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INTERACTIVE SEISMIC VIEWER "OP" – SHORT REVIEW

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ABSTRACT
We introduce an interactive seismic viewer "OP" (developed in MATLAB platform), primary designated for detailed processing of selected events. Few examples of graphical outlook are presented (main display window, particle motion diagram, etc.), available tools are briefly described, uncommon special tools (simultaneous display of original and filtered signal or time-spatial correlation of seismogram components) are emphasized. Features of the viewer are discussed, some programming solutions are also mentioned.

KEYWORDS: interactive seismic viewer, seismogram processing, MATLAB

INTRODUCTION

Digital seismic data are often processed or interpreted by interactive seismic viewers. Even if there are numerous such viewers,[1] it raised a demand for another one – a viewer oriented on individual detailed analysis of selected, possibly roughly preprocessed, seismograms. Therefore we created an interactive viewer "OP", which is briefly described in the paper. The viewer OP is a next generation of previously developed programs (Kolář, 2000), it enlarges its progressive features, includes users demands based on previous experience and is also oriented on interactive graphical controls. The viewer is designed in MATLAB platform.

Any seismic viewer possesses routines for data input/output, data effective display and common mathematical routines as e.g. data filtration, Fourier transform, rotation, amplitude and time picking, … and others, in dependency of particular task for which is the viewer designated. In commented figures given below, we present basic graphical outlooks of OP, the outstanding special tools are mentioned in more details. Finally, we discuss positives and negatives of the program, some notes on used program algorithms are given in a separate paragraph.

Note, that viewer OP has been already reported (Kolář, 2006a), however this proceeding may not be quite accessible to the seismological community and therefore we present this paper.

MAIN OP WINDOW – MULTIPLE RECORDS SHOW

In Fig. 1 there is a main OP window with a multiple records show. This window serves for displaying of all processed data, quick overview of them and also for "routine" application of already tuned procedures (e.g. filtration with particular values of parameters). The controls are logically grouped and can be evocated from pull-down menus placed on the bar in the upper part of the window. Under the plots there are a few direct controls for basic plot features as e.g. absolute versus normalized amplitudes of seismograms. The whole data plot can be zoomed and/or moved interactively.

MAIN OP WINDOW – SINGLE RECORD SHOW

In Fig. 2 there is a main window for single record show. This window serves for display of one station record. It is designed for detailed analysis with help of available tools (e.g. filtration, amplitudes and

[1] Let's mention here some examples of the viewers:
* Seismic Handler by K. Stammler (1993)
* Siesbase by Fischer and Hampl (1997) - used for processing of WEBNET data
* Antelope (BRTT, 2006) - used, among others, for seismic service in Geophysical Institute
* Event by M. Musil (1993) - formerly used for seismic service in Geophysical Institute
* SeisGram2K by A. Lomax (2005) used for Orfeus data with possibility to process also individual offline events (this viewer mode was used e.g. in Kolář, 2006b).

