

Auriga, or Trading your Survey Notebook for a PDA

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The Auriga software was initially designed to support an electronic surveying instrument developed by Martin Melzer. This development work is described by Martin in a companion article in the current issue of the CREG journal [1]. The software has subsequently been rewritten by Luc Le Blanc to become a general-purpose package for entering, storing, processing and viewing survey data on a PDA (Personal Digital Assistant). This article describes how the software can be used at present, and possibilities for future development.

In March 2000, before leaving for Mexpé, our annual 3-week caving expedition in the Mexican Sierra Negra, I realized that we would again be performing the required survey data conversions on our programmable calculator with its antique text mode interface. We could indeed run more sophisticated cave survey software on a laptop computer, but the closest village is a 1.5-hour walk away and does not even have electricity. Solar recharging works fine in Mexico, although 7 hours of bright sun are consumed in 2.5 hours of laptop use. Could a simple low-cost Palm PDA, powered by two AAA batteries that last for about a month, be a viable solution? After all, we had already designed a spreadsheet to perform basic survey data conversions into XYZ co-ordinates on a Palm. A few days before departure, Martin Melzer replied to my enquiry about the existence of a Palm OS cave survey software posted on the Cavers' Digest... I left for Mexico with Martin's Auriga software in my Palm, along with two sample caves.

I was immediately delighted with Auriga. It was living proof of the feasibility of field-oriented cave survey software on a Palm device. Working in real-time software development, I was well aware that even a 16 MHz CPU can do wonders with number crunching, but in those times of bloated OSes and resource-hungry sloppy software, I did not yet know where the Palm OS stood.

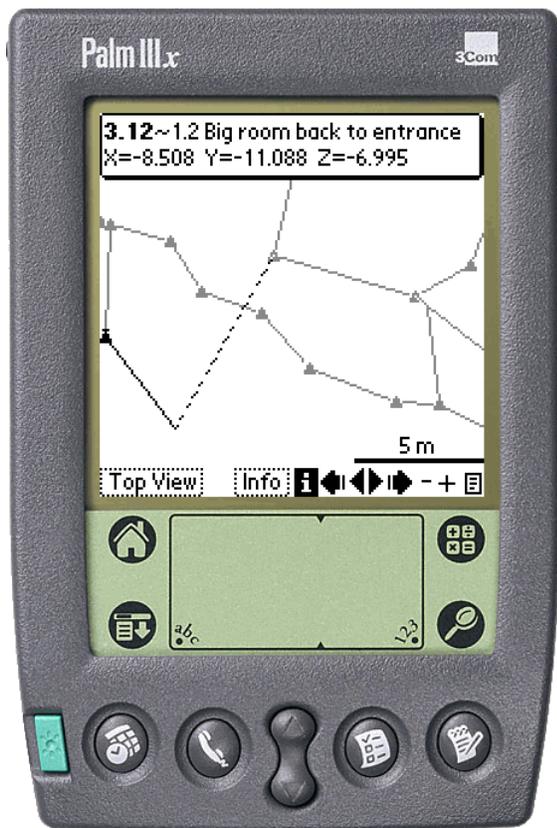


Figure 1: Palm top running Auriga: the cave map screen. Loop errors are graphically displayed with a dotted line between the actual and theoretical ends of erroneous survey shots.

At the time Auriga was mostly meant to support Martin's sensor box prototype, but it nonetheless offered a good user interface to manually input survey data and display the resulting cave map (topographical path). Unfortunately, computed co-ordinates were kept internally, Auriga offering no list display of any sort. In order to start plotting our maps while at camp, we needed these co-ordinates. I submitted to Martin a long list of suggestions for improvement. Knowing words are cheap, I also proposed help. Martin had already received several information requests about Auriga, but this was the first offer of help. Since he had already stopped developing his prototype, he sent me his source code. We had both taken a risk that turned into a successful collaboration: the Auriga code base was healthy and well-thought out, whilst I was willing to put the necessary time and energy into the adventure. And time and energy it took. I decided to make Auriga as universal and user-friendly as can be - almost everything is now configurable, often with overridable defaults if applicable:

- naming format and auto-incrementation scheme of survey stations;
- map units (length, angle, and slope 0 reference);
- handling of reverse headings and slopes (backsights);
- handling of gallery dimensions;
- handling of unsaved data;
- handling of duplicate and incomplete shots;
- hardware button use.

Since our caving group did not have Martin's sensor box, still in prototype state up to this day, I concentrated on the manual input side. But our need was broader than Martin's single input approach: we had to survey a complex cave system with several simultaneous teams, possibly with different instruments (e.g. metric tape in small passages and Topofil in collectors) using different measurement units (e.g. a Topofil counting in centimetres) and bearing different calibrations. Of course, we would have to merge all this data once back at camp.

