Building a standards-based visualization framework for customized seismic analysis and quality control workflows

A picture is worth a thousand words goes the saying. What if we could have quick and simple access to quality control (QC) and basic analysis of data without loading projects into expensive and complicated interpretation software? Olivier Lhemann,[1] Paul Schatz[1*] and Philippe Flichy describe how visualization company INT set about meeting this challenge.

The E&P industry has undoubtedly benefited from advanced data visualization and volume interpretation applications over the last 10-15 years. Such software platforms have played an important role in deciding which prospects are serious candidates for exploration and have helped to increase success rates. However, these solutions have come at a substantial price. It is increasingly being acknowledged in the industry that most exploration geoscientists could benefit from an easy-to-use and affordable visualization solution for data quality control sessions, prospect reviews, and joint venture presentations. That was the objective guiding the development of a new style of visualization. It was a question of imagining a cross platform tool kit to build custom workflows that allows navigation and interaction with data quickly and efficiently!

Visualization of disparate data sets of various sizes and formats in a powerful graphical environment is the answer to efficiently understanding data quality problems, anomalies, and trends. Such an environment responds dynamically to manipulation when analyzing many data sets on one common canvas, or it can allow travel through time in a 4D visualization process comparing one survey to another. In today's context this means empowering an expert with the right tools that will be used repeatedly, guaranteeing great return on limited investment.

Geoscientists are looking for a visualization tool for such rapid analysis of G&G data, geared to reviewing pre-stack and post-stack seismic volumes, horizons, and attributes. Ideally, an intuitive user interface should allow users to visualize complex geophysical data, capture and share snapshots of data analysis sessions, and personalize workflows with proprietary plug-ins and utilities. A common need across the industry is to provide easy access to visualization of large datasets, as well as synchronization mechanisms between views and horizon management. A framework for rapid prototyping and analysis will help users interested in developing customized technology to concentrate on solving their specific challenges without having to build an extensive infrastructure.

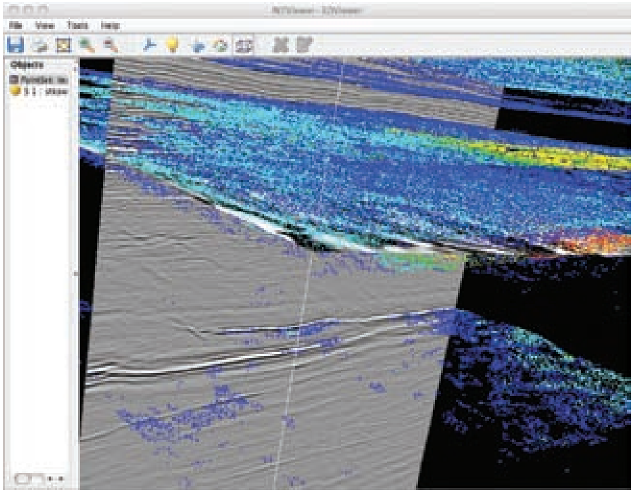

Figure 1 Attribute selection workflow. Visibility range of attributes can be controlled and attribute values can be edited interactively.

Standards based

An important starting point when building the INTViewer to be used as an accessible viewing tool was to write the software in Java and the NetBeans Rich Client Platform to support its plug-in architecture. Java is a cross-platform programming environment with object-oriented language, good developer productivity, and a well established performance track record. The NetBeans platform offered the requisite reliable and flexible application architecture that makes it easy to create robust and extensible applications. A NetBeans application typically consists of a set of modules or plug-ins. The NetBeans runtime environment understands what a module is, manages dependencies and versioning, handles modules lifecycle, and enables the interaction between modules in the same application. Net Beans has a further advantage of being an Open Source project that

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makes up a very active and diverse community, in which many people around the world are developing blogs, books, tutorials and training material.

By leveraging Java and Net Beans, the intention was to offer a flexible viewing platform that could be enhanced through plug-ins for implementation of new data formats, new processing functionality, new data views, and even complete custom workflows. Each plug-in is packaged as a single jar file (java archived format) that can simply be dropped inside a special folder for activation.

