TERRAIN MODELLING USING AUTOCAD

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Abstract
This paper describes the use of a widely-used CAD drafting system, in conjunction with a specialist contouring package, to provide a low-cost facility for terrain modelling, volumetric calculation, and landscape visualisation.

One such system is in use at the Department of Architecture & Landscape, Manchester Polytechnic, to enable graduate students on the Landscape Design course to explore the visual and quantitative implications of design proposals, particularly when related to large scale landscape modelling.

It is also in commercial use by professional surveyors, waste management contractors, local authorities etc.

In addition to AUTOCAD, two further packages are employed, one to recover coordinates from existing AUTOCAD drawings, and the other to generate contours and volumes from those, or other coordinate data files. The first known as BADGER (Basic Autocad Data Grabber & Exchange Routine), and the other is SURVCAD CONTOURS - a contouring program capable of converting large coordinate data files (2500 + points) to a 2.5D terrain model.

Educational Objectives

The educational objectives of using the system is to provide the students of the Architecture and Landscape Departments with the following:

Experience in using a CAD drafting system

Familiarity with modern surveying techniques (EDM)

The use of a simple to use volumetric package

A facility to create 3D terrain models

Bearing in mind the limited availability of hardware, the majority of students utilising the system are third year, or above. Because their project time is limited, and resources scarce, it is imperative that both the drafting system, and the supporting contouring software, is quickly and easily learned, whilst at the same time providing the power required for evaluating large scale proposals.

AUTOCAD is not the only drafting system available to the students of the Department, but it is inarguably the one most quickly assimilated, and will typically become useful to a 'first-time' user after about eight hours of basic tuition. SURVCAD likewise, demands little user interaction, other than to define the name of the data file, and the contour interval required. Teaching experience has shown that a first time user can be taught to use the EDM and logger, and the two software packages referred to, in under three days.

PROCEDURE FOR CREATING A TERRAIN MODEL

Data Collection

There are two options for data collection. The first is by conventional modern survey techniques using an EDM or 'total station', and the second is by digitising an existing Ordnance Survey map, or similar, into the drafting system. (Fig 1)

The first method demands the availability of an EDM and data logger, plus the appropriate software to convert the site readings to cartesian coordinates -more generally referred to as Eastings and Northings. These coordinates are subsequently converted, by the SURVCAD software, to a 2.5D contour map of the site, and written to a disk file in DXF format suitable for import into AUTOCAD, either as a finished drawing, or as an addition to a previously generated one. The advantage of this method is that there is no loss of accuracy - the original measured data is converted directly to a drawing with no intermediate 'fudging'. The primary disadvantage is the cost of the EDM 'front end' except, perhaps, for the professional surveying company.

The second method requires that a scale drawing of the area under consideration is 'digitised' into the drafting system, and assigned the necessary 'spot heights' at intervals determined by the surveyor. Typically, the boundary profile of the site is identified by placing a series of 'Points', each with the appropriate elevation, along the perimeter. Other levels within the site can also be identified by this method, or if existing contour levels are shown, these too can be digitised into the drawing. The existing layout is first output to DXF format, and the BADGER software is then run to extract all the coordinate and level data. Once the raw data has been obtained, SURVCAD can be used as before.

This alternative technique is generally more approximate for estimating purposes, because the limited quantity of data provides a less finely tuned terrain model than that obtained by the first method. The advantage of this technique is that it neither demands the availability of the EDM, nor does it require the exhaustive survey implicit in the first example. Nevertheless, the opportunities for 'quick-fire' volumetric measurement, for the purposes of tipping or mining, cannot be underestimated.
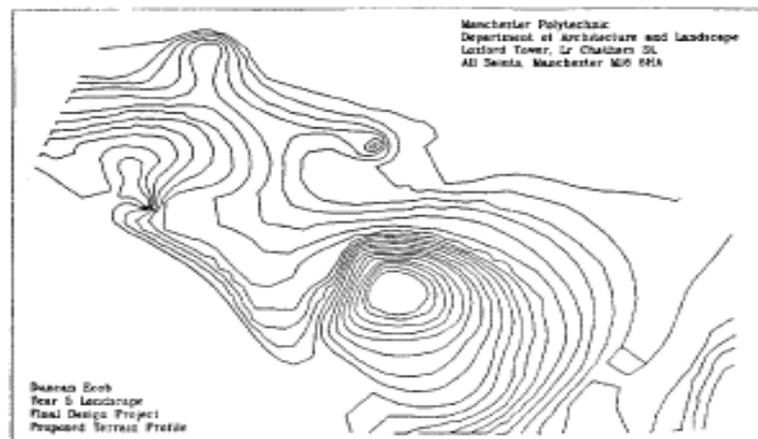
OUTPUT