Mixing Instruments Thanks to Sessions

This ability to mix heterogeneous data was made possible with the addition of sessions, a concept already present in some Windows/Mac OS cave survey software. Each survey shot now belongs to a session, i.e. an abstract time period (its actual duration is left up to the user) during which survey shots are taken. Each survey session consists of two sets of instruments, calibrations, measurement units, and some default settings (see screenshots in Figure 2). The data read from the instruments can then be input "as is" into Auriga; the surveyor is not bothered by the broken beginning of his metric tape, the magnetic deviation, or the compass shift since the session takes care of these. When computations are performed, Auriga simply uses the proper session settings to interpret the survey data, without altering it. In this respect, Auriga is as faithful as a paper notebook.



Figure 2: Session settings screens: calibrating instrument sets and shot settings.

Tight Storage

Despite an effort to squeeze as much survey information as possible into the meagre 52 bytes used for each survey shot record in the Auriga cave databases, limits are few. Length, heading, slopes, and reverse headings and slopes are each stored with two-decimal precision as 16-bit integers, i.e. in hundredths of units. Survey shot length is thus “limited” to 635.55 meters (or feet, depending on user choice), an uncommon span in caves. In addition, a note of up to 255 characters (bytes) can be appended to each survey shot and session record, and to the cave database as a whole. Auriga cave databases can hold up to a maximum of 16 384 records (one per survey shot or session), a Palm OS limit.

Managing Galleries

Survey stations can be named with up to 8 characters, with user control over the permitted character set (numeric, alphanumeric, punctuation, etc.) The user can choose between a 4.4 format (e.g. "2.6" or "A31.74") and an 8-character free format (e.g. "Cascade", "X24-46b"). Both formats allow the use of series, a concept inspired by Toporobot. A series is simply a suite of survey stations and shots sharing a common root (like "A2.0", "A2.2" and "A2.31b") which can be acted upon collectively. As series are usually, and appropriately, made equivalent to galleries, their use allows users to selectively hide galleries from a crowded cave map, distinctively colourize them in the map, exclude surface shots from total cave development, select the projection direction of a gallery in the projected cross-section cave map view, or just navigate between galleries when reviewing survey shots. The sole prerequisite for series is to have a “series-beginning survey shot”, i.e. a virtual survey shot linking the series-beginning virtual station to the rest of the cave (or to itself, if it represents the cave entrance). The series-beginning station must bear the smallest station number within the series (e.g. station 2.3 cannot be the beginning station of series 2 if there exists a physical station 2.1). Since series-beginning shots are virtual (zero-length) shots, the unused shot data storage space in their database record can instead hold a geographic location (like the UTM co-ordinates of the cave entrance) or an absolute XYZ coordinate - a convenient feature when working with cave subsets.

Sharing the Data

If several teams are let loose surveying a cave, conflicts are to be expected (...) with regard to station names or session numbers. To circumvent these, Auriga offers various maintenance functions to rename or shift station names or series numbers, renumber or merge sessions, or move survey shots to another session. Ideally, teams should harmonize their data before merging it, in order to minimize tedious subsequent clean-ups.

Two mechanisms allow sharing survey data between teams: infrared (IR) beaming and the Palm HotSync process.

IR beaming is the common device-to-device Palm OS data sharing mode. Auriga can send a whole cave database, or a subset of it, to another device. In the latter case, every survey shot sent is accompanied by its corresponding session, so as to make the beamed data complete by itself. If the cave database does not already exist on the target device, it is created and filled with the beamed data. Otherwise, a record-by-record merge process is triggered. Similar but different survey shot or session records are duplicated and logged into a text memo for subsequent clean-up by the user. Otherwise, if the beamed records contain a note or gallery dimensions and the target device does not have this information, while the rest of the record is the same, records on the target device are simply updated with this additional information.

The HotSync process takes place on the target PC (or Mac) through a conduit launched by the Hotsync Manager. This process of synchronizing the Auriga cave databases with those present on the PC is a more complex process than IR beaming, for two reasons: it runs between heterogeneous databases (Auriga and non-Auriga) and it is a bidirectional process (insertions, deletions and modifications must be reflected on both sides).

It is highly unlikely that another PC cave survey software would have its internal data format match Auriga databases field for field. Some software recognize sessions, some don't; and the same goes for series, reverse measurements, mixed direct and reverse shots, mixed measurement units, gallery dimensions, etc. Thus, in order to transfer the Auriga survey data to the desktop software, the conduit may have to adapt this data to a format the target software can understand. This can mean merging the session calibration with shot data, removing series-beginning virtual shots, inverting reverse shots to make them all forward, etc. In the process, some information could be lost. To prevent this information loss, the conduit performs a two-phase sync: the Auriga data received through the HotSync manager is first stored into a mirror database on the PC before being adapted for the target software. This way, if the survey data is modified via the PC software, thus requiring a transfer back to Auriga (data consistency between the PC and the Palm must be maintained if further Auriga surveying is to take place in that cave), the conduit can fetch from the mirror database the previously dropped data and re-attach it back to the synced records before writing them into the Auriga database. Of course, the extent of this data removal and recovery depends on the target software, some being more restrictive than others. The Auriga conduit structure supports both the usual single user mode and a multiple user mode where several users can collectively sync their data with the same cave database; this choice is made within Auriga when creating a new cave database.

