Modelling the cityscape with geometry engines

T W Maver

This paper records an experiment in using an advanced colour graphics workstation, in conjunction with existing visualization software, to model the city centre of Glasgow. The 'geometry engines' of the workstation allow the user of the system to change the viewing parameters dynamically and thus to simulate a 'walk-round' or 'fly-through' quite large data sets. The workstation had video output and it is difficult to communicate the potential of this system in any other medium; hard copy is reproduced in the paper mainly to give the reader some impression of the scale at which it is now possible to work.

computing technology, graphics workstation, visualization

In the UK, as in a number of other developed countries, the urban environment is presenting architects, planners and development agencies with some of the most significant and intractable problems facing them in the last decade of the 20th century. The problems are most chronic in those cities which rose to greatness at the height of the industrial revolution; as heavy industry has declined, industrial sites have become derelict, the working population has drifted away and housing has fallen below tolerable standards. Yet in most cases, much evidence of urban greatness remains – in the grandeur of the public buildings, in the scale of the cityscape and in the spirit of those who still have their homes and educate their children in the inner city.

To date, developments in CAD have offered little to those concerned with the wicked problems of design and planning at an urban scale. Major investment in software development has centred on:

- documentation rather than design
  - drafting systems – intended to increase the efficiency of documentation production at the detailed stages of design – are now ubiquitous; decent design systems – intended to improve the quality of the built environment – are scarcer than gold dust
- individual buildings at the expense of urban design
  - given the emphasis in CAD on drafting rather than design it is not surprising that issues in urban design have been neglected
- static as opposed to dynamic treatment of form
  - the constraints of affordable computer graphics have reinforced the formally static view of the built environment at the expense of a dynamically changing experience of the urban environment

Some software development has yielded tools appropriate to the needs of the planner and urban designer[1]. The ability to generate perspective views of proposed interventions quickly and easily, and to relate these to the site through photomontage (see Colour Plates 1 and 2) is of significant value; these techniques are already finding favour as objective evidence at planning enquiries.

Nowhere have the techniques for the representation of built form in an urban context been more rigorously developed than by the Interlab team directed by Professor Tee Sasada at the University of Osaka. Interlab, which enjoys a productive working relationship with Japanese TV, has fulfilled commissions to generate 'fly-throughs' of sections of a number of cities: Tokyo, Paris, Osaka and – currently – Shanghai. The impression of 'flying through' the city is created by painstakingly generating by computer a very large number of discrete views of the existing or proposed cityscape. Each view is displayed in turn and committed to a film frame; in effect, the sequence of views is animated on film.

The films and video tapes produced by Tee Sasada and his students are extremely impressive and illustrate the power of merging computer generated images with video or filmed images of the existing urban environment[2]. Obviously, however, each 'fly-through' is prearranged and may or may not be appropriate to the needs of the planner, architect, developer or concerned citizen. If some other sequence of views is desired, it is a case of 'back to the film studio' for a long, painstaking and error-prone animation session.

Recent advances in the technology of computer graphics offer a change in this scenario and hold out the prospect of a truly interactive dynamic interface with whosoever wishes to explore the city – on foot, by bus or by helicopter. In the Spring of 1986 the Abacus Group in the Department of Architecture and Building Science at the University of Strathclyde was invited by the Rutherford and Appleton Laboratories to evaluate the relevance and efficacy of the Silicon Graphics Iris 2400 Colour Graphics Workstation to building design and urban planning. The Iris – similar in computer architecture to the new generation of 32-bit Unix CAD workstations such as those produced by Sun and Whitechapel, which are becoming increasingly common in CAD environments – has, in addition, a number of 'geometry accelerators' which automatically carry out, at great speed, perspective transformations of any 3D data set[3].

Intent on demonstrating the relevance of this technological advance to urban design, Abacus volunteered to build a model of Glasgow city centre within the Iris through which architects, planners, developers and others could 'fly' or 'walk'. Funding from Glasgow Action was sufficient to employ six architectural students over two summer months to capture the geometry of the city centre.