Both methods terminate in the production of volumes, contours and, if required, a triangulation map of the area under consideration. The volumes may be quantified in relation to a user defined datum, for example, earthwork volumes above 85.60. Contours may be generated for any interval down to a minimum of 100mm, and will be written to a DXF file for later import into the drawing. The triangulation map may also be output in DXF format. Contours, triangulation and text are assigned to different 'layers' and so will not interfere with any other data resident in the drawing into which it may be imported. Once in AUTOCAD, the resulting picture may be viewed either in plan, or by using the VPOINT function. Use of the latter will provide a simple 3D view of the terrain, with the contours appearing as 'slices' of the appropriate height .

INTERACTION

The terrain models generated by the EDM and logger tend to be more complex, and are therefore used primarily as 'passive' 3D site models. Manipulation is normally restricted to obtaining the best 'views' for subsequent design work, or for record purposes. Nevertheless, it is possible, providing the existing terrain profile is altered within the drafting system, to re-calculate the earthworks by outputting a DXF file of the proposal and then running the conversion and contouring modules as described earlier.

The simpler method, using the digitising technique, lends itself more readily to 'back and forth' interaction. Typically, after the existing volumes have been established, the designer will develop one or more proposals and evaluate each both visually and quantitatively, by passing them out for re-contouring and remeasurement. In one recent case, the designer wanted to input his finished proposals, not so much for a volumetric appraisal, but to confirm that his contour proposals produced the terrain model that his design intended.

CAPACITY

The contouring program, SURVCAD, has a capacity in excess of 3500 data points, almost eight times as many as the original contouring package first used by the Department. Although the biggest project run to date, by a commercial company, consisted of around 2500 data points, the DXF output file created exceeded 1.7mB, but successfully loaded into AUTOCAD on the first attempt. Many other systems, nominally capable of DXF import, will fail to load files exceeding 64K in size. It is therefore important to remember that the large amounts of data generated by contour models demand effective file import facilities.

Time is also an important issue when dealing with contouring software, because some packages take hours to run a relatively small data file. Such a situation would preclude any meaningful interaction - particularly in the design development situation. On a 'standard' PC or 'clone', SURVCAD will produce a contour map from a 1000 point data file in approximately 15 minutes. Machines with 286 or 386 processors will reduce this time considerably.

LOGISTICAL PROBLEMS

Hard Disk Space

For a terrain modelling project to be of any educational value, a number of different alternatives require to be generated and evaluated. This leads to a multiplicity of files residing on the system/s, and for each ground model there has to exist:

1. A drawing file of the proposed contours

2. A DXF(Drawing Exchange File) of the above

3. A Coordinate Data file of the ground model

4. A triangulation DXF input file (optional)

5. A contoured DXF input file (after volume calcs)

The size of the files will vary, depending on the level of detail included, but for a typical post-graduate project, at least one megabyte of disk space will be required for each alternative proposal.

File Size

There is a close correlation between the size of the survey data file (whether digitised or surveyed) and the resulting DXF drawing conversion file. As a general rule, one thousand data points will convert to one megabyte of DXF file, two thousand points will yield two megabytes of DXF file.. and so on. These figures are based on contours at one metre intervals, smaller intervals will generate larger DXF files.

Once the DXF file has been converted into a drawing it may be removed. The resulting drawing will then occupy about one third of the DXF filespace. If several projects are 'live' on any system, it is essential that the large DXF files are removed as soon as possible.

DXF File Compatibility

The discussion so far has assumed that the drafting software into which DXF files are to be loaded, is AUTOCAD Release 2.6 to 2.9. Other drafting systems, such as ROBOCAD, PC-DOGS etc can often be used as an alternative. In such cases, however, there may be difficulties in loading the large DXF files, or certain linetypes, recognisable to one system but ignored by another.

