Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

GeoSlicer-X: A 3-D Interactive Software for Geothermal Data Analysis

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Keywords: Software, geothermal, three-dimensional visualization, interactive

ABSTRACT

GeoSlicer-X is a software developed to help geoscientists and engineers in analyzing geothermal data in three-dimensional view. The software is interactive and user friendly. The software was developed using Graphical User Interface (GUI) facility of MATLAB. The software can produce static (still) or dynamic (animated) images. In this paper it is shown the usefulness of the software by exhibiting its application to the geoscientific data.

1. INTRODUCTION

Results of 2-D and 3-D numerical modeling or inversion of geoscientific data such as MT, CSAMT, TDEM, resistivity, gravity, geomagnetic and other geoscientific data would be easy to analyze if the results could be visualized by using 3-D interactive software. However, 3-dimensional interactive software is not always available due to expensive software, difficulty in their use and requires too much effort. Accordingly, we attempt to develop 3-D interactive visualization software to be applied to geothermal data visualization, especially for geoscientific data. The aim of this study is to produce 3-D interactive visualization to help geoscientists and engineers in analyzing geothermal data in three-dimensional view. This paper describes the GeoSlicer-X software from algorithm to visualization features and application of the software to magnetotelluric data.

2. PROGRAM DESCRIPTION

2.1 Software Algorithm

GeoSlicer-X is a rapid 3D data representation to aid data modeling and interpretation. It visualizes 3-D distribution property by drawing plane (in 3-D coordinate) and use coloring as the fourth coordinate (Figure 1).

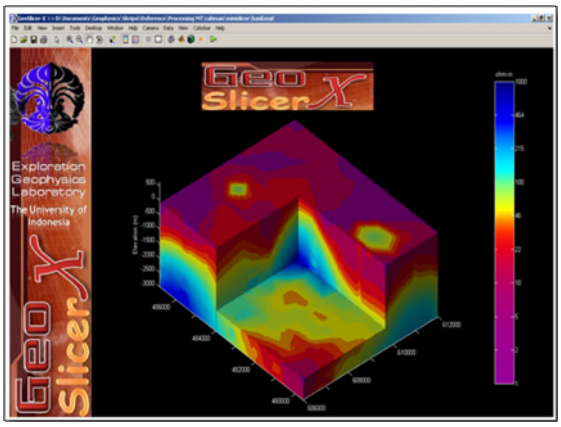

Figure 1: GeoSlicer-X Software Front Page.

The software not only visualizes data but also can do interpolation for gridding purpose from scattered data.

The source code of the software was scripted using MATLAB language. At the time this paper written, the development environment used was MATLAB R2006a. Although the MATLAB itself is heavily script oriented, GeoSlicer-X was developed using GUI (Graphical User Interface) facility of MATLAB. With GUI facility, user can make use of this software easier. Executable file was made by compiling the source code using MATLAB Compiler Version 4. The executable needs MATLAB Component Runtime to run (in analogy of Java Virtual Machine). At present, the software is available only for Windows platform but the executable for other platform (like Linux or Macintosh) can be easily generated by recompiling the code in the specific platform. This can be done because the engine for the software to run (MCR) is a cross-platform package.

The core computation in this software is interpolation. Data at scattered points cannot be directly plotted. It must first be interpolated. Two dimensional interpolations only use data on interpolation plane (on-plane data). It does not calculate the effect of off-plane data (except the data is projected to the plane, but this technique may be not accurate). Two dimensional interpolations are suitable when dealing with coplanar data but when handling three dimensional data, 3-D interpolation is a must. In contrast with 2-D interpolation, three dimensional interpolations are incorporating all data in the volume region so it may produce more realistic data.

GeoSlicer-X uses 3-D interpolation. It assigns interpolated value to grid corners (uniform ordered location) from scattered data (data not in ordered location). This process is termed gridding. Main data needed for gridding purpose are: property data (plus its location) and topography data. The grid number was chosen (default) to 100.000 grids for balance of computational resource and graphical presentation. More grids make visualization better but need more resource and longer calculation time while less grid make the topmost grid (grid near surface) looks more jagged.

