1998 CREWES software release

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INTRODUCTION

This paper provides a description of the contents of the 1998 CREWES software release. Each program comes with instructions on how to use and install it.

The 1998 release consists of software for the Matlab system, the ProMAX seismic processing system, and Window 98/NT platforms.

SOFTWARE RELEASE - PLATFORM OVERVIEW

Matlab programs

Matlab is a commercial product providing a computing environment with high performance vector, matrix and visualization functions. The Matlab package is available for most Unix platforms, Windows 98/NT and Macintosh PC's. Once code is developed for Matlab, it will run on all Matlab supported platforms.

Landmark Graphics Corporation - ProMAX processing system

ProMAX is a commercial seismic processing system running on a Unix platform. We are supplying each ProMAX module's as source code and Solaris 2.5 executable for Promax version 7.0.

Windows 98/NT

The 3C-3D design program is only available for Windows 95 and Windows NT.

SOFTWARE RELEASE CONTENTS

Matlab Programs

Seismic Toolbox - update

The CREWES seismic toolbox is a collection of seismic processing routines, seismic data input/output, viewing routines and graphical utilities originally written by Dr. Gary Margrave, and subsequently added to by CREWES personal. This toolbox adds tremendously to the power of the Matlab computing environment, making it an almost ideal platform for the testing and development of new seismic processing techniques. This is an update of the seismic toolbox, first released in 1995.

This update is primarily a maintenance release, and contains several new functions plus bug fixes and improvements.

ELMO

Elmo is an elastic wavefield modelling package. The software uses the phase shift cascade method to model wave propagation through 2-D horizontally layered media. Based on the elastic wave equation, the method propagates P and S wave potentials to model an earth response. Elmo includes parameters to reduce artifacts, and the ability to isolate various wavefield effects in order to partition a seismic response into component wavefields. As well as P and S potentials, Elmo can compute horizontal and vertical displacements.

Authors: Chanpen Silawongsawat (Silawongsawat, 1997), Gary Margrave, Carrie Youswishen (Youzwishen, 1998)

Nonstationary Deconvolution

Nonstationary deconvolution (NSD) is designed to approximately correct seismic data for source signature and anelastic attenuation. The time-variant amplitude spectrum of the forward operator is designed directly from the input data. The time-variant amplitude spectrum of the input data is calculated and then smoothed in an attempt to remove the reflectivity and leave the source signature and anelastic attenuation effects. The amplitude spectrum of the forward operator can be combined with a minimum-phase spectrum, estimated with the Hilbert transform of the natural logarithm of the amplitude spectrum. The forward operator is then inverted and applied to the input data with nonstationary filter techniques. NSD is a data-driven method and can be thought of as a combination of stationary deconvolution and inverse-Q filtering.

NSD has been developed in two different modes. The NSD operator can be designed and applied for each individual trace (trace-by-trace NSD), or a single operator can be applied to an ensemble of traces (profile-mode NSD). The advantages to profile-mode NSD are that it has increased computation speed and it improves reflector continuity relative to the results from trace-by-trace NSD.

Authors: Alana Schoepp and Gary Margrave (Schoepp, 1997)

V(z) f-k migration

The Stolt f-k migration algorithm is a direct (i.e. non-recursive) Fourier domain technique based on a change of variables (or equivalently, a mapping) which converts the input spectrum to the output spectrum. The algorithm is simple and efficient but limited to constant velocity. A v(z) f-k migration method, capable of very high accuracy for vertical velocity variations, can be formulated as a nonstationary combination filter which avoids the change of variables. The result is a direct Fourier domain process which, for each wavenumber, applies a filter matrix to a vector of input frequency samples to create a vector of output frequency samples. The filter matrix is analytically specified in the mixed domain of input frequency and migrated time. It is moved to input frequency and migrated frequency by a fast Fourier transform. For constant velocity, the v(z) f-k algorithm recreates the Stolt method but without the usual artifacts related to complex-valued frequency domain interpolation. Though considerably slower than the Stolt method, vertical velocity variations,

through an rms velocity (straight ray) assumption, are handled with no additional cost. Greater accuracy at minimal additional expense is obtained by extending the method to a WKBJ phase shift integral. This has the same accuracy as recursive phase shift and can be made to handle turning waves in the same way.

The Matlab programs vz_fkmig.m and vz_fkmig_mixed.m implement this algorithm in the full Fourier domain and the mixed (frequency and migrated time) domain for post-stack data.

Author: Gary Margrave (Margrave, 1998).