Flexible data support

Although a few standards such as SEGY exist for seismic data, in practice many applications rely on their own format. A lot of productivity is lost reformatting data when moving from one application to another. For a visualization tool to be most effective it should natively support as many formats as possible. Furthermore, it is important to be able to integrate disparate data into a single display. Formats currently used in the industry include SEGY, SEGD, SU, SEP, JavaSeis, ProMAX, CST, etc. In addition, it should be possible to add new formats via plug-ins.

The seismic data access functionality in the viewer design was encapsulated in an API rather prosaically christened SeismicDataAdapter. The idea was that users could create their own processing plug-in utility using this API which would support both random access read and write.

Custom workflows were made much easier utilizing the standards-based framework and plug-in architecture to build advanced applications. Specialized analyses, custom menus and dialogues, communication with external applications, creation of new types of windows, or extending existing ones were all planned as options with the extended functionality. For complex tasks, a workflow window could be activated which was designed to guide users through each step required to complete the task.

Pre-stack seismic QC workflow

Seismic data volumes can be huge, with many marine surveys consisting of several Terabytes of pre-stack data. Any processing sequence of such large datasets can take weeks, even on the most powerful clusters. Any solution that requires conversion of the data to a different format, or storing multiple processed copies of the data, is often not an option. The answer to this problem was a powerful yet simple solution for visualization and rapid QC of very large datasets via an indexing mechanism that builds a small index file for quick random access of inlines, crosslines, gathers, and arbitrary traverses. In this way traces can be processed on the fly and users can create virtual data sets for visualization without the need to save multiple copies of the data on disk.

Plug-ins were also included for basic tasks such as filtering, phase shift, mute, etc… and also more advanced algorithms such as calculations for angles of incidence and corrections for spherical divergence. In practice, this approach has worked. Using available plug-ins plus a number of utility plug-ins developed in house, Cimarex, a Denver-based independent oil and gas E&P was able to develop a complete workflow to analyze and process gathers for AVO analysis. The company has deployed over fifty utility plug-ins, some requiring only a few days of development.

Marine acquisition QC workflow

In collaboration with Statoil a navigation quality control plug-in has been designed. In this case the idea was to be able to visualize navigation data for analysis and quality control purposes. Different attributes can be provided by or computed from navigation data. The user is then able to define a rectangular gridded region where different kinds of attributes can be computed for each bin of the grid. It is also possible to create, display, and export different attribute maps, including water-bottom, azimuth, deviation, fold, and feather maps.

Navigation data represents shot and receiver positions and these can be described as point data with a user defined symbol. A huge number of points can be displayed at the same time yet the display remains efficient and the application responsive. The viewer is able to load 300 navigation files each defining a sail line. There are about 3000 shots per sail line. A vessel can tow up to 12 streamers 8000 meters each. With a channel spacing of 12.5 m each streamer has 640 channels (or receiver points). So the viewer handles up to 900,000 shot points and 6,912,000,000 receiver points.

Navigation data usually comes in standard ASCII formats such as P1-90 or SPS. Sometimes when these files are not available, the navigation data can be directly extracted from the SEGY dataset. Parsing of this data can take hours, which makes it unavailable for interactive processing. To overcome this hurdle, an intermediate format where the source and receiver locations are stored in raw binary format was devel-

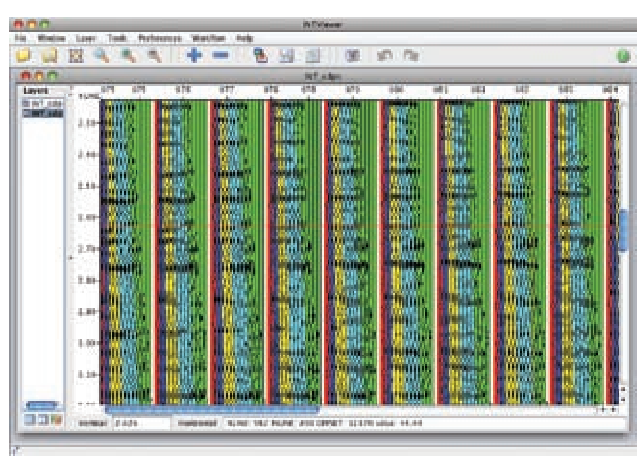

Figure 2 *A velocity model is selected and the gathers are converted to angles of incidence on the fly.*

