ProfileR

version 2.5

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Summary

ProfileR has been designed for surface array resistivity profile imaging. ProfileR is an inverse solution for a 2-D resistivity distribution based on computation of 3-D current flow using a quadrilateral finite element mesh. The inverse solution is based on a regularised objective function combined with weighted least squares (an 'Occams' type solution).

ProfileR requires very little input for generation of the finite element mesh. The minimum the user must specify is the number of electrodes and the co-ordinates of the end electrodes. ProfileR can account for variation in topography by user specification of position of intermediate electrode positions and elevation. The spacing of electrodes does not need to be uniform.

The mesh that is generated consists of a foreground region and a background region. The foreground region is the area investigated by the survey and it will be the resistivity variation in this area that will be output by ProfileR. The background region is transparent to the user and is employed to account for the infinite boundary conditions.

The mesh is generated with two finite elements between electrodes in the horizontal in the foreground region. In the background region the mesh is extended to the left and right of the electrode array using exponentially increasing elements. In the vertical elements increase in size with depth.

The region is parameterised in terms of resistivity blocks by grouping patches of elements. In the foreground region a parameter block is defined as a 2 by 2 block of elements.

File specifications

ProfileR requires only one input file: *profiler.in* (see next page for details).

ProfileR will output a number of files:

- *profiler.log* which will contain main log of execution,
- *profiler.bln* contains the horizontal and vertical co-ordinates of the foreground region. The first line shows the number of co-ordinates in the file. This is followed by 2 columns with horizontal and vertical positions (in m), respectively. The file can be used to overlay the boundary in Surfer, for example.
- *electrodes.dat* contains the co-ordinates of the electrodes. You may find this useful for overlaying on your final resistivity image (using a post map in Surfer, for example).

If you select an inverse solution then you will get the following two additional files

- *profiler.dat* which will contain the resistivity result of the inverse solution. The output format is 4 columns: Column 1 is the horizontal position, Column 2 is the elevation, Column 3 is the resistivity (in Ωm), Column 4 is log10 resistivity.
- *profiler.err* will contain five columns. In the first column is the normalised data misfit, the second column contains the observed data recorded as an apparent resistivity, the third column contains the equivalent apparent resistivities for the computed model, the fourth column shows the original data weight, the fifth column is the final data weight (a '*' will indicate if any weights have been changed).

If you select a forward solution then you will get the following file

- *forward.dat* will contain seven columns. The first column contains the measurement number, columns 2 to 5 contain the electrodes used for that measurement, column 6 contains the resistance, column 7 contains the apparent resistivity. ***NOTE: The apparent resistivity calculation assumes that the ground surface is horizontal and that z=0 corresponds to the ground surface. If this is not the case then ignore the calculated apparent resitivity values. Also, with the current version the forward model is computed for a uniform resistivity of 100 Ωm***

Details of profiler.in

Line1: (Character*80) *header*
where *header* is a title of up to 80 characters

Line 2: (Integer, 2 Real, 2 Integer) *num_electrodes, survey_depth, resis_start, data_type, num_poles*

where *num_electrodes* is the number of electrodes (maximum 128); *survey_depth* is the maximum survey depth (in m), *resis_start* is the starting uniform resistivity (in ohm m) for the inverse solution; *data_type* is 0 if the data used in the inversion is not to be transformed to log values or 1 if the data is to be log transformed (the normal approach). If *data_type* is 2 then a forward model is selected, *num_poles* is the number of 'infinite' pole electrode sites. For a pole-dipole this should be equal to 1, for pole-pole this should be equal to 2, for all other arrays this will be equal to 0. Note that *survey_depth* will control the mesh discretisation in the vertical and so it must be determined even if a forward model is selected.

Line 3: (Integer) *num_electrode_positions*

where *num_electrode_positions* is the number of positions at which electrode horizontal postion and elevation will be stated. Note that the positions of the start and end electrodes must be stated and so *num_electrode_positions* must be greater than or equal to 2.

Line 4: (Integer, 2 real) *electrode, electrode_x, electrode_z*

where *electrode* is electrode number, *electrode_x* is horizontal position (in m) and *electrode_z* is elevation (in m), positive upwards.

Repeat Line 4 for all *num_electrode_positions*

Ignore Line 5 if forward model is selected
Line 5: (Real) *data_error*

where *data_error* is typical (expected) % error of data. *data_error* must be greater than zero. Typical values are 2.0 to 5.0

Line 6: (Integer) *num_meas*

where *num_meas* is number of measurements to follow in file (maximum 1500)

Line 7: (5 Integer, Real) *n, elec1, elec2, elec3, elec4, R*

where *n* is the measurement number; *elec1* is electrode number (not co-ordinate) for P+ electrode; *elec2* is electrode number for P- electrode; *elec3* is electrode number for C+ electrode; *elec4* is electrode number for P- electrode; *R* is measured resistance (in Ω)

If *num_poles* = 1 then *elec4* will be omitted. If *num_poles* = 2 then *elec2* and *elec4* will be omitted.