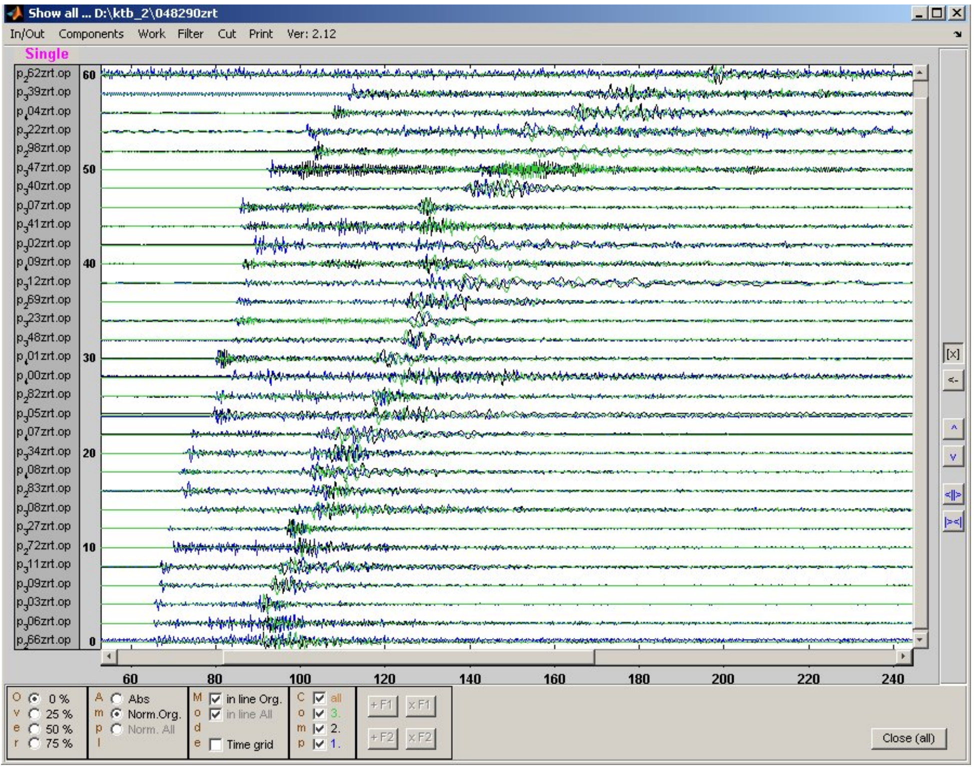

Fig. 1 Main OP window for multiple records display. Records of an event from an active experiment in deep (9km) borehole KTB (Germany) are displayed as an example. During this experiment fluids were pumped into the borehole (for details see e.g. Baish et al., 2002, or also Vavryčuk et al., 2007 and Kolář, 2007). The fluids' pressure induced numerous events, which were recorded by a stations' network. They are displayed normalized velocigrams of 3 components seismograms sorted according to increasing epicentral distance.

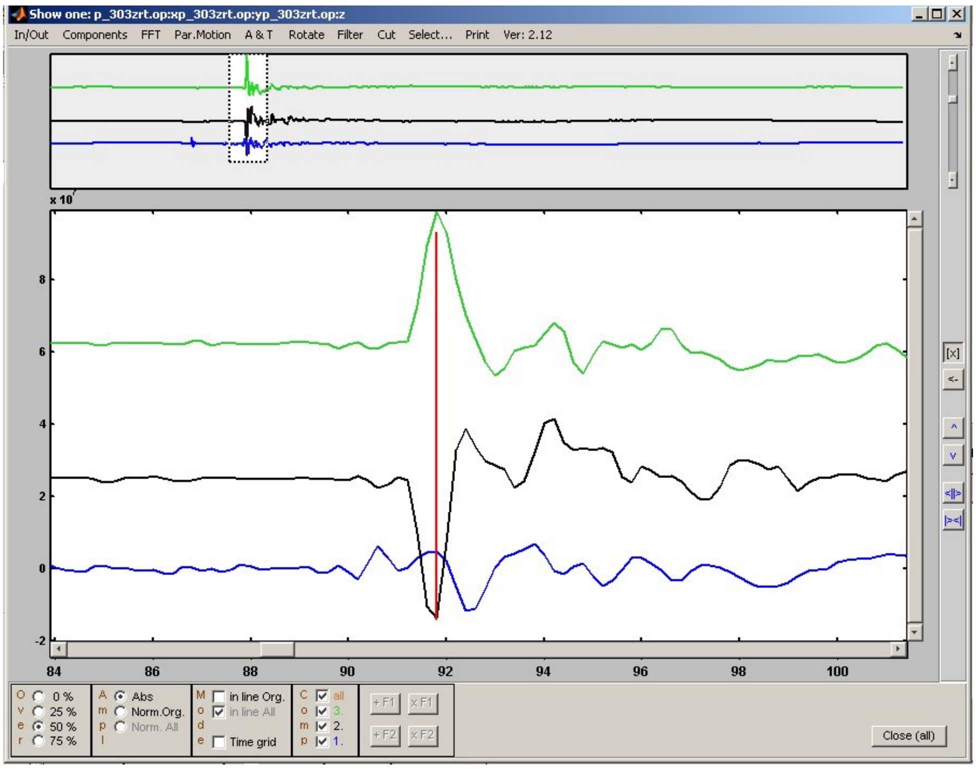

Fig. 2 Main OP window for single record display. An example: one record of a selected station from Fig. 1 is displayed, displacement (integration of original record) is used; trend and offset of the data was removed also. Zooming of a selected area is demonstrated.