In effect, three databases were constructed: the terrain, the road network and the buildings:

- Glasgow is a hilly city and it was considered necessary to model the topography; this was done by digitizing the contours at 1:10 000 scale over an area of 64 km^2.

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Figure 1. Line perspective of Glasgow city centre generated by Viewer

- The roads, over the central city area of 6 km^2, were digitized as if they existed on one plane; they were then 'floated' down onto the terrain model until they took on the 3D shape of the landform.
- The buildings required, by far and away, the greatest effort. The heights of buildings were obtained from a variety of sources – a recent architectural survey of the merchant city, a physical model owned by Glasgow District Council and the stereoscopic analysis of aerial photographs. These heights were entered onto the 1:1250 scale ordnance maps which were then digitized as 20 separate sections of the city. These 20 files were then 'floated' down onto the terrain and combined to give a database of some 2500 buildings extending over the 6 km^2 of the city centre.

The database of terrain, roads and buildings exist in a format which allows them to be viewed individually and in combination, in wireline or in colour, by the Abacus programs Viewer and Vista. When accessing the database from a conventional graphic terminal the user can generate line perspectives from any chosen viewpoint using Viewer (see Figure 1); these can be displayed on the terminal screen and can be plotted to any scale; with access to a colour terminal, the user can generate shadowed and textured colour perspectives for any hour of the day and any day of the year.

It is the facilities offered by the Iris, however, which put computer graphics truly at the disposal of the urban modeller. Dynamic control of the viewing parameters are effected by the mouse and by the keyboard, individually or in combination; the degree of control can be summarized under three headings: movement, image and viewpath. The three mouse buttons (L = left, R = right, M = middle) allow the following 'eye' movements:

- L = turn left
- M = move forward
- R = turn right
- LM = turn up
- LR = move back
- MR = turn down
- LMR = rotate

The keyboard controls the following movements of the object:

- q = move up
- w = move down
- < = move left
- > = move right
- z = zoom in
- x = zoom out

The image may be viewed in wireline or in surface filled colours; in either case, colours can be attributed to individual bodies within the data set. The thickness of the wireline vectors can be changed and the wireline images can be depth-cued over any range. In surface colour mode, the user can call for surface depth sort and for a horizon line.

Facilities exist to program any viewpath; it is thus possible to explore, interactively, a variety of viewpaths and then program a particular one for video recording.

Video output is possible for 60 Hz and PAL (phase alternation by line) monitors.

Obviously, the degree of dynamic interaction with a database depends on its size. The buildings on the 6 km^2 centre of Glasgow – represented (see Figure 1) as extruded