The first prototype Auriga conduit, developed by Chris Chénier, shared data with Éric David's Visual Topo. Chris is now focusing on a uni-directional conduit towards Compass, before implementing bi-directionality. Once completed, the general Auriga conduit architecture should be set up so as to make other conduits easier and faster to write. In order to be able to develop Auriga conduits for both the Windows and Mac OS platforms with as little code port as possible, Chris chose to use an ODBC mirror database, implemented with MS-Access under Windows. Alas, there seems to be no free ODBC database manager under Mac OS.

Surveying with Auriga

Auriga can be used as:

- an electronic notebook to store numeric survey data and instantly view the cave map whilst in the cave;
- a scientific calculator to convert survey shots into Cartesian coordinates whilst at camp;
- an input device to transfer survey data from the paper notebook to the PC without wasting battery power.

It is likely that the most common use for Auriga will be to input survey data while in the cave. But carrying a Palm underground? Once you accept that you must treat a device as fragile as a Palm (compasses are also fragile) with proper care, it is no problem. In easier caves, wrapping the Palm in a Ziploc bag and carrying it inside the survey notebook (still required for sketching) may be sufficient. Otherwise, Armor makes, for US\$ 49, a watertight box with a write-through film on the front to allow one to use the Palm without opening the box (see Figure 3). This box was used for my own field testing, and Auriga was improved accordingly to ease data input, up to the point where the usual stylus is not required any more: a field-aware self-adaptive custom alphanumeric keypad with finger-tappable keys was developed for navigation between fields and survey data input (see Figure 4).

A configurable input Assistant (Figure 5) further increases the user-friendliness of the whole input process by automatically creating survey shots based on the previous one, auto-incrementing station names (with both digits and letters), popping-up the custom keypad when necessary, preventing mishaps that could result in data loss and even turning off the device after the shot was saved! Combined with the use of the hardware application buttons, Auriga really lets your fingers do the tapping.



Figure 3: Using Auriga to input survey data underground.



Figure 4: Field data and keypad screens.

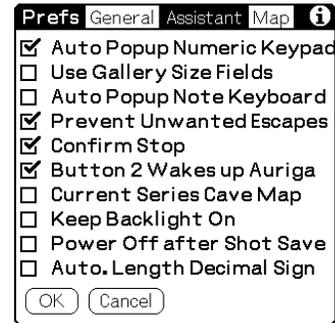


Figure 5: Input Assistant configuration screen.

A typical fully assisted data input sequence goes like this:

- start the Assistant mode by tapping its pushbutton in the Survey Shot form,
 - a new survey shot gets automatically created,
 - the custom numeric keypad pops up;
- finger-tap in the survey data, changing fields with the arrow keys;
- when the last numeric field is input, the custom numeric keypad changes to an alphabetic layout to edit the survey shot note;
- edit the note and finger-tap the OK button;
- hit the To Do hardware button to save the survey shot;
 - a new survey shot gets automatically created with incremented station numbers,
 - the Palm turns itself off (turn it back on again when ready to input the next shot by hitting the Address Book button).

Computing the Cave

Auriga performs, automatically and on demand, all the computations required in order to display the cave map and essential statistics (Figure 6). In order to handle every possible survey shot arrangement beyond those originally supported in Martin's version (like multiple shots leaving from or arriving at a station) and to pave the way for a future loop closure algorithm, a full-blown non-oriented graph is now internally constructed to represent survey stations (nodes) and survey shots (vertices) between them. An iterative algorithm scans in alternating directions the list of survey shots in the cave database to compute XYZ Cartesian station locations relative to the origin.

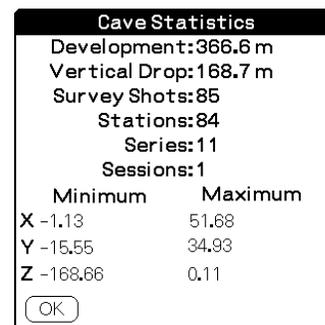


Figure 6: Survey statistics summary screen.

