GeoVisionary – Virtual Fieldwork for Real Geologists

By Bruce Napier - project leader, BGS Virtual Field Reconnaissance

GEOVISIONARY, the result of a three year research collaboration between the British Geological Survey (BGS) and Virtalis, is a stereographic software system used for virtual field reconnaissance. Now, following its application in a large number of diverse applications around the world, the development team behind it is planning the next frontier. Users have analysed how, over time, their ways of working have changed and they've reported back which new features would be most beneficial.

What is GeoVisionary?

GeoVisionary was developed initially to allow high-resolution visualisation of the kinds of spatial data that are generally used in geological mapping projects. One of the design goals was to ensure that data sets for large regions, national to sub-continental, could be loaded simultaneously and at full resolution, while allowing real-time interaction with the data. One of the major advantages GeoVisionary offers over current visualisation software (3&4D GIS) is its ability to integrate very large volumes of data from multiple sources, allowing a greater understanding of diverse spatial datasets.

Virtalis' 20 years of expertise in VR and handling large engineering CAD datasets made that goal possible. It provides high-resolution 3D and 3D stereo visualisation that is limited only by the resolution of the data. It is highly scalable and is able to provide "fly-through" viewing of mid-continent-scale data sets in real-time at full speed. GeoVisionary is primarily a visualisation software package, but it does have useful landscape feature interpretation tools. For example, it allows for digitisation in 3D space, enabling geologists to digitise geological features directly on the 3-D elevation model and orthophotography.

This preliminary mapping capability saves much time especially because it improves the agreement of resultant geologic lines with the topographic base that is used for mapping. GeoVisionary has been designed in such an open way, using XML formats, that other software, such as ESRI, links into it easily. Links to other software packages include individual georeferenced and non georeferenced image files, GeoTIFF images, JPG images, TGA images, SRTM data, most formats of GOCAD, GSI3D – GXML, LiDAR point cloud data surface or points and Enhanced Compression Wavelets.

To compliment the impressive visualisation and data capture features of GeoVisionary, BGS has created a suite of tools, Arc2GV, for ArcGIS, comprising a "fake GPS" location linkage, and several tools that allow for easy transfer of data from corporate databases to the immersive environment. Borehole databases can be interrogated for specific rock- types and rendered in 3D. For added realism, GPS track-logs can be used to visualise moving models in their true location.

By using GeoVisionary and Arc2GV, BGS scientists are presented with an intuitive virtual environment in which they work with greater efficiency than was previously possible. By augmenting the virtual landscape with geoscience datasets, maximum use can be obtained from these valuable resources, and the scientist can effectively target interesting or problematic areas for a field visit.

3D Data – How will it be used in the Future?

Although Version 1.0 of GeoVisionary was only launched a little over a year ago, the next release will not be a series of incremental improvements, as is the software custom. Fittingly for a Virtual Reality (VR) software package, the next version of GeoVisionary will incorporate a 3D Graphical User Interface (GUI), that will appear to hover in space above the landscape or geographical strata and will be intuitive to interact with.

Although still some way off completion, the broad user base around the world, which includes some of the most influential geological surveys, are in agreement that voxel and 4-D visualisation capability would increase the value of GeoVisionary not only to geologists, but also to the mining industry and those managing environmental clean-up programmes, such as that seen recently in the Gulf of Mexico.

Voxels are, for the uninitiated, pixels with volume attached to them. They therefore represent the best way of denoting areas of, for example, differing concentration, density, porosity, pressure and temperature. Examples include oil and gas reserviors, pollution plumes and groundwater movement. When voxels are deployed in process models, it is very easy to monitor change, allowing geoscientists to build up accurate 3D, dynamic models of flow patterns and temperature patterns. Visualising and interpreting process models is highly complex. An illustration is that if one were to take a raster image to act as a snapshot of, say, $2km^2$, with a resolution of 1m, then four million pixels would be sufficient to depict the model in 2D. However, if one wants to build up a 3D representation of the same sized area, and therefore use voxels to depict the scene, eight billion of them would be required. The difference in data processing power required for four million pixels, as opposed to eight billion voxels is immense, but, owing to the way GeoVisionary was designed at the outset, this additional feature will be accomplished in the current development programme.

A critical advance for GeoVisionary's users within BGS is a seamless link to GSI3D (Geological Surveying and Investigation in three dimensions). This is a methodology and associated software tool for 3D geological modelling which enables the quick and intuitive construction of 3D solid models of the subsurface for a wide range of applications. This software was developed jointly by BGS and INSIGHT GmbH and has been rolled out right across BGS. GSI3D is designed for the geoscientist, rather than expert software users, with the modelling workflow following the geologists' train of thought as an understanding of the subsurface is built-up. The model is built by enabling the user to construct traditional cross-sections by correlating boreholes and outcrop data to produce a network of interlocking sections, or geological fence diagram, which is then processed to produce 3D volume models.