First, three dimensional Delaunay triangulation is carried out on main property data. A Delaunay tessellation is a set of simplexes with the property that, for each simplex, the unique sphere circumscribed about the simplex contains no data points. In two-dimensional space, a simplex is a triangle. In three-dimensional space, a simplex is a tetrahedron. The outmost faces of those tetrahedral is called convex hull.

After tessellation geometry was constructed, interpolation and extrapolation is carried out on the data distribution profile. Inside convex hull, linear interpolation is performed while outside convex hull, nearest neighbor extrapolation is made. The final interpolated grid data is combination of those two methods. This gridding process of main property

data results main gridded data. The main gridded data is a cube shaped.

The topography data is also interpolated so it matches grid position of main data using biharmonic spline method. Gridded topography data is used to nullify (remove) the grid value at points located higher than topography surface so the upper part of main grid cube can follow the topography shape.

2.2 Visualization Features

GeoSlicer-X uses right handed coordinate system. Elevation axis (positive z-axis) is directed upward (some software uses positive-z axis downward). After gridding process, the gridded data are then displayed inside those axes. The software can produce static (still) or dynamic (animated) image.

a. Static (Still) Image

There are six plot types of static image that the software can create: **plane slice, cube slice, isosurface, surface topography, point/line plot**, and **north arrow.**

Plane slice is used to display data value on a flat surface (Figure 2). Either vertical or horizontal slice can be made. For vertical/cross-section slice, the line of slice can be made arbitrary (not must a straight path). It is very useful because it can be used to display cross-section of data along a survey line. User can create this kind of plot interactively using mouse or by conservative method using keyboard input. Interactive method is easier but keyboard input has its own benefit. Entering value by means of keyboard can make slice at exact position on space. Keyboard method also has benefit that it can produce evenly spaced plane slice faster than mouse method.

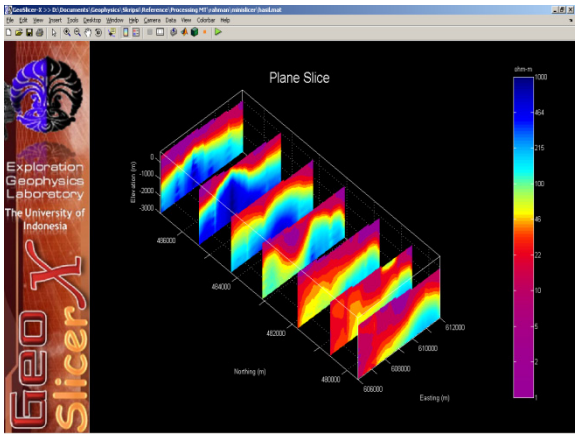

Figure 2: Example of Static Image (Plane Slice).

Cube slice is plane slices on six sides of a cube (Figure 3). Similar to plane slice, the cube boundary can be picked interactively using mouse or entered exactly using keyboard input. By combining three or more cube slices, user can make chopped/truncated cube slice (3-D "cake" model).

Isosurface is surface of isovalue (Figure 4). In two dimensional data, isovalue is tracked by line (contour line) while in three dimensional data, isovalue is tracked by surface. This isosurface plot is created either using isovalue picked at cursor mouse position or by specific known value. Isosurface can be used to visualize body delineated by certain value of data property. For example, using subsurface resistivity data, one can display clay cap or aquifer boundary when the resistivity value of the object of interest is known.

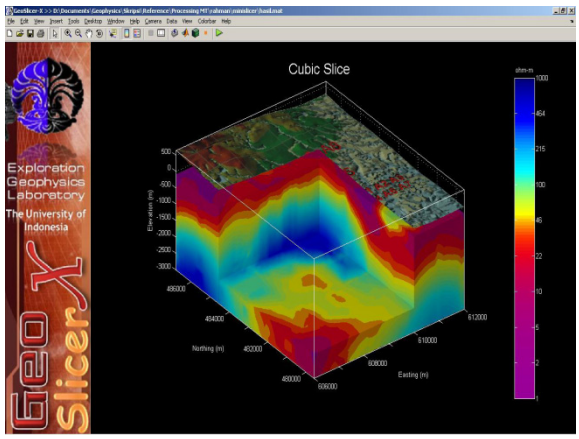

Figure 3: Example of Static Image (Cube Slice).

