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A visualization-based post-processing system for analysis of acoustic data

David G. Socha, Jonathan L. Watkins, and
Andrew S. Brierley

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A commercial data-visualization package, AVS, and database are used as the basis for a powerful and highly flexible acoustic data analysis system. The system is easy to use and can be modified by the user to incorporate novel visualization and analysis capabilities as required. Multi-frequency ping-by-ping or integrated data from a variety of echo-sounders may be viewed and manipulated within the system. Here, we describe the main features of the system and illustrate how it may be used to mark, transform, analyse, and compare dual-frequency acoustic data.

Key words: acoustic analysis, AVS, echo-sounders, post-processing, SIMRAD EK500, visualization.

D. G. Socha, J. L. Watkins, and A. S. Brierley: British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 0ET, England. Correspondence to Watkins [tel: +44(0)1223 251605, fax: +44(0)1223 362616].

Introduction

Acoustic techniques are widely used to provide data for the management of commercially exploited fish stocks (MacLennan, 1990) and for the scientific study of pelagic organisms ranging in size from zooplankton through micronekton (such as Antarctic krill) to squid and fish. As the complexity and volume of acoutic data have increased, so has the requirement for systems to control the collection, storage, visualization, and analysis of such data (Dawson *et al.*, 1989; Knudsen, 1990; Foote *et al.*, 1991). With the development of multi-frequency acoustic systems and the potential to classify acoustic targets on the basis of their multi-frequency signatures (Holliday *et al.*, 1989; Madureira *et al.*, 1993a, b), there is an additional need to be able to visualize and manipulate such multi-frequency data easily and rapidly.

For this purpose we have adapted a commercially available visualization software package to post-process acoustic data. In this paper we provide an overview of the system and describe how the system is typically used to: (i) read and view dual-frequency integrated volume backscattering (Sv) data; (ii) edit and mark data; (iii) assess and filter background noise; (iv) display multi-frequency data and δSv (dB difference between Sv recorded at two frequencies); and (v) output data for storage or further processing in specialized statistical packages.

System overview

Application Visualization System (AVS) software (Upson *et al.*, 1989) run on a UNIX workstation is used to visualize and transform acoustic data. Raw data are held as compressed binary files and a catalogue of raw data plus associated meta-data (such as calibration or machine settings) are stored in an Oracle database (Cheu and Linden, 1990). AVS provides a robust visualization environment with many standard features, and can be customized to handle acoustic data. Within AVS, a network editor is used to link together software modules to build a network to undertake specific analytical tasks within a graphical environment (Fig. 1a). Processing modules receive input data from other modules and from parameters whose values are controlled by the user through graphical interfaces. Modules' output data to other modules for further processing produce visualizations in separate windows, or output data to files. Standard networks to carry out our regular acoustic processes can be chosen from a menu and modified further as necessary.

Much of the power and flexibility of AVS derives from the large number of modules provided with the

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(a)

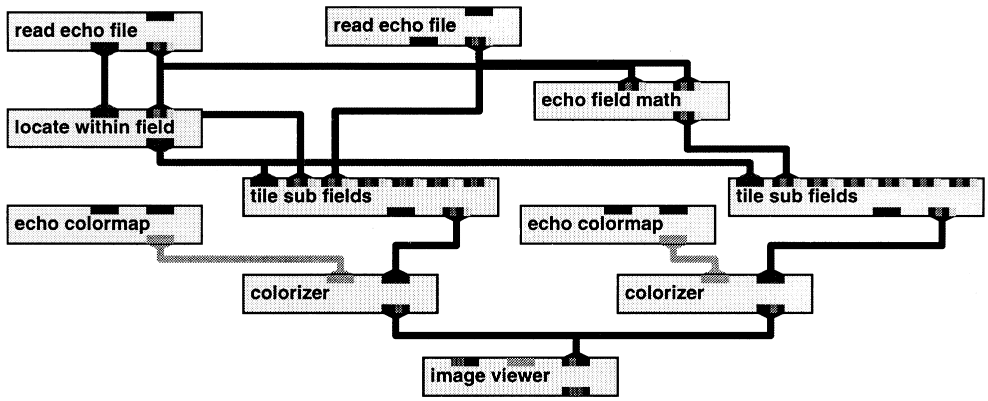

Figure 1 (a).