Any station can be manually selected as the Cartesian origin (0,0,0) of the cave, or as a point with a known fixed offset from this absolute origin. If the cave does not have a determined origin, the computation process chooses the first survey station (sorted in alphanumeric order) as the origin and assumes a null offset. It is also possible to assign a pre-determined XYZ co-ordinate to a series-beginning (presumably computed somewhere else), thus allowing the computation of "real" co-ordinates from a cave subset that does not include the cave origin.

Likewise, any series-beginning station can be manually selected as the geographic reference for the cave; if this station corresponds to a series-beginning to which a geographic position was assigned (UTM or latitude-longitude, with or without altitude), the geographic location of any other survey station displayed in the cave map can then be queried for its geographic location!

Viewing the Cave

The cave map display, with full pan and zoom capability and ability to graphically poke stations (with survey shot note) was already present in the original Auriga, but its user-friendliness has been enhanced since then (see Figure 7). Apart from new drop-down lists instead of single-letter buttons to select the map view (top view and S-N, W-E, developed and projected cross-section views) and stylus mode (zoom, pan, info or line), hardware buttons can now be used to navigate between galleries or pan and zoom the map, depending on stylus mode. Additionally, all survey stations linked to another station (selected with the stylus) can be cycled through with the push of a hardware button. But the most interesting new feature is probably the ability to get the orientation of a gallery, the inclination of a slope, or the distance between two points by dragging a line with the stylus. Orientation angles obtained through this feature are automatically copied to the clipboard to allow quick pasting into the projection angle selection dialogue.

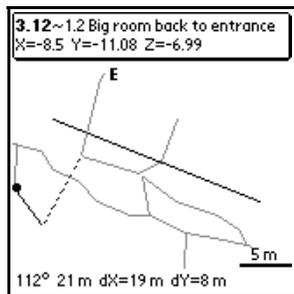


Figure 7: Poking the Cave map display screen to obtain distance and angular information.

The cave map is probably the most compelling feature to use Auriga underground: surveying with Auriga allows cavers to see the cave map whilst the cave is being surveyed. Not only can survey errors be detected faster, but it can orient the exploration process: by knowing right away where the cave is heading to, surveyors can decide which way to take or which gallery to survey in priority. If a junction is expected, Auriga can let cavers know how close they are from the other gallery and eventually keep hope... Actually, Auriga could become an incentive to survey while exploring, a good practice in every respect!

And, thanks to Markus Dresch/PalmSide's free right of use of his XPrint Library granted to Auriga, this map can now be sent, right from the Palm, to various PCL, ESC or Postscript-enabled printers via a serial, infrared or Bluetooth link.

What's Next?

The next feature to be implemented should be spreadsheet-like displays of survey shots and survey station co-ordinates, to provide surveyors with the co-ordinate data required to draw their cave maps on paper whilst at camp. This may, in turn, prompt the implementation of the anticipated loop closure algorithm.

On the nice-to-have-at-camp feature list is the cave system concept, where several caves can be logically linked and geographically positioned on a common display. This feature would take advantage of the recent implementation of the persistence of computed XYZ co-ordinates on the device for faster cave map redraws.

Other minor improvements include theodolite and depth meter logic (to handle cave diving survey data), better statistics etc. Of course, the release of a first public beta this Autumn may prompt unforeseen new demands.

Meanwhile, the rising activity in the field of electronic data acquisition may well push Auriga into looping the loop by re-activating its serial link with sensor boxes. This would give Auriga a great boost: cavers may be reluctant to bring a Palm underground just to add features to their classic notebook, but the prospect of affordable electronic cave surveying may well become irresistible. Martin Melzer's article in the current issue of the CREG journal [1] considers the options for building such an electronic surveying instrument, and describes his work to date.

The ultimate future addition to Auriga will be the ability to sketch the cave walls directly onto the Palm screen. This may sound like a heresy to purists, but a full screen of drawing space for every single survey shot on a grid displaying that shot, in scale with the surveyor's own visual perception, would possibly lead to better sketches. This feature would definitely render the paper notebook useless, while allowing cavers to come back to the surface with an almost finished cave map. But the complexities of this feature, with regards to curve handling, storage and conduit syncing could be the topic of an article by itself.

Trying Auriga

The software can be downloaded from the Auriga homepage [2], along with sample caves and a complete user manual. Do read the manual at least once. Auriga is not complicated, but complex; the manual should give you a good understanding of the underlying concepts and may help you discover features that are not immediately obvious in the user interface.

If you do not have access to a Palm OS device, you can nonetheless try the software under a free Windows-based emulator. Get the details at the Auriga homepage [2].

Luc Le Blanc is president of the Société québécoise de spéléologie.

References

- [1] Melzer, M. (2003). How to design an electronic surveying instrument, *Cave Radio and Electronics Group Journal*, 54, 12-15.
- [2] Auriga home page, online at: <http://www.speleo.qc.ca/auriga> [accessed Nov. 2003]