Note that *R* is only required if an inverse model is selected. If you are running a forward model (i.e. *data_type* is 2) then Line7 will only contain 5 integer values.

Repeat Line 7 for all *num_meas*

Examples

Example 1. Forward model with pole-dipole array

An example dataset is supplied for a 32 electrode pole-dipole survey. The electrode spacing is 1m. The contents of *profiler.in* are shown below.

```
** Example 1 : Pole-dipole forward model **

32 5.0 100.0 2 1 << num_electrodes,survey_depth,resis_start,data_type,num_poles

2  << num_electrode_positions
1      0.0   0.0   <<  electrode, electrode_x, electrode_z
32    31.0   0.0   <<  electrode, electrode_x, electrode_z


155  << number of measurements
     1     2   3      1
     2     3   4      2
     3     4   5      3
     4     5   6      4
     5     6   7      5
     6     7   8      6
     7     8   9      7
     8     9  10      8

       ....

   151    12  21      3
   152    13  22      4
   153    14  23      5
   154    11  21      1
   155    12  22      2
```

The forward model is produced in *forward.dat* and is shown below. Note that the last column shows the apparent resistivity and thus indicates the forward modelling error (since for this case all values should be equal to 100Ωm).

```
     155 measurements
    n  P+  P-       C+           R               Rho
    1   2   3        1    0.8101163180E+01      101.79624
    2   3   4        2    0.7980153344E+01      100.27561
    3   4   5        3    0.7983424489E+01      100.31665
    4   5   6        4    0.7984650111E+01      100.33198
    5   6   7        5    0.7985201300E+01      100.33884
    6   7   8        6    0.7985491673E+01      100.34242
    7   8   9        7    0.7985663114E+01      100.34451
    8   9  10        8    0.7985773263E+01      100.34582

       ....

  151  12  21        3    0.8617979379E+00       96.92653
  152  13  22        4    0.8623535850E+00       96.98266
  153  14  23        5    0.8627666985E+00       97.02263
  154  11  21        1    0.7695414950E+00       96.04595
  155  12  22        2    0.7705553349E+00       96.16477
```

Example 2. Wenner survey of spoil heap

An example dataset is supplied for a 32 electrode Wenner survey on a spoil heap of a former tungsten mine in the North West of England. The survey was conducted using 1m spaced electrodes. The contents of *profiler.in* (with most of the data removed) are shown below. Note that in this example the ground surface is assumed flat and so only the co-ordinates for the first and last electrode are needed.

```
** Example 2 : Wenner Survey **

32  5.0  100.0  1 0 << num_electrodes,survey_depth,resis_start,data_type,num_poles

2  << num_electrode_positions
1      0.0   0.0   <<  electrode, electrode_x, electrode_z
32    31.0   0.0   <<  electrode, electrode_x, electrode_z

5.0 <<  data_error

155  << number of measurements
1       2   3      1   4       17.30616
2       3   4      2   5       15.63835
3       4   5      3   6       11.48075

     ....

153    14  23      5  32        5.25296
154    11  21      1  31        5.70286
155    12  22      2  32        5.46249
```

The figure below shows the results from ProfileR as supplied in *profiler.dat* which shows clearly the extent of the spoil heap by it's associated high metal content (confirmed by later drilling) and also the depth to bedrock.

