JCB Software and its recent upgrading

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ABSTRACT

JCB Software is a set of seismic modelling and migration software, which was originally developed by John Bancroft. It has been used for years in graduate courses and many other training courses. It helps people understand the basic concepts of migration. In addition, it is a great starting point for beginning seismic software developers.

Recent upgrading of JCB Software includes a new module for accessing SEG-Y files, new modules for parameter file interface, and incorporation of accurate interpolation methods in the f-k migration program.

JCB SOFTWARE

JCB Software has been used for years as laboratory material in the graduate course "Seismic Modelling, Migration and Inversion" (GOPH 659) and other training courses at SEG, CSEG and ASEG, along with the course notes "A Practical Understanding of Pre- and Poststack migrations". The software is written to be "stand alone", independent of the platform used, but does use VISTA software to display the results.

JCB Software provides a sound foundation of seismic modelling and migration principles. The software is composed by seven independent executables (Table 1), which illustrate the basic concepts of seismic modelling, Kirchhoff poststack migration, f-k migration, phase shift migration, Kirchhoff prestack migration, and Equivalent Offset Migration (EOM).

Table 1. JCB Software executables.

Program	Description
Modelling	To create seismic sections contain reflection of lines, points, and diffractions.
Kirchhoff-1	A basic Kirchhoff or diffraction-stack program that simply sums data in a hyperbolic path.
Kirchhoff-2	a more developed Kirchhoff migration program with amplitude scaling, dip limited aperture control, antialiasing filters and interpolation
F-k migration	an f-k migration program
Phase shift migration	downward continuation migration using the phase shift method
Prestack Kirchhoff	a simple brute-force Kirchhoff prestack migration (PSM) program
EOM migration	a prestack migration using the equivalent offset method

In addition to teaching seismic modelling and migration concepts, the source code is a great starting point for beginning seismic software developers. First, it is straight forward to set up the working environment because the software is developed and using a free software platform, Cygwin, which is a Unix-like environment for Windows. The needed compiling tools, GNU c and FORTRAN compilers, are both included in Cygwin. Secondly, the independent software architecture of the separated executables is easy to understand and modify. Thirdly, great details of FFT, anti-aliasing filtering, accurate interpolation methods in time domain and frequency domain, float point data formats, SEG-Y file format, etc., can be found inside the source code.

EXAMPLES OF APPLICATIONS

Poststack Migration

A numerical model and its migrated sections from different migration approaches are shown in Figure 1. The input section (a) has 150 traces and 750 samples in each trace. The Kirchhoff migrated section (b) is used an antialiasing filter (AAF) turned off for the first half of the section, and then turned on with a sin(x)/x type AAF for the second half of the section. The FK (c) and phase-shift (d) migrations use the Fourier transform that required 256 traces with 1024 samples in each trace. This additional space is displayed in the corresponding figures to illustrate the movement of energy into this space.

a)   b)

