

Brief instructions how to get started working with the ATOM-3D code

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Stage 1: Preparation of the code

Step 1.1. Download the file “atom_3D.zip” from the web site on:

www.ivan-art.com/scence/ATOM_3D/atom_3D.zip or copy from the CD.

Step 1.2. Unzip and copy to any location of your computer. ADVISE: try to use simple paths, (for example `D:/PROGRAMS/PROFIT`) and **avoid** the system paths related to “My Documents” or “Desktop”. This will make operating with files much easier.

Step 1.3. Check if visualization tool works correctly in your computer. Go to “/CREATE_PICS” and run “visual.exe”. As a result, a new file “picture.png” will appear in the same directory (check the time and date to see that this is really newly created file). In the case of correct working the program, it should be identical to “picture_correct.png” located in the same directory. In the case if it does not work, the problem can probably be solved if a free package “dotnetfx.exe” is installed. It can be downloaded from www.ivan-art.com/scence/dotnetfx.zip , unzipped and executed.

Stage 2. Observed data inversion using existing examples

Step 2.1. Define the model to proceed. Open the file “model_all.dat” in the root directory:

`/model_all.dat`

```
1: name of the region
2: name of the model
3: number of iterations
DATASET1 MODEL_01 5
```

Starting from line 4, one or several models are defined. The structure of the data has two-steps hierarchy: AREA - MODEL. In this example “DATASET1” means the AREA folder. “MODEL_01” is the name of the current model. “5” is the number of iterations to perform.

Step 2.2. Check if this model exists in folder “DATA/DATASET1/MODEL_01”. In the case of observed data inversion, there should be at least two files inside this directory:

`MAJOR_PARAM.DAT` and `refmod.dat`.

Step 2.3. Check the availability of the initial data in folder “DATA/DATASET1/inidata” There is one mandatory file “rays_xyz.dat” which contains information about observed source-receiver pairs and travel times. The other files are strongly recommended, although the calculations can be performed without them. These include:

`topo_xyz.grd`: topography/bathymetry in the study area
`shots_xyz.dat`: list of shots (only for visualization)
`stat_xyz.dat`: list of stations (only for visualization)
`coast_xyz.dat`: list of stations (only for visualization)

Step 2.4. Check the availability the files required for visualization and previewing should be created as described in Section 3 of the manual.

```
DATASET1/sethor.dat  
DATASET1/setver.dat  
DATASET1/config_rays_grid.txt  
DATASET1/config_hor.txt  
DATASET1/config_ver.txt  
DATASET1/config_rays_grid
```

Step 2.5. Run the batch file “START_REAL.BAT”. A console with information about running the program will appear. Running the entire inversion procedure (5 iterations) for the selected procedure will take 20-40 minutes depending on the computer.

ADVICE: We recommend defining larger console buffer to be able to check the course of calculations backward. Click right bottom of mouse on upper panel of console – select Properties – select Position (3rd Tab) – update Height of the Screen Buffer (for example up to 3000 lines).

Step 2.6. If calculations run successfully and preview tool is available (checked in [Step 1.3](#)), a set of PNG image files should appear in the corresponding folder. In the considered example they will be created in “PICS/DATASET1/MODEL_01/”.

Preview files created:

(//it// is a number of iteration, //gr// is a number of grid, //lev// is a number of depth level, //ver// is a number of vertical section)

rays_grid//gr//.png: node distributions and ray paths after 1st iteration;

dv//it//lev//.png: velocity anomalies in horizontal sections after a current iteration;

abs//it//lev//.png: absolute velocity in horizontal sections after a current iteration;

vert_dv//ver//it//.png: velocity anomalies in vertical sections after a current iteration;

vert_abs//ver//it//.png: absolute velocities in vertical sections after a current iteration;

profiles.png: locations of profiles in map view;

resid.png: distribution of residuals versus S-R distance after the final iteration;

The high quality pictures can be created using a commercial tool (e.g. Surfer). The program creates .DAT, .GRD and .BLN which can be used directly in Surfer. The generated files are stored in FIG_files directory and they overwrite the older ones.

List of the main files for visualization:

FIG_files/result/hor/vabs//lev//it//.grd: Absolute velocities in horizontal sections;

FIG_files/result/hor/dv//lev//it//.grd: Velocity anomalies (in%) in horizontal sections;

FIG_files/result/vert/abs//ver//it//.grd: Absolute velocities (in km/s) in vertical sections;

FIG_files/result/vert/ver//ver//it//.grd: Velocity anomalies (in%) in vertical sections;

FIG_files/result/vert/topo_line//ver//.bln: Topography line in vertical sections;

FIG_files/result/vert/shots//ver//.dat: Shots projected onto vertical sections;

FIG_files/result/vert/stat//ver//.dat: Stations projected onto vertical sections;

FIG_files/result/vert/mark_//ver//.bln: Locations of the profiles in map view;

`FIG_files/result/rays/rays_hor.dat`: Rays in a defined depth interval;
`FIG_files/result/rays/nodes_hor.dat`: Parameterization nodes in a defined depth interval;

Step 2.6. Download the file from www.ivan-art.com/science/PROFIT/srf_examples.zip. Unpack this file and use file “`srf_examples/example1.srf`” as a template to visualize the files obtained in [Step 2.5](#).