Figure 1. An AVS network and resulting output. The network of AVS modules (a) reads acoustic data at two frequencies (*read echo file*), calculates δSv (the dB difference between the frequencies) using *echo field math*, and produces a composite colour image as an output (*title subfields*, *echo colourizer*, and *image viewer*). The portion of the data set viewed is controlled with the *locate within field* module. The image (b) is composed of three separate parts; 120 kHz Sv on the left, 38 kHz Sv in the middle, and δSv on the right. Each part is displayed as a depth (y-axis) time (x-axis) matrix. The range of δSv displayed has been restricted to emphasize targets of a particular class.

system or is available from an international library by anonymous file transfer protocol (ftp). Additional modules may be written using the AVS application interface. The acoustic processing uses many standard AVS features, but considerable development was required to incorporate specific acoustic data manipulation and storage functions. New modules were written in C++ (Ellis and Stroustrup, 1990) using the GNU libg++ class library.

Typical system use

Data input

Data are imported into AVS using the purpose-written *read echo file* module to read compressed binary input files (Fig. 1a). Data in original echo-sounder output formats are converted to the binary input format using UNIX scripts prior to input. This facet makes the system very flexible and removes any dependence on a particular type of echo-sounder. Database modules allow the user to query the Oracle database catalogue from within AVS, and to use SQL (standard query language) to select subsets of data to import.

Once in AVS, acoustic data are usually viewed in a two-dimensional image viewer. The colour scale used in the projection of such views is defined in *echo colourmap* and applied using the *colourizer* module (Fig. 1a).

Data editing and marking

Data displayed in the image viewer are inspected and if necessary may be edited and marked. Data may be marked because they are suspect, for instance because they contain a noise spike or a false bottom echo, or to aid classification, for instance to highlight krill swarms that have been verified by target fishing. Areas of the image may be selected with the mouse and an appropriate mark applied using the *mark image* module. Multiple marks and selections may be defined and distinguished in the image viewer. Marks applied to data at one frequency may be applied either directly or with modification to data from other frequencies. Mark information is stored in separate data files with depth/time references back to the original data. This approach avoids destructive changes to the raw data and reduces the storage needs by storing only a brief description of modifications instead of an entirely new data set.

Noise assessment and filtering

After importing and marking data, it may be desirable to inspect and filter background noise levels, for example using the technique described by Watkins and Brierley (in press). The time varied gain (TVG) function applied by the echo-sounder to compensate for spreading and attenuation losses also amplifies background noise. The degree of amplification varies with frequency and so may affect the calculation of δSv, which is used in the classification of targets (Madureira *et al.*, 1993a, b). Background noise levels can be estimated using the *fit TVG curve* module and removed from the data by subtraction. Parameters describing the background noise may then be stored in the database.