c)   d)
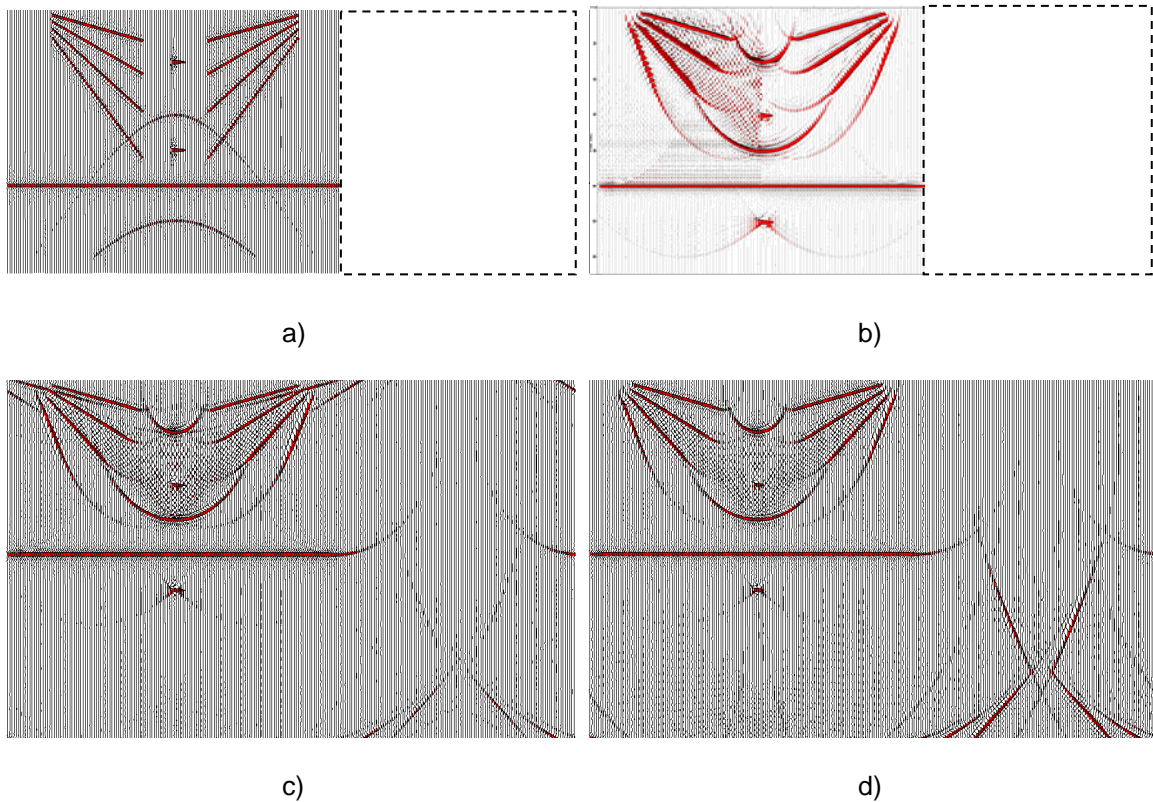
FIG. 1. The created seismic model a) is migrated b) with Kirchhoff, c) with f-k migration using linear complex linear interpolation, d) with phase shift migration approach.

Equivalent offset migration

The last two modules illustrate the capability prestack migration by a brute force Kirchhoff migration and Equivalent Offset Migration (EOM). The prestack data, in source record format, was created from a scatterpoint, a short horizontal event, and a dipping event. EOM creates prestack migration gathers (equivalent offset (EO) gathers) that contain all the input data with offsets designed to focus scattered energy when located at the position of the scatter point, and to disperse the energy when located away from the scatterpoint. The images in Figure 2 contain CSP gathers, after moveout correction, located (a) at the scatterpoint, and (b) at ten traces away from the scatterpoint. The coherent gathering of the scattered energy is shown in (a) that will stack with high amplitude. This same energy is dispersed in (b) and will tend to "stack out". The stacking of these data is shown in (c) that contains migrated data in the area of the scatterpoint.