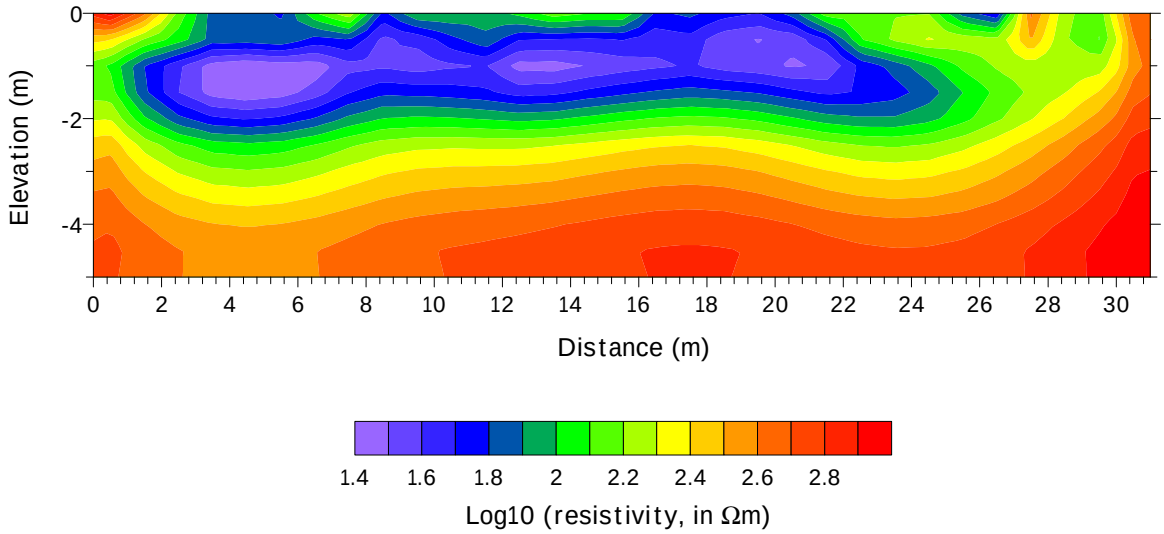

Figure 1. Resistivity image from data in Example 2.

Example 3. Wenner survey with topographic variation

The second example illustrates how to account for topography in the inversion. An example dataset is supplied for a 48 electrode Wenner survey at a site in the North of England. The survey was conducted using 5m spaced electrodes. The contents of *profiler.in* (with most of the data removed) are shown below.

```
** Example Wenner Survey with topography **

48  20.0  100.0 1 0 << num_electrodes,survey_depth, resis_start,data_type,num_poles

6  << num_electrode_positions
1      0.0   0.0   <<  electrode, electrode_x, electrode_z
12    55.0   0.5
15    70.0   0.75
20    95.0   0.25
40   195.0   -0.5
48   235.0   0.0   <<  electrde, electrode_x, electrode_z

2.0 <<  data_error

223  << number of measurements
1      2     3     1     4     4.62357
2      3     4     2     5     4.73952
3      4     5     3     6     4.90588

     ....

221   34    40    28    46     0.281350
222   35    41    29    47     0.292930
223   36    42    30    48     0.298600
```

The figure below shows the results from ProfileR as supplied in *profiler.dat* Here, the electrode locations (in *electrodes.dat*) and the boundary (in *boundary.bln*) have been used for presentation. The image identifies a large conductive feature between 150 m and 200 m from the start of the survey. This feature is a clay channel (confirmed from observations in a nearby quarry). A series of 2-D surveys carried out along parallel lines identified the direction and extent of this channel.

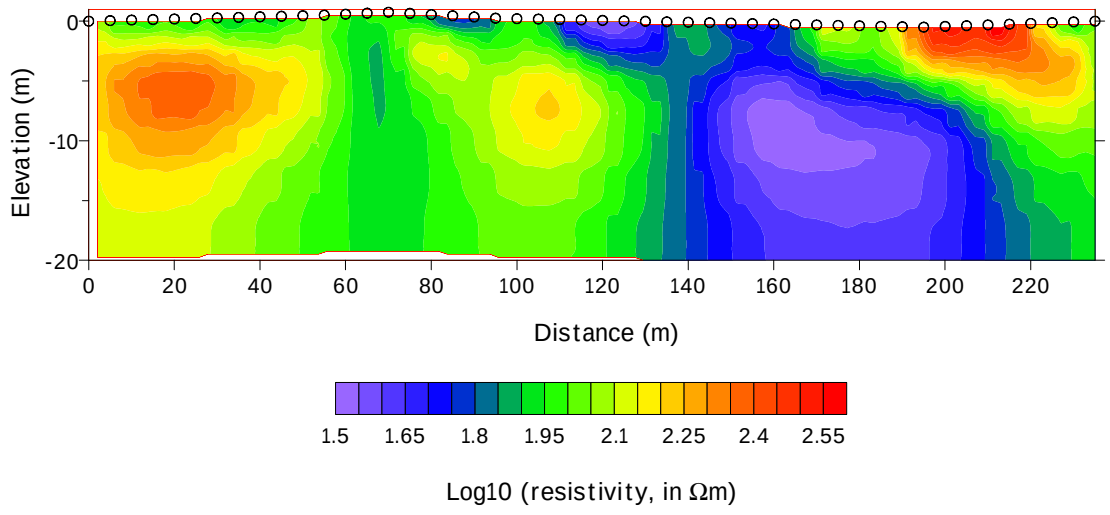

Figure 2. Resistivity image from data in Example 32.

For more information, including example files contact:

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