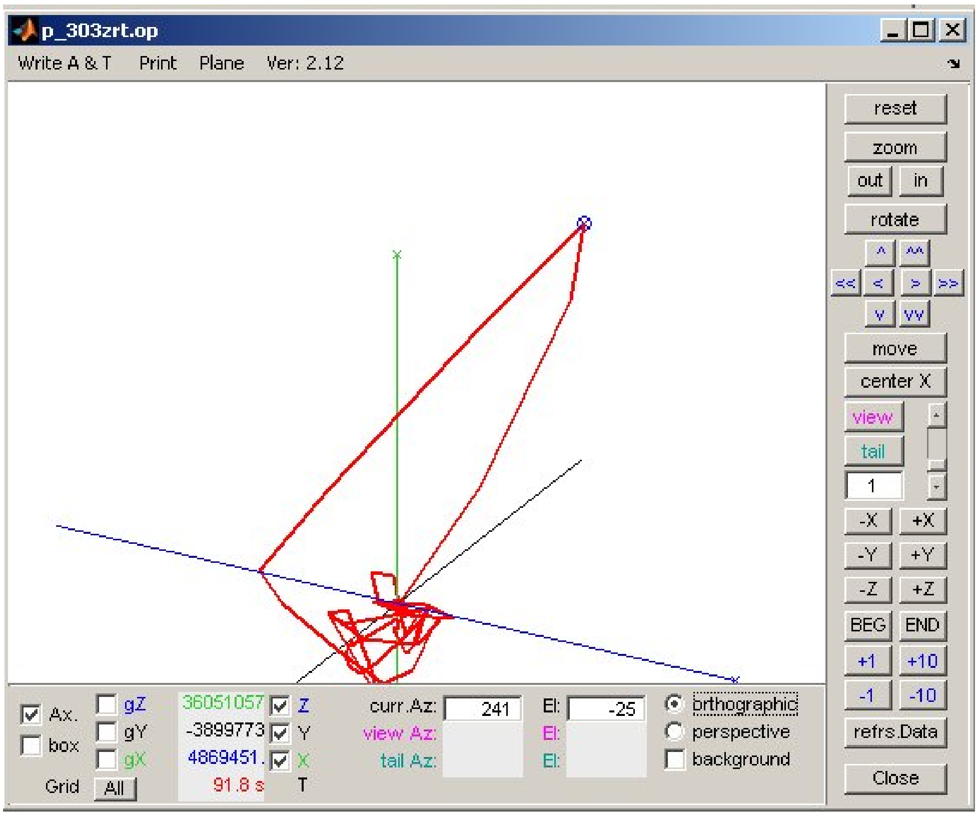

Fig. 3 Particle motion diagram. The same data as in Fig. 2 are used as an example. Point marked with circled cross corresponds to the maximal amplitudes, which are also marked by a vertical line in a seismogram in previous figure (in the presented case, the waveforms are so simple, that maximal amplitudes can be easily determined without studying its particle motion diagram).

times picking etc.). Whole seismogram is displayed in upper part, bellow is magnified its selected part. Zone of selection is marked in upper part and can be also zoomed or moved interactively.

From this window can be invoke a particle motion diagram window– see Fig. 3.

For detailed tuning of filtration we have developed virtual layers – see Fig. 4. These layers enable simultaneous display of the original and the filtered signal, then filter parameters and/or type can be modified, if desirable. There are up to 3 such layers available, which means that original data and two different filtrations can be seen simultaneously. All common types of filtration are available (causal or acausal, band-pass, band-stop, low-pas and high-pass Butterworth filtration) as well as other common procedures as e.g. rotation, integration, derivation, trend and/or offset remove. The parameters of these procedures can be possibly controlled also interactively.

Among other available routines, we would like to mention minimalization of one component of 3 component seismogram (i.e. geometrical plane intersection of 3D seismogram) and evaluation of correlation between two (time shifted and/or rotated) seismogram components.[2]

COMMENTS ON PROGRAM'S ALGORITHMS

In this paragraph there are discussed some problems which we have to deal with during the viewer development.[3]

Even if the seismograms are 3D data in their nature [station : component : sample], they are converted into 2D matrix of internal OP's format. 2D matrix is more convenient for plotting (MATLAB function '`plot`'), filtration (MATLAB function '`filter`') or for Fourier transform (MATLAB function '`fft`').[4] If appropriate input/output interface to feed this internal data matrixes created, viewer can then process any data format.[5]

[2] Algorithm designated by Silver and Chan (1991) is used to determine optimal parameters of the transformation.
[3] This paragraph can be skipped by standard users who are not interested in programming details without loosing continuity.
[4] Mentioned MATLAB functions support input of single time series (a vector) as well as multiple ones (a matrix). Therefore organization of data in 2D matrix formally simplified the code and makes it also probably faster.
[5] Notice that up to now only input/output of columns of ASCII data are supported; in case of users' interest an extension of e.g. GSE format would be possible.

