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MATGPR: A freeware MATLAB package for the analysis of common-offset GPR data

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The Ground Probing Radar (GPR) has become an almost indispensable means of exploring thin and shallow structures for geoscientific, engineering environmental and archaeological work. At the same time, GPR analysis software is mostly proprietary and usually available from GPR manufacturers or a handful of other vendors. At present, the handful of exceptions is generally unorganized, outdated, limited in scope and power, or definitely not cross-platform. This paper reports of an attempt to address this problem with a truly cross-platform freeware analysis and interpretation package, which can also be extendable and customizable by the user with relatively little effort. MATLABő is an ideal engine for the development of such a kind of software. It provides a high-level, vectorized, object-oriented programming language, which is complete in all respects, but not as demanding as C/C++ or FORTRAN because it does not bother the programmer with the details of low-level functionality.

MATGPR is a two-layered software system: The top layer is modular program that organizes the bottom layer functions and automates data management and the flow of work by means of GU Interfaces. The bottom layer comprises a suite of self-contained and self-documented functions to handle, display and process the data. The design philosophy is quite simple: work flows in a continuous cycle between the “current input data”, i.e. that data before some processing operation (step) and the “output data”, i.e. the data resulting from this operation. The user imports and displays the current input data. Then he/she decides and applies a processing step and evaluates the result. If satisfied, the user will ‘keep’ the result, replacing the current input data with the output data and will cycle through the same procedure with a new processing step. If not, he/she will ignore or discard the result and cycle with another processing step. Both the Top and Bottom layers can be expanded by the user. Special care is

taken to provide in-place solutions for those algorithms and analysis techniques that are necessary but not supplied with the MATLAB core system. Thus, MATGPR can be used, even by those possessing only the basic MATLAB license.

At present, data can be accepted in the formats of GSSI (RADAN) and Måla Geophysics. (RAMAC). The facility to import S&S (Pulse EKKO) data is in the short term wish list. Because the package was developed for common-offset surveys, only single-channel data files are acceptable. Data stored in SU and SEG-Y Revision 0.0 and 1.0 formats can also be imported. The raw and interim data can be saved in native binary format (MAT files) for faster and easier subsequent access. For distribution or exchange, the data can be exported to SU and SEG-Y format files. Data visualization options include image (colour-coded) displays, wiggle-trace displays and variable-area displays. It is also possible to plot and scrutinize individual traces and trace spectra in individual windows.

Basic data handling includes graphical determination and adjustment of time-zero, trace editing facilities, removal of the global mean (background trace), dewowing, gain manipulation, instantaneous attribute calculations and resampling in time and in space using band-limited sinc interpolation. For instruments not equipped with survey wheels, a suite of marker interpolation routines is also provided, so as to transform data collected at equal-time spacing mode, to data at equal-distance spacing. This suite of routines also facilitates the three-dimensional determination of trace locations, with respect to some local co-ordinate system.

Filtering and smoothing utilities include mean and median spatial filtering in one and two dimensions, removal of a sliding window mean (background) trace to enhance dipping reflections, or, removal of the sliding-window's "foreground" traces to enhance sub-horizontal reflections. Spatial noise suppression is also facilitated using a form of Karhunen-Loeve filtering. The software also provides for zero-phase FIR filtering of the frequency and/or wavenumber content. All types of filters are available (low / high / band pass, band stop and notch). This suite of functions is complemented with an interactive F-K filter design and implementation routine, facilitating the application of zone pass / stop filters, fan (velocity range) filters and updip/ downdip mapping. A utility to perform predictive deconvolution is also available.

The package also offers a number of imaging and modelling tools to assist interpretation. These include velocity analysis by interactive fitting of diffraction front hyperbolae. Advanced 1-D interpretation tools include static corrections, F-K migration for layered velocity structures, Phase-shifting migration for layered velocity structures and time-to-depth conversion. 2-D interpretation tools include Split-step migration and Phase-shifting Migration plus Interpolation. Finally, interpretation is aided with

2-D forward modelling tools. These includes a model designer and constructor, which is fully graphical and facilitates the easy and fast creation and editing of models comprising multiple bodies of polygonal or circular cross-section, with point-and-click operations. The modelling technique implemented herein is in effect adjoint Split-step imaging.

At this point, MATGPR does not aspire to become a substitute for commercial analysis programs, which have been developed, debugged and perfected for long. It merely attempts to offer a decent means of treating zero- and common-offset GPR data. It may, however, become competitive if maintained, developed and expanded over time with contribution from other authors along the spirit of the GNU project. The package is freely available by personal communication and over the Internet, in the immediate future.

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