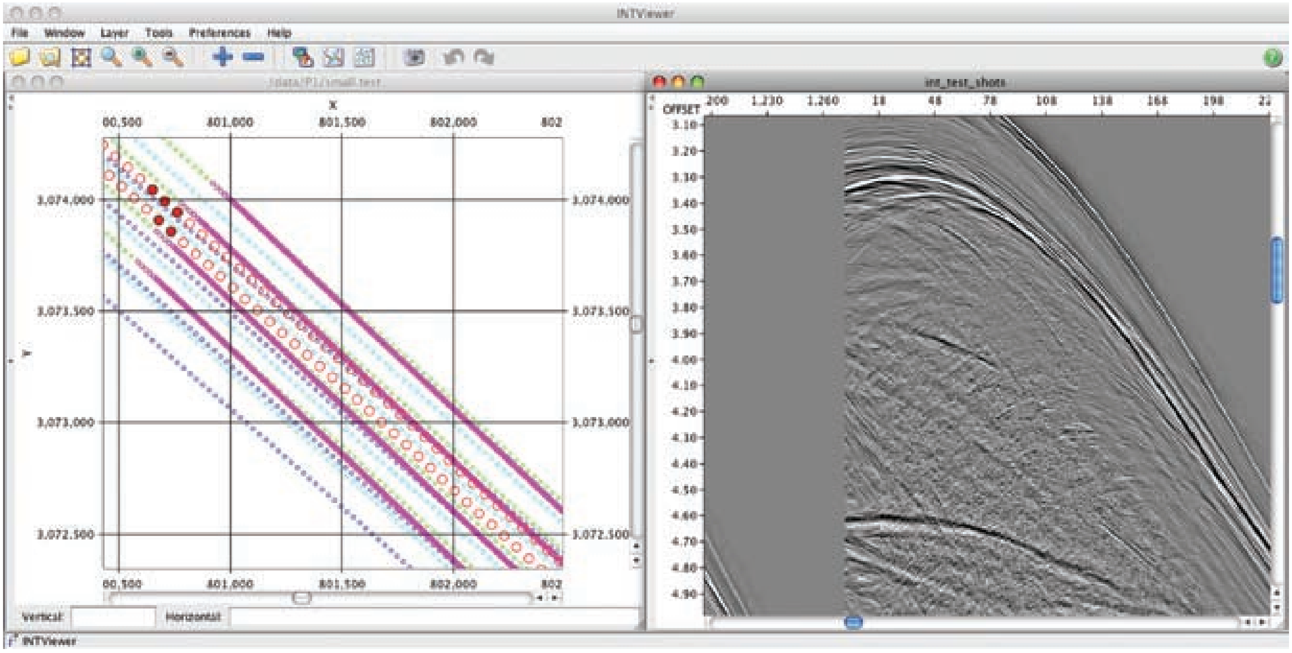

***Figure 3** Navigation QC workflow: sources are selected on the map views and the corresponding shots are displayed in the x-section panel.*

oped. This format can also serve as a disk cache for receiver data which is simply too big to fit in memory.

Operators want to be able to QC the navigation data before embarking into costly processing sequences. Unfortunately very few commercial tools are available for QC of navigation data, and business tools like Excel simply cannot handle the amount of data involved in today's marine surveys. The benefit of a powerful graphical framework is that it allows users to review massive amounts of data quickly and efficiently. Anomalies stand out and can be corrected interactively.

A companion workflow, currently under development, allows the QC of ocean bottom cables (OBC) or 4D surveys. Those surveys are used to provide seismic reservoir monitoring over the life cycle of a field. A base survey is first acquired and processed. Over time, additional (monitor) surveys are acquired and compared with the base survey. For the comparison to be meaningful, the repeatability of the acquisition geometry is critical. The goal is that a user will be able to visualize the surveys; and build histograms and maps to compare distance and azimuth between corresponding receivers or shots. In this way non-coinciding shots or receivers can be eliminated from the surveys before processing of the seismic data.