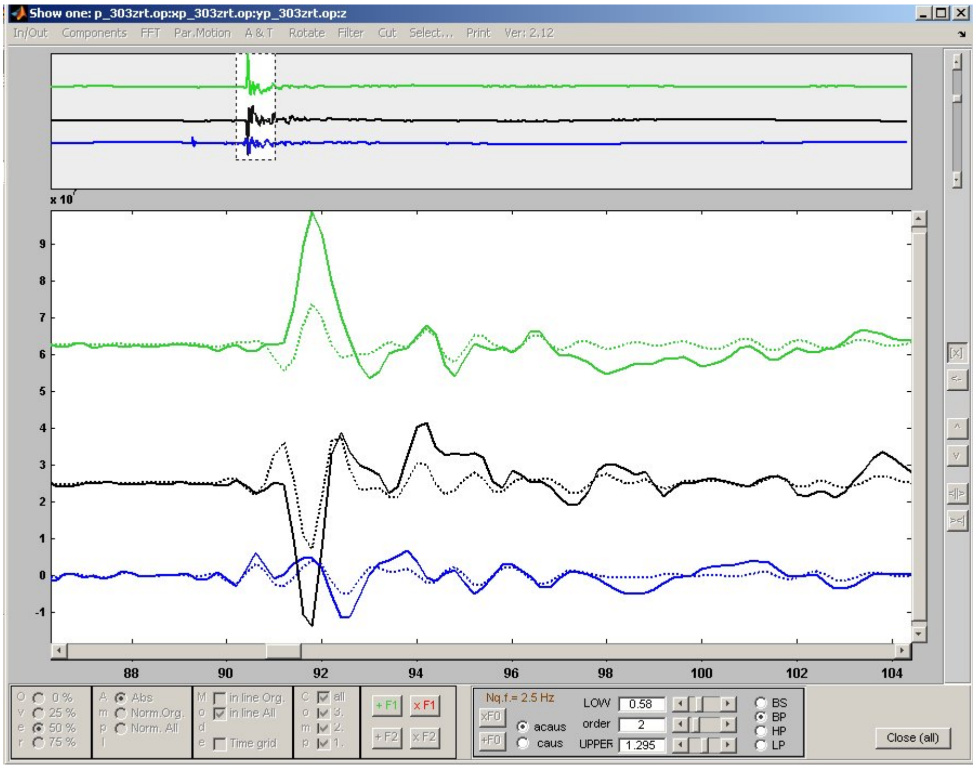

Fig. 4 An example of virtual layers. Original record (full line, the same data as in Figs. 2 and 3) is filtered (dotted line) with band pass Butterworth filter, 0.6 – 1.3 Hz, order 2, sampling 200 Hz is used.

Table 1 OP features discussion

Feature	Value [+/0/-]	Comment
Interactive graphical control	+ 0	This is an above standard feature in MATLAB [+], however a standard for users [0]
Developed in MATLAB	- 0	MATLAB is a commercial product and therefore not generally accessible to everybody [-], however most of other graphical compilers are also commercial [0]. Moreover, the program itself can be run independently on MATLAB platform (with support of run-time library).
1 author; fairly large code (cca 13000 lines)	+ -	Everything can be control by one person [+], modification by other (experienced) users would be difficult if not impossible [-]
(up to now) only few users	-	Weak feedback, slower improvements and bugs reparation
Special tools	+	Namely: * Interactive filtration displayed in virtual layers * Components time-spatial correlation
(up to now) only relative time scale available	-	For processed selected event, there was no need of absolute time scale; it can be added if required
Input format: (up to now) only ASCII columns	-	Some standard formats (e.g. GSE) can be added if required
No database	0 -	Any database is not intended [-], as it is not necessary part of a viewer of our type [0] (N.B. picked phases can be saved and reload again)
Code ownership	+	Program code can be modified or extended whenever required

Interactive control is a common tool in modern graphical programs and users naturally expect it also in this case. However such features are not directly supported by standard users MATLAB's function set. Therefore we have developed several required utilities: a utility for interactive selection of a figure area – this utility is then used for selection and control of an area for zooming. Also slider bars on sides of a displayed area of the whole plot and repeated buttons were developed – for details see Kolář (2005).

As we wanted OP to enable multiple times simultaneous runs, special care was devoted to variables storage and their passing among program's sub-functions. Therefore MATLAB variable declaration 'global' could not be used in this case. Instead we pass variables as a function's arguments from one function to another, use nested functions formalism or exchange the data via MATLAB functions '`setapp`'/'`getapp`'.

Mainly due to relatively complicated relationship and interactions between used graphical object and used graphical interactivity, we did not succeeded with our starting intend: to have a base (graphical) frame in which individual plug-in modules, arbitrary created by qualified users, can be added in a simple manner. On the contrary, rather complicated inner structure of the program would need deep knowledge of the system for most of future possible modifications.

OP FEATURES DISCUSSION

We summarize, evaluate and briefly comment basic features of viewer OP in form of a Table 1.

CONCLUSION

Several years of viewer OP (and its ancestors) development and utilization proved, that such viewer is useful and desirable tool next to all others. On the base of our development experiences it can be concluded, that at the present time all the required mathematical functions (for seismogram processing) already either exist or can be easily programmed on the base of standard function libraries.[6] On the other hand a rich, flexible and stable graphical library of interactive graphical tools is strongly needed for development of a viewer.[7]

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[6] This is completely different situation in comparison with the situation 10 or 20 years earlier (see e.g. history of FFT algorithm development).

[7] Unfortunately, despite of all MATLAB poverty, we have met some difficulties in this point – see the text above.