Step 2.7 Create a new model (e.g. “`MODEL_02`”) and play with parameters in “`MAJOR_PARAM.DAT`”. The most important parameters are:

1. **Smoothing** (2nd line in “INVERSION PARAMETERS” in “`MAJOR_PARAM.DAT`”)
2. **Amplitude damping** (3rd line in INVERSION PARAMETERS in “`MAJOR_PARAM.DAT`”)
3. **Horizontal node spacing** (3rd number in 1-2 lines in GRID PARAMETERS in “`MAJOR_PARAM.DAT`”)
4. **Vertical node spacing** (5th line in GRID PARAMETERS in “`MAJOR_PARAM.DAT`”)
5. **Number of rays** (5th line in TRACING PARAMETERS in “`MAJOR_PARAM.DAT`”)
6. **Velocity model** (values in file “`refmod.dat`”)

Produce the results as PNG images and SRF files. Analyze the effect of each of these parameters on the result.

Stage 3. Synthetic modeling with existing examples

Step 3.1. The synthetic model is defined as velocity anomalies (file “`anomaly.dat`”) in respect to the 1D velocity distribution (file “`refsyn.dat`”) in the corresponding MODEL folder. Check if these files exist in the model you wish to proceed.

Step 3.2. Define name of the AREA and MODEL folders in file “`model.dat`” in the root directory (for example, Area: “`DATASET1`”, Model: “`BOARD_01`”):

```
/model.dat
DATASET1
BOARD_01
1
```

(the last number is not important in this step)

Step 3.2. Run the EXE files for visualization of the synthetic model in horizontal sections: “`PROG\a_set_syn_hor\create.exe`”,
and/or in vertical sections: “`PROG\a_set_syn_ver\create.exe`”

In the considered example the following PNG images will be created:

“PICS/DATASET1/BOARD_01/syn_dv_ //lev//.png”: synthetic anomalies in horizontal sections

“PICS/DATASET1/BOARD_01/syn_abs_ //lev//.png”: synthetic absolute velocities in horizontal sections

“PICS/DATASET1/BOARD_01/vert_dv_syn_ //ver//.png”: synthetic anomalies in vertical sections

“PICS/DATASET1/BOARD_01/vert_abs_syn_ //ver//.png”: synthetic absolute velocities in vertical sections

And the corresponding GRD files which can be visualized in Surfer:

FIG_files/hor/syn_dv_ //lev//.grd : synthetic anomalies in horizontal sections;

FIG_files/hor/syn_abs_ //lev//.grd : synthetic velocities in horizontal sections;

FIG_files/vert/syn_dv_ //ver//.grd : synthetic anomalies in vertical sections;

FIG_files/vert/syn_abs_ //ver//.grd : synthetic velocities in vertical sections;

As a result of this lesson one should obtain the images of different synthetic models in horizontal and vertical sections. Try to use more complicated visualization with SURFER. Compare the derived images with PNG files obtained automatically.

Step 3.3. Define the model to proceed. Open the file “model_all.dat” in the root directory:

/model_all.dat

```
1: name of the region
2: name of the model
3: number of iterations
DATASET1 BOARD_01 5
```

Starting from line 4, one or several models are defined. The structure of the data has two-steps hierarchy: AREA - MODEL. In this example “DATASET1” means the AREA folder (name of the profile). “BOARD_01” is the name of the current model. “5” is the number of iterations to perform. Check if this model exists in folder “DATA/DATASET1/BOARD_01”.

Step 3.4. Run the batch file “START_SYN.BAT”. A console with information about running the program will appear. First, the code will create the files for visualization for the synthetic model (as in Step 3.2) and will compute the synthetic travel times. Then it performs the same steps of iterative inversion as for the observed data (Step 2.2)

Step 3.5. Visualization of the results is the same as for the case of observed data (Step 2.6).

Step 3.6. Perform the calculations for other examples of synthetic models

Step 3.7. Create a new model (e.g. “BOARD_02”) and play with parameters of the synthetic model. (e.g. increase or decrease the size of checkerboard anomalies in file “anomaly.dat”). Produce the results as PNG images and/or SRF files. Find the minimal size of patterns resolved with the existing data.