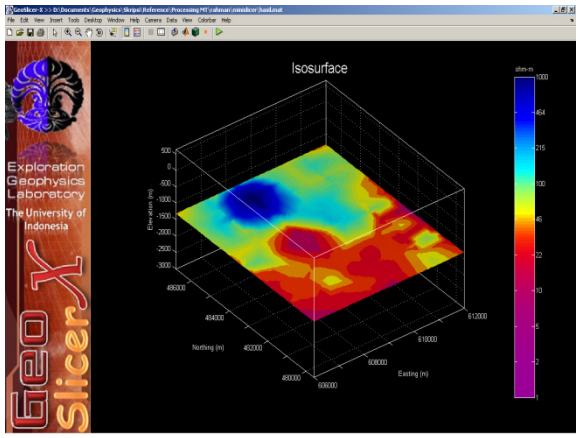

Figure 4: Example of Static Image (Isosurface).

Surface topography is plotted using bitmap picture as its texture (Figure 5). Textured surface gives more impression on the display and can help the interpretation routine. Point/line plot in 3-D space can be displayed to mark station, well position, surface manifestation, or other important point/line position. North arrow can be plotted at any location in the graphics so user doesn't lost orientation in space.

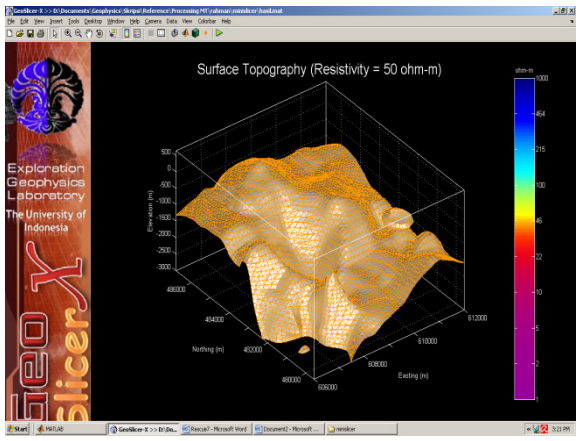

Figure 5: Example of Static Image (Surface Topography).

b. Dynamic (Animated) Image

The software can also animate three kinds of plot: **plane slice animation, rotation animation, and isosurface animation**. Plane slice animation is animated cube view with one of its face propagating northside, eastside, or

downside (Figure 6). Rotation animation animates data display observed at whole angle of view (Figure 7).

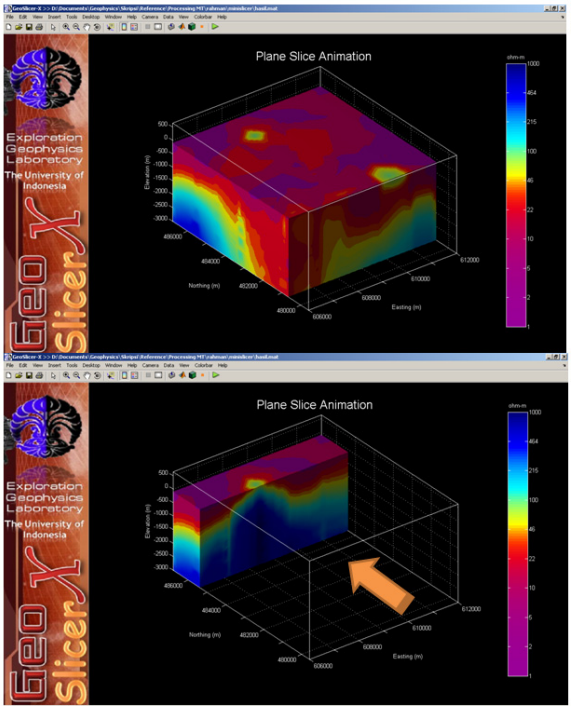

Figure 6: Example of Dynamic (Animated) Image (Plane Slice Animation).