Processor Power

Although the DXF files can be generated on 8086 based PC/XT's, the time taken is approximately four times greater than on a 80286 based PC-AT. The availability of a co-processor, an optional requirement for the SURVCAD software, is essential for running AUTOCAD and most other CAD drafting packages.

EDUCATIONAL BENEFITS

What benefits then are to be derived from introducing this type of project in a School of Architecture & Landscape?

First of all, for both Architecture and Landscape students, the project provides a composite 'package' consisting of a number of different activities, and which can be carried out within a limited timescale - usually 4 to 6 weeks. In some instances, the initial project is extended to encompass a more detailed one later in the term.

The project commences with a site survey which uses the EDM (Electronic Distance Meter or 'Total Station') and data recording equipment, and is designed to familiarise students with the techniques for obtaining terrain data. Most of them will already be familiar with some other traditional survey techniques and are therefore able to compare the relative speed of data acquisition between the two methods. Providing the weather stays fine, the fieldwork module is a popular alternative to working within the Department!

Once the data has been collected, it is processed, and the students shown how to load and manipulate the various files. Some of the architecture students may already be familiar with the drafting system, but the landscape students require a short introduction. Fortunately, the conversion and manipulation of the models does not rely on an extensive knowledge of other aspects of computer drafting, and an ability to digitise drawings is generally all that is required.
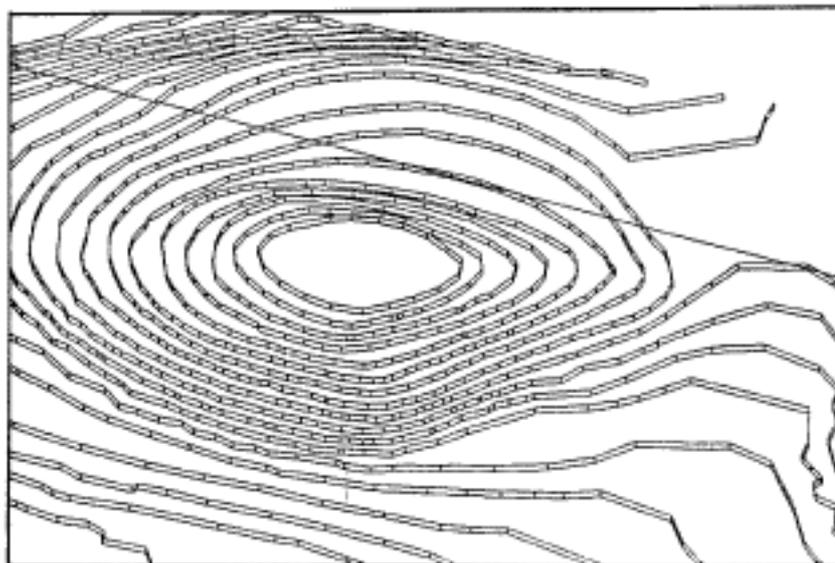
When the model has been entered into the system, and evaluation begins, the benefits become more apparent. Generally speaking, the landscape students discover that their proposals, when viewed in 3D, turn out to be far less dramatic than they envisaged, whilst the volumes of cut or fill seem to be much greater than even the most pessimistic estimate! Time permitting, a great deal of further interaction takes place at this stage.

