Surveying software

The thought processes behind survey management systems

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LEVELLING has always been a very important activity in surveying. Before the advent of digital levels and software, it could be a very challenging task. This is especially so in subsidence monitoring, where utmost care is taken in data capture and processing. It was common to spend weeks carrying out a survey of a network of monitoring points and as much time in processing, computing and presenting the results. However, if subsidence is observed, it would become necessary to increase the frequency of monitoring. At this point, crisis and chaos may set in as the survey organisation may be overstretched in manpower to cope with such increase in frequency.

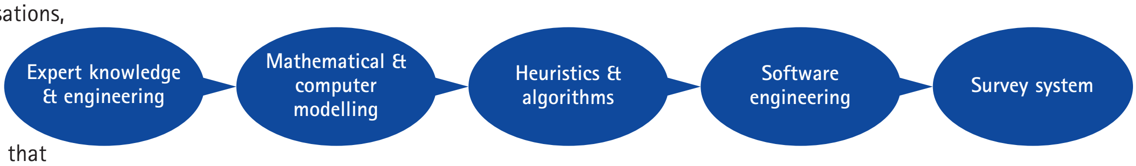
Even in large organisations, pressure and haste add to errors and there is always a backlog of reports to present. It is against this background that in the mid 1990s, Windows based survey measurement systems were designed. My own, the Level Monitoring System, became part of my successful presentation to the Royal Institution of Chartered Surveyors for my assessment of professional competence. In the course of time, many survey measurement systems developed and rebranded to reflect new functions, including 2D/3D traverse, earthwork quantities and land records.

Methodology

In computer science, an expert system is a software solution that acts as the mind of a human expert in a given field and so is able to make complex decisions as would a professional. It is usually defined with respect to specific domains, and examples include wizards/assistants in many packages and the more complex application of robots in industries. Also, in the medical field, in the areas of diagnostics and surgery, such applications are common. In the case of survey measurement systems, they may be described as expert software for level monitoring.

Surveying often involves subjective judgment and decision making, both in the field and office. As a result, a purely algorithmic approach to modelling solutions can lead to inflexible and rigid situations. There have been many times when surveyors would return from field only to realise that direct input of data into a computer system is not possible. This could occur for a number of reasons; a change in modality, for example, and thus inability to follow survey strategy and topology. However, the surveyor would eventually sort out this work manually and arrive at an acceptable result. And if the task can be done manually, it can also be handled by software. That requires introducing heuristics – intuition – to survey algorithms in order to equip survey systems with artificial intelligence.

Against this background, the methodology in development starts with acquisition of survey expertise in order to provide the requisite knowledge engineering. It is followed by mathematical and computer models that represent expert descriptions. Sound heuristics and algorithms then ensure a working expert system.



The methodology behind survey measurement systems.

Data structures

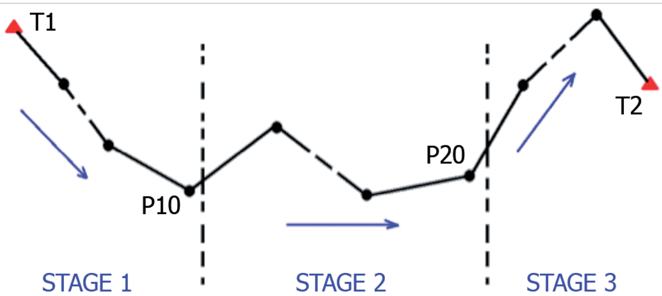
A key component in the design of survey measurement systems is object oriented programming. It allows data encapsulation and polymorphism. Survey observations are therefore attributes in object classes with member functions. The base class definitions provide foundations for subsequent child objects in the hierarchy.

A fundamental data structure is the defined data type, setup_obj. This structure holds all the observations for each level setup. By design, a setup_obj comprises core data, a head and a tail, with imaginary positive and negative poles respectively. These poles are pointers respectively for backsight and foresight stations. One can then visualise all such observations in a raw data file, in observed or random order. However, once the raw data is downloaded into the fieldbook, most programs can realign member functions and sort data into survey topology.