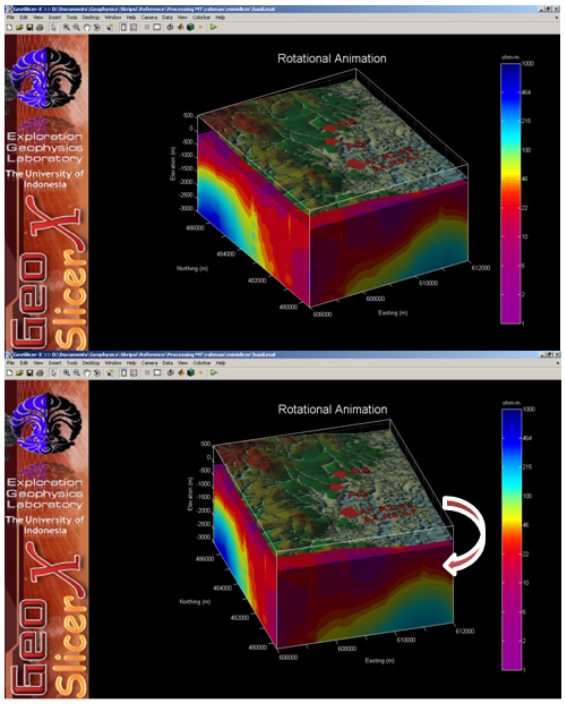

Figure 7: Example of Dynamic (Animated) Image (Rotation Animation).

And isosurface animation displays transformation of isosurface shape (Figure 8). Those all can give better comprehension in data analysis and can serve as presentation tools.

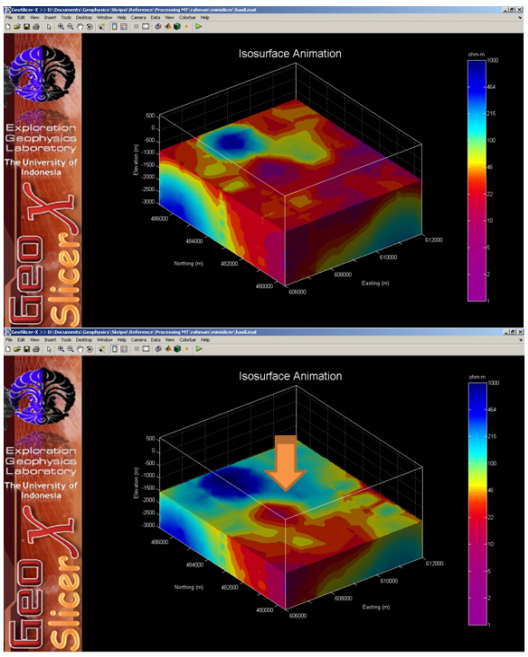

Figure 8: Example of Dynamic (Animated) Image (Isosurface Animation).

c. Other Features

Other features supported by GeoSlicer-X are: data tracking, rotation, zoom in/zoom out, lighting position, color scale (linear and logarithmic), blocky or smooth model, and transformation of data value using math formula.

3. DISCUSSIONS

As shown in the previous examples of the GeoSlicer-X features, now geoscientific data can be easily and interactively visualized. Geophysical data is used to be visualized using single cross section. Now we can interactively visualize several cross-sections of geophysical data within one (combined) figure using the GeoSlicer-X software (Figure 2, Figure 3, Figure 4 and Figure 5). To get more examples of the GeoSlicer-X applications, we can also look into the paper written by Daud et al. (2010). In this paper, the magnetotelluric data of the Tawau geothermal prospect, Sabah, Malaysia can be fully visualized using static and dynamic images. The GeoSlicer-X software can also be utilized for presenting any other geoscientific data such as geological, borehole and reservoir parameter data as far as the (X, Y, Z, V) format of the geoscientific data is available.

In the future, we would improve the GeoSlicer-X software in order to get more interactive and more comprehensive three-dimensional visualization software.

4. CONCLUSIONS

GeoSlicer-X is a user-friendly and interactive three-dimensional visualization software. It can produce static (still) or dynamic (animated) images. This software is useful to help geoscientists and engineers in analyzing geothermal data in three-dimensional view.

REFERENCES

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