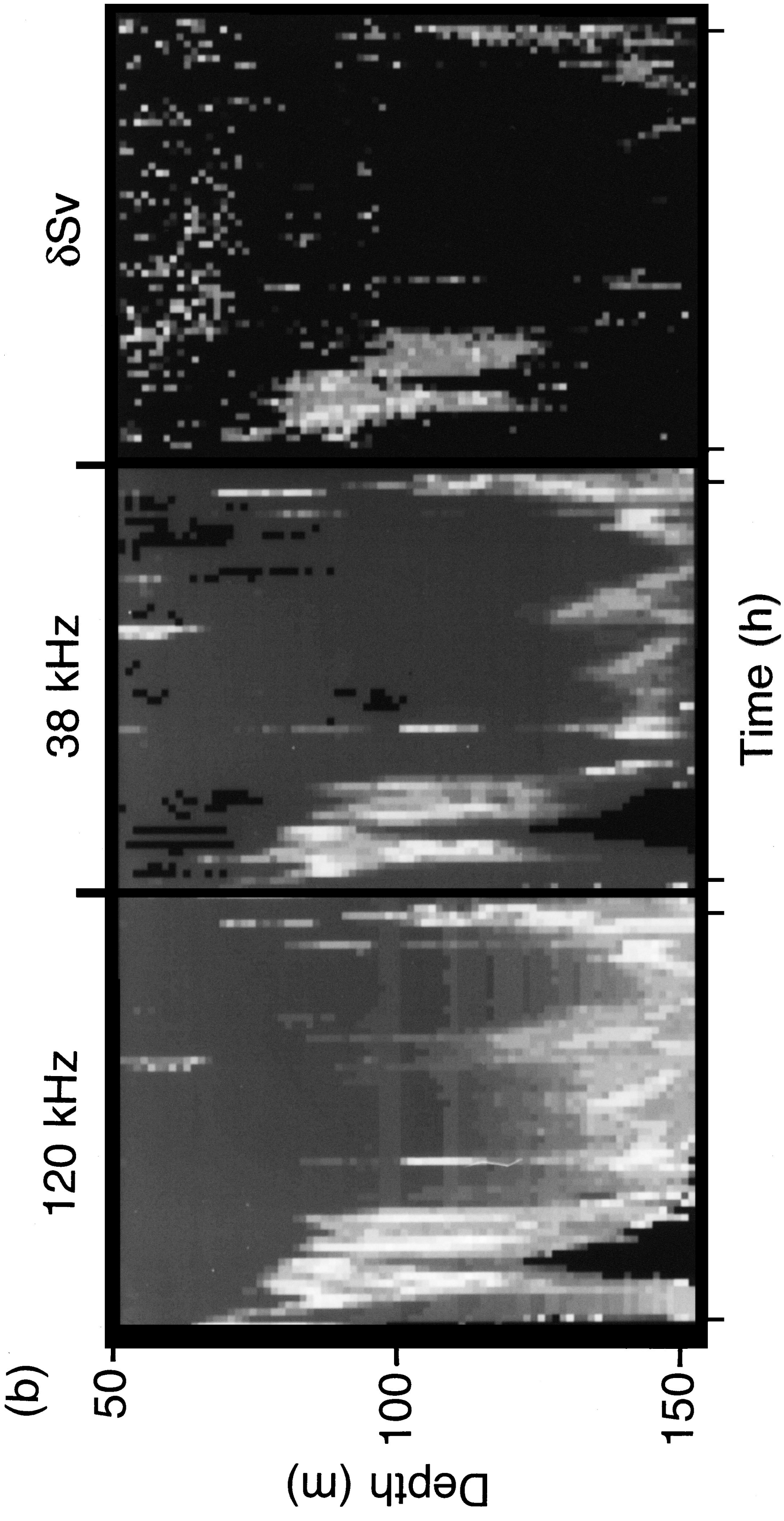

Figure 1 (b).

Multi-frequency data display

Marked and noise filtered data for several frequencies may be viewed together for interpretation. Figure 1b shows 120 and 38 kHz data sets displayed within a single image viewer using *tile sub field* and *locate within field* modules. The δSv between frequencies (calculated by the *echo field math* module) is also shown. Each image is linked so that zooming or moving around within one image zooms and moves all others simultaneously. Thresholds are easily applied to the data displayed; so, for example, we can view only data where δSv falls within a range indicative of a particular class of target (Madueira *et al.*, 1993a, b). It is also possible to display the data in a three-dimensional format (Watkins and Brierley, in press).

Data output

Data are exported from AVS, for instance for specialized statistical processing, via the *write echo file* module. The resulting binary file can be converted to the required ASCII format using UNIX scripts.

The Oracle database stores data for defining marks, calibration parameters, and other variables. To reduce storage needs and to ensure that derived data continue to reflect any changes in the data from which they originated, derived data are stored as *views* which describe how to produce them. The view concept is common in databases, but implementation here is more difficult because Oracle must store a description of how to use a specific AVS network, including input files, parameter settings, and location and format of multiple outputs.

Conclusion

The post-processing system described in this paper was developed in response to a growing need to visualize multi-frequency echo integration data. It has enabled us to detect and edit suspect data easily and quickly. Data collected by a SIMRAD EK500 echo-sounder operating at 120 and 38 kHz have been loaded and windows created that allow the simultaneous inspection of the original raw data for each frequency, the noise-filtered data for each frequency and the dB difference between the two frequencies. Targets relating to particular ranges of dB difference have been revealed and the effects of changing this range on target classification and on calculations of biomass made from single frequency data have been studied. Although it has been used only with echo-integrator data so far, the system has been designed to function with ping-by-ping data as well.

Other post-processing systems, such as the BEI500 system developed for the SIMRAD EK500 echo-sounder, are powerful and incorporate many functions (Knudsen, 1990; Foote *et al.*, 1991). The AVS-based system described here, however, has the advantage of versatility, and is not tied to any one make of echo-sounder. Most importantly, the ease with which new networks can be constructed means that the system can be quickly expanded or modified by the scientific user to meet their evolving analysis requirements.

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