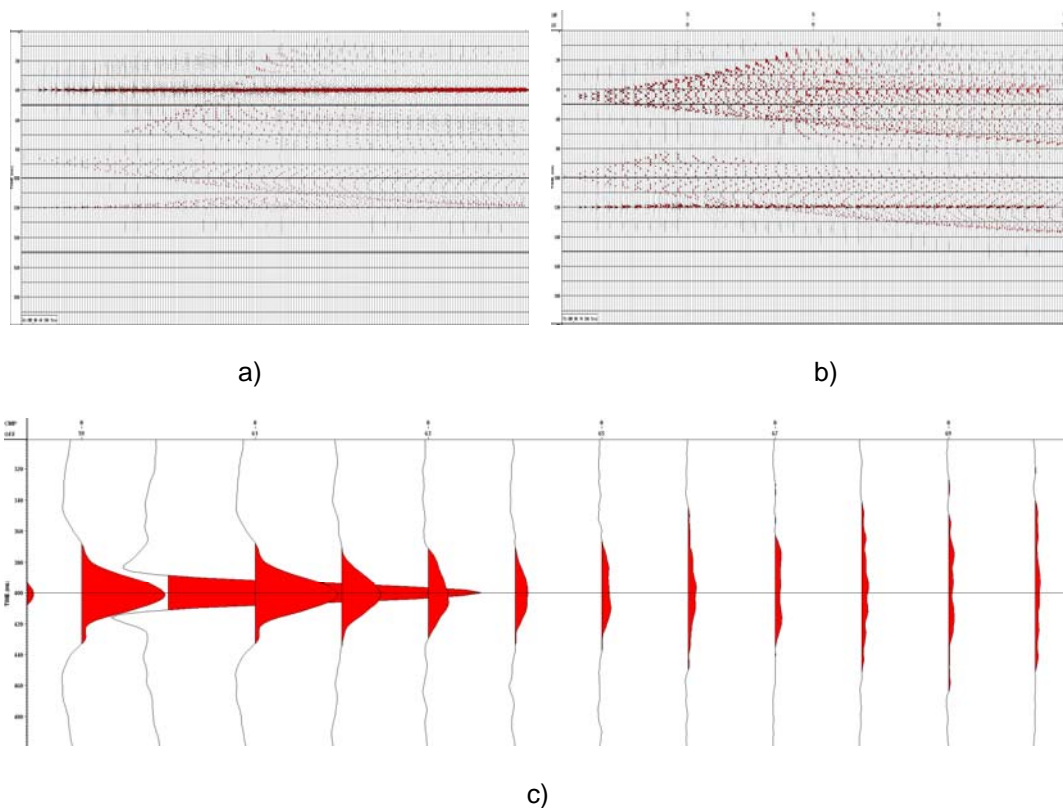a)   b)

c)

FIG. 2. CSP gather formed a) at the scatterpoint location and b) ten trace way from the scatterpoint location. The image in c) demonstrates the Equivalent Offset Migration in the area of the scatterpoint.

RECENT UPGRADES

Recent main upgrading of JCB Software includes use of parameter files and their software interface modules, a new module for reading and writing SEG-Y files, and accurate interpolation methods for f-k migration.

Parameter file

The concept of a parameter file originally existed in the modelling program. Recently, we developed parameter file software interfaces for all the other executables.

A parameter file is an ASCII file that contains a list of initialization parameters and a value for each parameter. The user specifies initialization parameters that direct the executables.

The following are sample entries in a parameter file used in f-k migration:

```
file_in            mod50.sgy              # input file name
file_out           FKmig-CplxSinc.sgy     # output file name
ffttraces          256                    # number of  traces for FFT
fftheight          1024                   # number of samples for FFT
interp             6                      # type of interpolation
samp_length        1024                   # number of interpolation samples
```

The first two entries specify the input and output SEG-Y file name, the following two specify the size of the two-dimensional FFT, and the last two specify the interpolation method and how many samples to be used in the process of interpolation.

By using parameter files, hard coding and rebuilding of the executables can be avoided.

New module of accessing SEG-Y file

A new module to read and write SEG-Y files is incorporated into JCB Software to improve expansibility and to correct to improve the data sample format code. Originally, JCB Software used an external library to access SEG-Y files. Since the source code of the library was available, we had to write our own code.

Features of the new SEG-Y access module include:

- Developed according to "SEG Y REV 1 Data Exchange format" (SEG Technical Standards Committee, 2002).

- Supported data sample formats include both 4-byte IBM floating-point and 4-byte IEEE floating-point.

- Basic functions include but not limited to creating SEG-Y file from scratch, reading SEG-Y file, and accessing (reading and writing) SEG-Y textual header, SEG-Y binary header, trace header and trace body. Advanced functions such as sorting traces, extracting data, changing data sample format, and etc., can be easily implemented by combining those basic functions.

- The module is written in c and compiled by GUN c compiler. C++ style code is also developed and used in other research projects.

The reliability of the module is proved not only by being successfully used in JCB Software, but also by comparing resulted SEG-Y files with those from the VISTA Seismic Processing system by GEDCO, Seismic Unix (CWP/SU), and SEG-Y file I/O toolbox in CREWES MATLAB Library.

Accurate interpolation methods in f-k migration

The f-k migration program in JCB Software originally has four interpolation methods, which are truncation without scaling, truncation interpolation, linear interpolation, and complex linear interpolation. Among those four interpolation methods, complex linear interpolation results in the best migrated section (Figure 1c). Recently, two more accurate interpolation methods, complex sinc interpolation and Muir's interpolation, were added. The results of the two new methods are shown in Figure 3. Artifacts near time zero are significantly attenuated when compared with a simple two point complex linear interpolation scheme that was used to create Figure 1c.