Velocity scanning workflow

Another plug-in which has proved its value involves velocity scanning and was designed to help refine a velocity model in hard to image areas, such as below salt. The idea of the plug-in is to vary a velocity model using several fixed percentages (usually one lower and one higher), migrate the dataset with the scaled velocities, and update the velocity model by picking along a horizon of interest and selecting the velocity that creates the best image. This workflow consists of a number of steps:

- Migration of the seismic dataset with the 100% velocity model and some variations (95% and 105% for example). This step is done outside the viewer.
- Loading of the migrated datasets and the 100% velocity model. A different colour is assigned to each migrated dataset (corresponding to a percentage of the 100% velocity).
- Loading of a reference horizon (velocity has been perturbed only below this reference horizon).

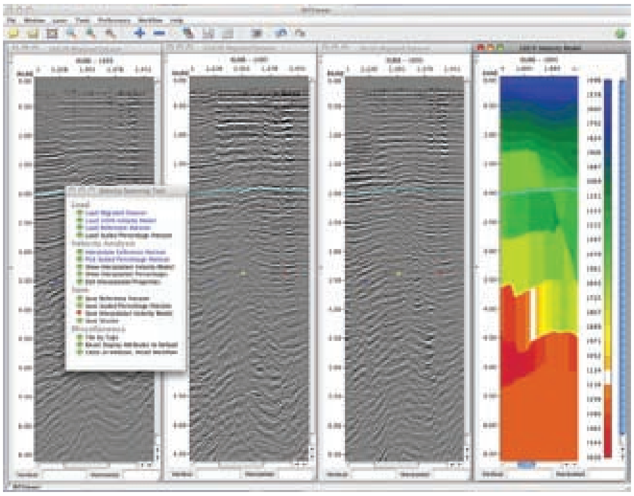

***Figure 4** Velocity scanning workflow:a velocity model is refined by picking on migrated panels where the energy is better focused.*

- Picking along a horizon using the migrated panel where the event energy is better focused. Each pick will be displayed in the colour assigned to the percentage velocity.
- As the user picks, a new velocity model is calculated on the fly, by first interpolating the picks along the horizon, and then by interpolating and scaling the velocity vertically.
- The user can save the new velocity and repeat the process for a deeper horizon.
- For user friendliness, this workflow was produced with a wizard that guides the user through each step of the process.

Benefits of a visualization framework

It is clear that a good framework addresses preoccupations of both application users and developers. From a user perspective there is the intuitive interface which can be configured with tailored workflows, allowing them to concentrate on analysis and not on mastering the software. In addition, flexible access to a variety of data formats from within the application gives users the ability to be creative with new workflows, such as overlaying pre-stack and post-stack data with attributes or merging industry standard data with specialized proprietary data.

Developers benefit from cross platform flexibility offered by Java, which allows their users to run the application on almost any computer system. For extensive customization, developers can build their own workflows choosing a preferred user interface to fit with other applications or guidelines. If desired they can create a completely customized presentation layer without incurring heavy maintenance costs since they are building on a commercial off-the-shelf library.

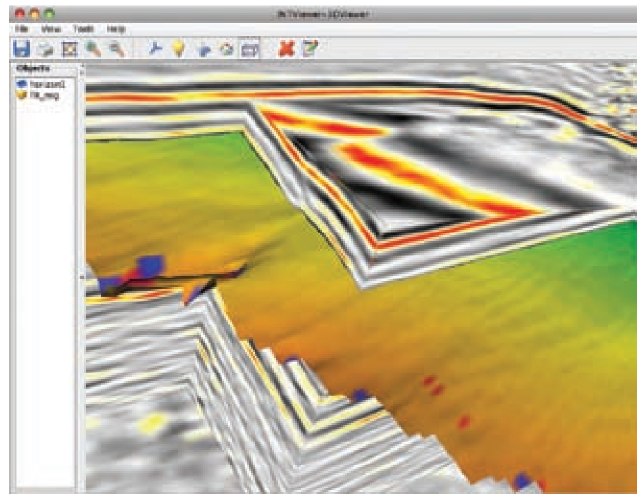

Figure 5 *Velocity workflow: the interpolated percentage horizon is displayed in 3D.*