The ability to generate accurate perspectives of landscaping proposals is beginning to affect the way in which projects are presented. Architecture students were already aware of the benefits of 3D visualisation, but the earlier difficulties of entering terrain data had discouraged all but the most determined landscape student from emulating their colleagues in the architecture school. Now, as a result of these projects, a much better appreciation of their design proposals can be gained by students of the landscape school.
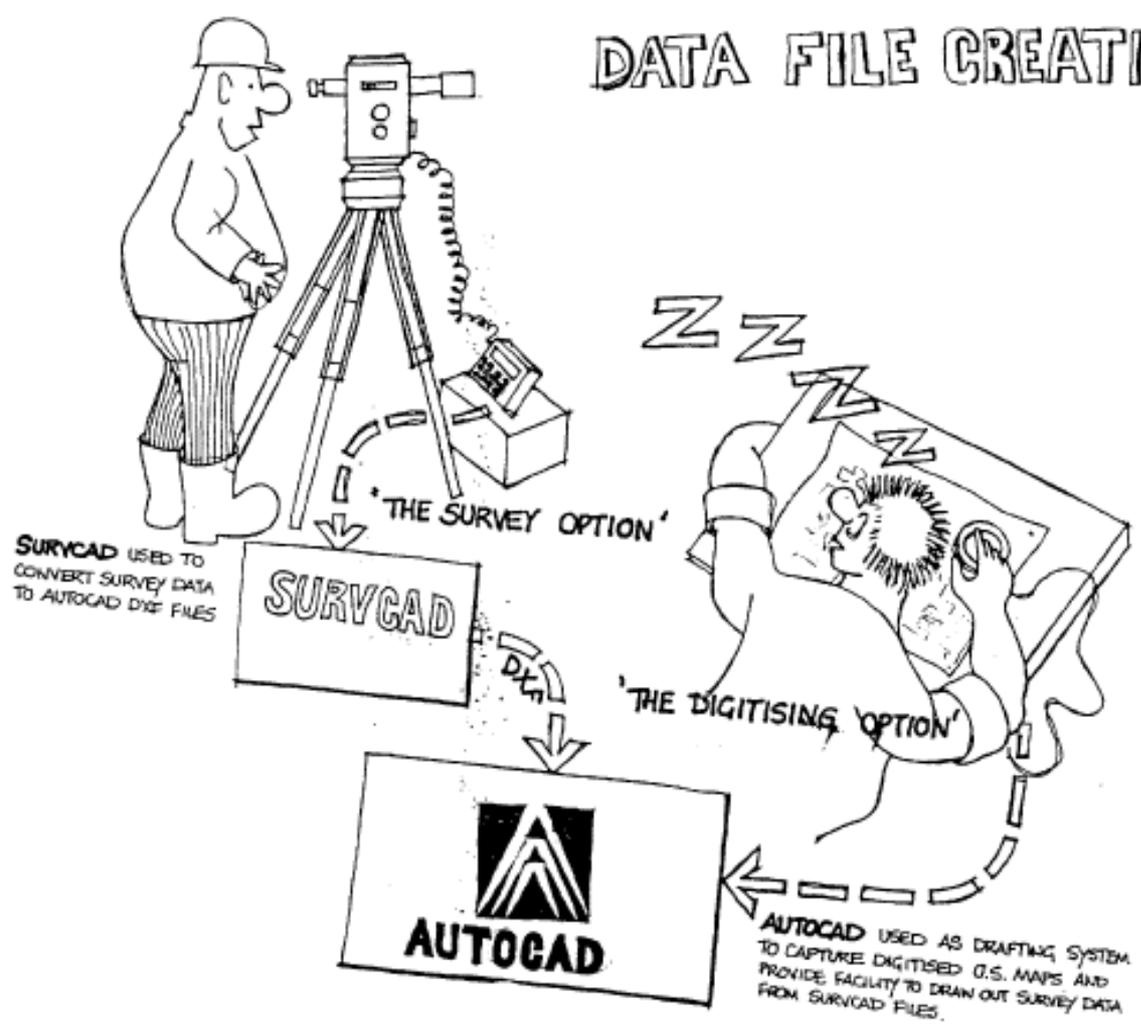
FUTURE DEVELOPMENTS

Until recently, we have been running AUTOCAD 2.6, which is limited in its 3D capabilities. Within the last few months we have upgraded to AUTOCAD Release 10, which now provides full 3D input and perspective drawing facilities.

Some work has already been carried out on the SURVCAD contouring software in order to alter the DXF structure to comply with the new format. Essentially, this will mean that the 2D triangulation diagram will become a 3-dimensional mesh, capable of being shaded and viewed in 3D Likewise, the contour 'slices' can be displayed as surface meshes

DATA FILE CREATION

'THE SURVEY OPTION'

SURVCAD USED TO CONVERT SURVEY DATA TO AUTOCAD DXF FILES

SURVCAD

'THE DIGITISING OPTION'

AUTOCAD

AUTOCAD USED AS DRAFTING SYSTEM TO CAPTURE DIGITISED O.S. MAPS AND PROVIDE FACILITY TO DRAW OUT SURVEY DATA FROM SURVCAD FILES.

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