *Scan* points and press OK.

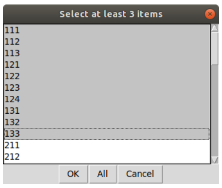
```
2019.03.30 15:25 - Vertical plane
N = -0.00119324 * E +0.054
Angle from east: -  0-04-06
Correlation coefficient: -0.390

Point num           E            N            dE          dN          dist
Scan0676         68.799       -0.004      -0.000      -0.024       0.024
Scan0677         67.798       -0.004      -0.000      -0.022       0.022
Scan0678         66.789        0.002      -0.000      -0.028       0.028
Scan0679         65.790        0.001      -0.000      -0.026       0.026
Scan0680         64.789        0.001      -0.000      -0.024       0.024
Scan0681         63.788        0.003      -0.000      -0.025       0.025
Scan0682         62.786        0.003      -0.000      -0.024       0.024
...

RMS=0.024
```

We got two points for the planned position of the diaphragm wall, these are points *S2* and *S3*. Let's check the distances from the planned position. Select **Calculate/Regression calculation/Distance from line** from the menu (vertical plane is the same as 2D line in this situation). First select the two points from the plan *S2* and *S3* from the point list. From the second point list select *Scan* points. In the *Calculation results* list we get the distances of the scanned points from the planned positions.

```
2019.03.30 15:45 - Distance from the S2 - S3 line
Point num           E            N        Distance         dE           dN
Scan0676         68.799       -0.004      -0.004       0.000       0.004
Scan0677         67.798       -0.004      -0.004       0.000       0.004
Scan0678         66.789        0.002       0.002       0.000      -0.002
Scan0679         65.790        0.001       0.001       0.000      -0.001
Scan0680         64.789        0.001       0.001       0.000      -0.001
Scan0681         63.788        0.003       0.003       0.000      -0.003
Scan0682         62.786        0.003       0.003       0.000      -0.003
Scan0683         61.785        0.003       0.003       0.000      -0.003
Scan0684         60.784        0.002       0.002       0.000      -0.002
Scan0685         59.784        0.003       0.003       0.000      -0.003
...
```

Regression circle

There are points on five horizontal sections of a chimney. Let's fit a regression circle on lowest section, point ids like '1nn'. Select **Calculate/Regression calculation/Circle** from the menu of any window. A list of point ids is displayed in a new window. Select all points from 111 to 133 and press OK button. You will be asked for the radius of the circle. Let the *unknown* value in the input box to calculate radius from the data. You can give a radius if it is known and you don't want to get an estimated value from the circle regression.



Points for circle regression

The result of the calculation is displayed in the *Calculation results* window. *E0* and *N0* are the coordinates of the center of the circle, *R* is the radius. The tabular data show the coordinates of the used points and the differences from the best fitting circle (in east, north and radial direction).

```
2019.03.29 23:10 - Circle
E0 = 635.693 N0 = 271.517 R = 2.442

Point num          E           N          dE          dN          dR
111          633.661     270.152       0.005       0.003      -0.005
112          635.355     269.096       0.000       0.002      -0.002
113          637.586     269.966      -0.004       0.003      -0.005
121          633.975     269.779       0.001       0.001      -0.001
122          634.477     269.404      -0.002      -0.004       0.005
123          634.520     269.378      -0.001      -0.003       0.003
124          634.520     269.378      -0.001      -0.003       0.003
131          637.898     270.468       0.000      -0.000       0.000
132          638.132     271.428       0.001      -0.000       0.001
133          638.129     271.655       0.002       0.000       0.002

RMS=0.003
```