Nonstationary phase-shift migrations

Ferguson and Margrave (Ferguson, 1998 ch. 41) introduce isotropic phase shift migration based on Fourier domain nonstationary phase shift. The post stack migration code comes in three forms corresponding to two nonstationary formulations: pspi_mig.m (phase shift plus interpolation) and nsps_mig.m (nonstationary phase shift). Input to the code is the FK spectrum of a post stack data set and a model of the P-wave velocity of the subsurface. The model of the subsurface (consisting of two files) can be built using iso_build.m.

Source gathers for isotropic media can be migrated using pi_shot_level.m. Input is similar to the post stack migrations. The resulting migrated source gathers can be stacked into common offsets using shot_stack.m.

Ferguson and Margrave (Ferguson, 1998, ch. 42) introduce TI migration for source gathers. The migration code is ti_shot_level.m. The required anisotropic model (one file) can be built using ti_build.m. To relate spatial wavenumber to angle of incidence ti_shot_level.m fits a polynomial to TI curves of veritical and horozontal slowness vs. angle of incidence. Polynomial order is a user parameter that can be optimized using q_test.m, a program which will plot the ideal vs. fitted curve. Plots of theoretical impulse responses can be made using ti_impulse.m.

Author: Robert Ferguson.

Promax Modules

V(z) f-k migration – 2D prestack P-P and P-S migration

Margrave (Margrave, 1998) introduces a new migration method based on his non-stationary filter theory (Margrave, 1998), which can handle the vertical velocity variation with at least the same accuracy as the phase-shift method. This method is called V(z) f-k migration. It retains the global wavefield mapping advantage of Stolt's method and properly accommodates the velocity variation.

Instead of using 2-D Fourier domain interpolation, the V(z) f-k method interprets migration fourier domain mapping as a nonstationary filter, where the input for the filter is the Fourier transform of the seismic traces and the output is the spectrum of the migrated traces. Besides the post-stack migration algorithm, V(z) f-k algorithm can be easily formulated to migrate both P-P wave and P-S wave seismic data.

The software developed in ProMAX for V(z) f-k pre-stack migration is divided into three steps, and each step is a ProMAX module. In this way the built-in data sorting routines in ProMAX are used, and the algorithm requires less memory for the 3-D Fourier transform. Many synthetic and real data sets have been used to test the software (Li, 1998).

Authors: Xinxiang Li and Gary Margrave.

Arrayform

Arrayform is used to test the effect of different kinds of receiver arrays when acquiring seismic data. The program reads shot records acquired by non-arrayed, closely-spaced geophones. Arrays are formed according to the input parameters: array width, number of elements, element spacing, and array position. The program builds the arrays and outputs new shot records. See (Hoffe, 1998).

The Arrayform program is implemented as a processing module for Landmark's ProMAX processing system. All I/O and parameter input is handled by ProMAX.

Author: Henry Bland.

Windows 98/NT

3C-3D survey design

This Windows95/NT 4.0 program is a modern implementation of the original 3C-3D survey design program (Lawton, 1994). From an input file describing the survey geometry, fold and offset maps are calculated and displayed. This is an early release with full computational functionality but minimal user interface features. A later release in winter of 1999 will include functions allowing full zooming and rotation of the computed image, loading and saving ASCII parameter files, customizable palette control, and survey parameter building using wizards.

Author: Mark Kirtland

SOFTWARE INSTALLATION

This software release is divided into sections based on hardware platform that each program is suitable for. All the software is in a folder called “Software1998” on the CREWES CD. Inside that folder, you will find two folders: “Unix” and “PC”.

The Matlab software is suitable for all platforms that run Matlab. The ProMAX modules are only suitable for Unix platforms, and the 3C-3D survey design program only works under MS-Windows.

Extracting the software release from the CD

The release requires 16 MB of free disk space.

1) Mount the CD-ROM disk. For Windows and Macintosh computers, simply insert the CD into the drive. On Unix systems, you must mount the CD from the root account. Please follow the instructions supplied with the CD.
2) The Windows and Macintosh files can simply be copied (drag and drop) from the CD onto your local machine. On a Unix machine, the README.install file contains complete installation instructions.

After extracting the release, view the README files located in each subdirectory for further instructions.

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All of the CREWES software is also available over the Internet via the CREWES Web page: http://www.crewes.ucalgary.ca/

CONCLUSION

The CREWES Project software release is a collection of prototype code. Much of our code is in a state of continuous evolution, so please ask us about updates of any modules you are using. The hope is that the software release is an effective means of technology transfer to our sponsors that complements the CREWES Research Report. Please let us know if you have any questions or comments about this or any other software release.

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