Stage 4. Start working with own data

Step 4.1. Create a new AREA folder. The name should consist of any eight (8) characters (e.g. “[DATASET2](#)”). Inside this folder create “[DATASET2/inidata](#)” folder. Inside this folder create files with the initial data “[rays_xyz.dat](#)” and other files, as described in Section 1.3 of the Manual. (Creating these files is on a responsibility of a user).

In addition, the files used for visualization and previewing should be created as described in [Section 3](#) of the manual and in [Step 2.4](#) of this document.

These files can be copied from the existing examples and scaled according to the size of the study area.

Step 4.2. Create a MODEL folder which should also consist of eight (8) characters (e.g. [DATA/DATASET2/MODEL_01/](#)).

Step 4.3. Create a file

[DATA/DATASET2/MODEL_01/MAJOR_PARAM.DAT](#)

This file can be copied from existing examples. Some of the parameters (e.g. grid spacing, and step for tracing) should be scaled according to the size of the study area. The inversion parameters will be tuned during several trials.

Step 4.4. Define starting 1D velocity model in file:

[DATA/DATASET2/MODEL_01/refmod.dat](#)

Step 4.5. Define the model to proceed. Open the file “[model_all.dat](#)” in the root directory:

[/model_all.dat](#)

```
1: name of the region
2: name of the model
3: number of iterations
DATASET2 MODEL_01 9
```

Step 4.6. Run the batch file “[START_REAL.BAT](#)”.

Step 4.7. Produce the results as PNG images and SRF files.

Step 4.8. Create a new model (e.g. “[MODEL_02](#)”) and play with parameters in “[MAJOR_PARAM.DAT](#)” (e.g. increase or decrease the smoothing or amplitude damping) to find the values which provide the minimum of the residual norm.

Step 4.9. Play with parameters in “[refmod.dat](#)” to find the values of the starting model (namely depths of levels and velocities in the 1D starting model) which provide the minimum of the residual norm.

Stage 5. Creating the own checkerboard test

Checkerboard test is the easiest synthetic test and it is the most convenient for learning.

Step 5.1. Inside the same AREA folder as used in Stage 4, create a MODEL folder for the checkerboard with the name which consist of eight (8) characters (e.g. [DATA/DATASET2/BOARD_01/](#)).

Step 5.2. Create synthetic velocity model which is described by two files:

[DATA/DATASET2/BOARD_01/refsyn.dat](#)
[DATA/DATASET2/BOARD_01/anomaly.dat](#)

In general, these files with starting and synthetic 1D distributions, [refmod.dat](#) and [refsyn.dat](#), are not necessarily identical. However, for the first run we recommend using same 1D velocity distributions in the starting and synthetic models. Definition of the checkerboard in [anomaly.dat](#) is described in [Section 4.2](#) of the Manual.

Step 5.3. Perform calculations and visualization of the results as described in **Steps 3.2-3.5**. The particular interest in this case is the relative anomalies.

Step 5.4. Play with different parameters of model, for example:

- Tune the smoothing/damping coefficients to obtain the best reconstruction results.
- Try different sizes of patterns.
- Try different empty spacing between patterns.
- Try single anomalies (when limits of the board coincide with size of the patterns) located in different parts of the study area.
- Try performing the reconstruction when synthetic reference model is not the same as the starting one.

Stage 6. Creating own synthetic models

Step 6.1. Inside the same AREA folder as used in Stage 4, create a MODEL folder for the synthetic model with the name which consist of eight (8) characters (e.g. [DATA/DATASET2/SYN_MOD1/](#)).

Step 5.2. Create synthetic velocity model which is described by two files:

[DATA/DATASET2/SYN_MOD1/refsyn.dat](#)
[DATA/DATASET2/SYN_MOD1/anomaly.dat](#)

To create these files use descriptions in Section 4 of the Manual.

In this step one may need to digitize polygons and polylines to create patterns for anomalies in [anomaly.dat](#). In our practice we use the digitizing tool in Surfer which is very convenient for such tasks. To do it in Surfer, make the following steps:

- Open a plot with some results for the current map or profile (e.g. observed data inversion, main results);
- Select the plot;
- Select Menu: “Map – Digitize”;
- Digitize the pattern in the plot (results appear in a separate window);

Save the file in BLN format to subfolder forms (e.g. [DATA/DATASET2/SYN_MOD1/forms/anom1.bln](#)).

Step 5.3. Check correctness of the model definition using the visualizing program in

“[PROG\a_set_syn_hor\create.exe](#)”,
“[PROG\a_set_syn_ver\create.exe](#)”
for horizontal and vertical sections as described in 3.2.

Step 5.4. Run the synthetic modeling using the Steps 3.3 – 3.5.

Closing remarks

If you passed successfully all the steps listed in this document, it would be not a problem for you to perform inversion for observed data and synthetic modeling using the *ATOM-3D* code for various datasets.

In case of any problem, please address to Ivan Koulakov (KoulakovIY@ipgg.nsc.ru).

Good luck.