Simultaneously, GeoVisionary will have the ability to natively ingest and visualise industry standard voxel formats – SEG-Y, GOCAD, Schlumberger, DataMine, Vulcan, etc. Once this development is achieved, GeoVisionary's application will inevitably broaden to encompass property modelling and process modelling. Being able to monitor, in real time, change occurring within a defined area will mean that the system will become vital to contaminant simulation, ocean and atmospheric property visualisation, oil and gas voxel models, mining, sensor networks and seismic cube visualisation, such as CO_2 monitoring. This further development will allow better integration with other environmental sciences to tackle global issues, better informing decision makers.

The fundamental goals of this work will be:-

- Interactive Visualisation of Voxel and point-cloud/spatial volume data.
- Dynamic/time varying visualisation – i.e. pollution plume, flood, glacier, ocean, and atmospheric flow.
- Integration with BGS systems and software such as: ALERT, GSI3D , ZOOM, PropBase, Deep Geology, Carbon Capture and Storage.
- Visualisation of industry-standard voxel formats.
- Investigate Real-time tools such as sectioning, iso-surfacing, thresholding and streamlining.

Fundamentally, GeoVisionary as well as a raft of other software such as, BGS·SIGMAmobile which is BGS's digital field data capture system, designed to run on rugged tablet PCs with integrated GPS units, and GSI3D (BGS' 3D geological modelling software) are changing the way geoscientists approach their work. Typically now, geologists access the base vector data from the storage area in the network and save any changes in GeoVisionary. They also use these tools to communicate much more frequently than was previously the case, utilising video conferencing via Windows Media Player. Nowadays, even colleagues working remotely or in the field can share observations about a 3D visualisation thanks to technology such as this. A team approach throughout projects has been found to improve accuracy, as colleagues can now both interpret in 3D, augmenting the virtual landscape with 2D data from GIS . When the GeoVisionary interpretation is completed, the data is stored within corporate databases and can be accessed by geologists in the field via BGS·SIGMAmobile. This process is so straightforward and seamless that all the active mapping projects in BGS are using the system, and 40 geologists have been trained to operate the software. Feedback has been unanimously positive and the mapping teams report a much better understanding of the landscape, especially where features that might have been easy to overlook prior to GeoVisionary, can now receive additional analysis, thanks to the enhance features function.

GeoVisionary Case Study: Mozambique

Coal reserves in Mozambique were the focus of a geological interpretation of satellite data by Dr John Carney, Principal Survey Geologist at BGS, carried out under contract for SRK Consulting (UK) Ltd.

GeoVisionary was his tool of choice, with the ability to integrate a Digital Elevation Model with Very Near Infrared (VNIR) data from the ASTER satellite, along with older interpretations in ArcGIS formats. Having quickly assembled the data in a GeoVisionary project, John used the Interpretation tools to analyse the data and produce a new digital geological appraisal of the area. By working with variable transparencies and combinations of layers, including boreholes and resource models from Vulcan 3D modelling software, along with vertically exaggerating the terrain and changing the direction of the virtual sunlight, relationships between datasets and the virtual environment were clearly visible and, as a result, a product of higher quality was produced in a shorter time than was previously possible.

GeoVisionary Case Study: Mars

The planet Mars is a great example of a very harsh fieldwork environment. BGS has recently collaborated with the Dutch Geological Survey (TNO) and the International Institute for Geo-Information Science and Earth Observation (ITC), and the University College London (UCL) in a recently completed, 16 month European Space Agency (ESA) funded pilot study of Mars. The aim of the project was to demonstrate data management, information extraction, and the application of modern state-of-the-art 2D and 3D digital geological mapping, visualisation, and interpretation tools which they have developed for terrestrial applications, but in a planetary context. The team used and processed medium to high resolution topographic and image data supplied by the European Space Agency and NASA.

The area of Mars that the team focussed on is called Nili Fossae. It is an area that is still being actively researched by other planetary geoscientists, and was one of the final 7 potential candidate landing sites for the NASA Mars Science Laboratory, which is due for launch in 2011.

GeoVisionary was used to combine topographic details with spectrally-derived mineralogical information. Then, by draping data from ArcMap into GeoVisionary, the geologists were able to make “on-the-fly” interpretations.

“The ability to mark contacts, structures and other geological features while fully immersed in a 3D environment is probably as close to real field mapping on Mars as is possible at the moment”, said Dr. Peter Grindrod, a planetary geologist and Aurora Research Fellow at UCL, and a member of the pilot study. “I expect that a wide range of planetary scientists that are already familiar with GIS environments would be interested in applying this technique.”

The team is now seeking further funding to realise the potential shown by GeoVisionary to aid geological interpretation and map production in other areas of Mars, and also the harsh environments of the other inner planets, where field work isn’t possible.