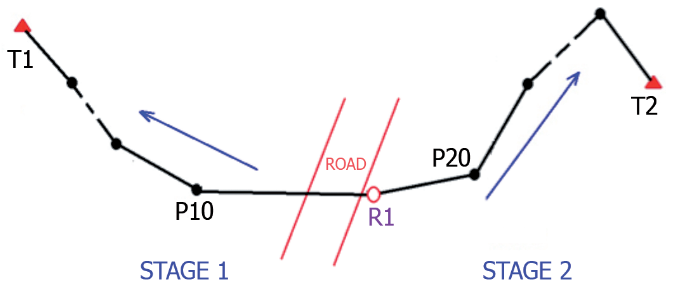
By virtue of these designs, a survey can start in any order and end at any point in a network. What is required is that every station has a unique identity, by unique numbering, and that the network is comprehensively observed to include at least one known and fixed station.

Resection

Surveyors often employ resection in theodolite work to get out of tight situations. This utility is so valuable that it is a standard function in total stations. The same concept could be applied in levelling to assist productivity.



The survey project may be divided into sections, each assigned to a survey party. Software can make it easier for each party to proceed at its own pace, complete work and download to the office.



Suppose that two survey parties arrive at R1 in the diagram below to carry out a survey, T1-T2. It may be advisable to commence work forthwith, from R1-T1 and R1-T2, in order to complete within the available daylight. Otherwise, by the time the surveyor arrives to take position at T1, bad light or bad weather may have set in. In computation, R1 is evaluated in a least squares routine so that the two stages can compute as normal. The results would be identical for the same readings as if observed from T1-T2. In other words, the result of a survey is not affected by direction of observations.

Processing

An important aspect of any processing is error analysis. This is provided in survey management systems by closures for every cycle or loop in the network. Actually, these cycles are expressions of condition equations. Historically, one needed to have a diagram of the network to be in a position to form such equations. And even with diagrams, it is an exercise that is fraught with difficulties. Many surveyors do not even contemplate such an exercise in a dynamic environment, except for a very small and well defined network.

Robust algorithms are employed to evaluate all the condition equations in a network. This information enables surveyors to isolate any loop or set of observations for resurvey. It is an asset that has proved very useful in a client's work of more than 3,000 setups of observations and about 200 loops. Within this large data set, it was possible to isolate errors to a few datasets and determine that they result from station numbering. Note that loops do not include double-levelled setups. These are normally resolved in one direction, as would be done manually.

Overall, the combination of condition and observation equations ensures that error information is available with respect to consistency in the network and also the co-variance of surveyed stations.

Computation

Users of survey management systems describe computations as bundle adjustment. That's drawing some analogy with methods of aero-triangulation in photogrammetry. However, this description refers to the automated nature of level computations. It used to be the case that nodes are abstracted from data sets based on a network diagram. Then height differences are reduced and the nodes computed by least squares estimation. It is then followed by inter-node computations and error distribution. The third stage is to compute the height for all intermediate sights from each reference station. On the whole, this is obviously a fractured process that is prone to errors. The result is that, in many organisations, survey work involving large level networks is inconclusive, even after weeks of processing and computation. These problems can be overcome by performing three computations simultaneously:

- Network adjustment by iterative method of least squares.
- Inter-node computations.
- Intermediate sight computations.

The results are generated with error information, statistics and graphic drawing of profiles for each level run in the network. By these techniques, surveyors can resolve networks of any complexity, including the confidence to revalue fixed stations.

Monitoring

Once data computation is complete, this information is available for monitoring in 1 to 3 dimensions. The registration of each epoch is automatic and also dynamic, meaning that once a date is changed in the header file, it takes effect immediately. It is common in some organisations to rely on spreadsheets and word processors to present reports. This, however, requires manually creating and managing such database files. It is also inefficient because if the survey is recomputed, the exercise is repeated. Furthermore, where stations are lost or new points added in the construction environment, the cumulative changes would also have to be done manually. In other words, the elements of automated judgment of likely human decisions are missing. There is also the limitation in charting monitoring results. Survey management systems provide customised and optimal options such that the duration of any project is the period of field activity.

Results

Results are important in presenting reports on monitoring exercises. They need to be comprehensive with precise information. This includes tables, graphic illustration of movements and statistical analysis. Hard copies also need to be available for records by direct printing of tables and charts.

Conclusion

Survey management systems are comprehensive packages that have been growing in order to attend to the industry's requirements. The success of the packages lays a foundation for future software developments. By adopting the technique of domain expertise and knowledge processing, many otherwise intractable problems would have a solution. And this, in line with current trends in technology, is the way forward.

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Results presented in 1 dimension.