The input parameter text file for the FK migrations are shown above in the section illustrating the parameter files. The size of the sinc interpolator is defined with the parameter "sample_length", which in Figure 3 was set to 1024.

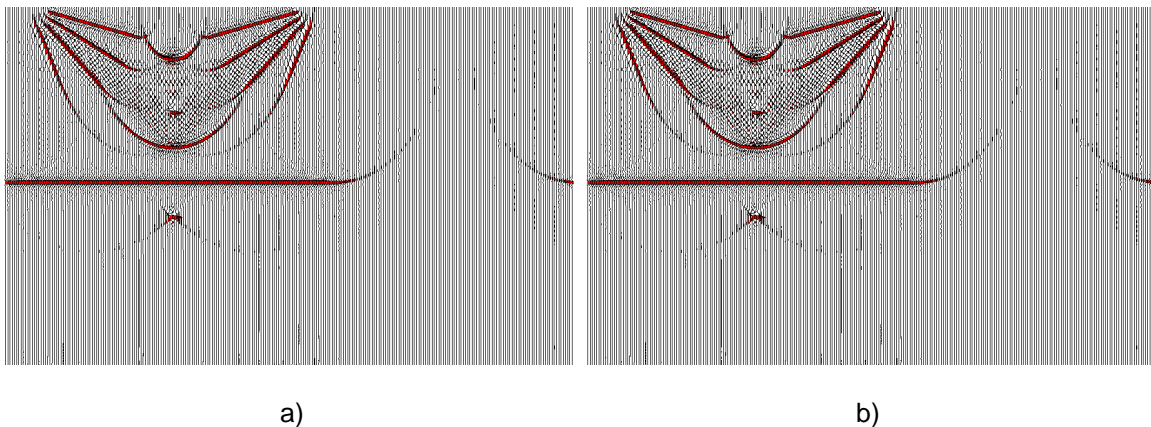a)   b)

FIG. 3. Migrated sections resulted from f-k migration using complex sinc interpolation (a) and Muir's interpolation method (b).

CONLUSIONS

JCB Software provides a sound foundation of seismic migration principles. In addition, the source code is a great starting point for seismic software developing beginners. The main purpose of this software is to provide a simple to use, stand alone package that is independent of the platform used.

Recent upgrading of JCB Software enables the system to be more reliable, expansible and user-friendly. New module about SEG-Y file provides flexibility of more intense SEG-Y file I/O process. Parameter file interface modules help us avoid hard coding and rebuilding of executables. Implementation of accurate interpolation methods in f-k migration results in better migration sections.

The above code was written as supplementary laboratory exercises to accompany Bancroft's course notes. The code and lab materials are now included in the CREWES software release.

ACKNOWLEDGEMENTS

REFERENCES

Bancroft, J.C., 2006, A practical understanding of pre- and poststack migration, Course notes.

Harlan, W., 1982, Avoiding interpolation artifacts in Stolt migration: **SEP-30**, 103-110.

Jiang, Z., and Bancroft, J.C., 2007, Interpolation methods for the kernel of f-k migration: CREWES Research Report, **19**, 40.1-40.11.

Lin, J., Teng, L. and Muir, F., 1997, Comparison of different interpolation methods for Stolt migration: http://sepwww.stanford.edu/public/docs/sep79/intime5/paper_html/index.html, accessed March 26, 2007.

Popovici, A.M., Blondel, P., and Muir, F., 1997, Interpolation in Stolt migration: **SEP-79**, 275-282.

Rosenbaum, J.H. and Boudreaux, G.F., 1981, Rapid convergence of some seismic processing algorithms: Geophysics, **46**, 1667-1672.

SEG Technical Standards Committee, 2002, SEG Y rev 1 Data Exchange format: www.seg.org/publications/tech-stand/seg_y_rev1.doc, accessed June 5, 2007

Wikipedia, 2006, Floating point: http://en.wikipedia.org/wiki/Floating_point, accessed June 6, 2007