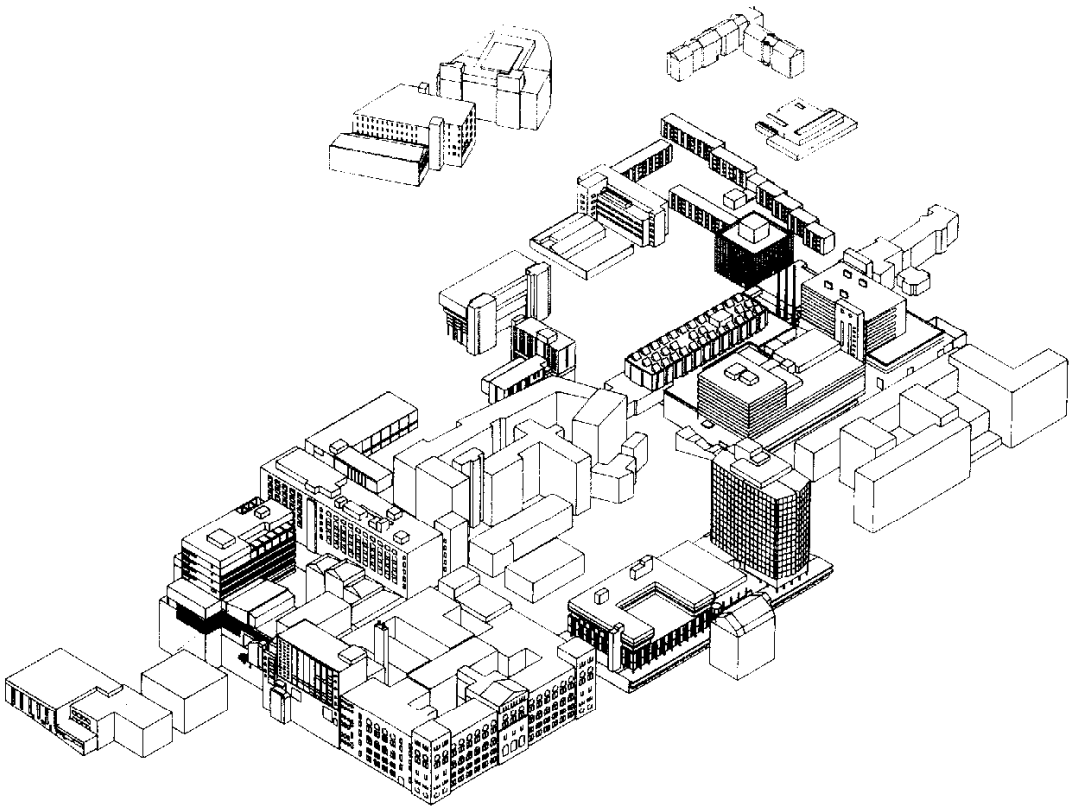

Figure 2. University of Strathclyde campus generated by Viewer

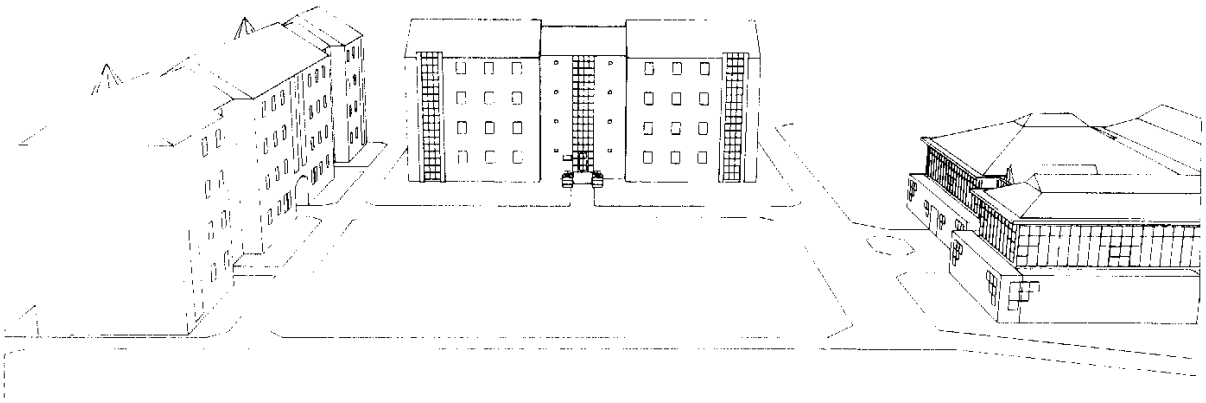

Figure 3. Detail of University of Strathclyde campus represented as extruded planforms

planforms – comprise 2700 bodies, 36 000 vertices and 53 000 edges; a delay of some 4 s is experienced when attempting to 'move through' this database. Reasonably fluent movement is experienced when the database is confined to approximately 1 km^2. Again when the detail of an area is elaborated, as in the case of the Strathclyde University Campus, interaction slows down. The student village within the Campus represents the threshold of complexity compatible with fluent movement on the Iris 2400. Figures 2 and 3 are typical of the elaboration of the original model (Figure 1) which users have already requested.

With the Glasgow Garden Festival scheduled for 1988 and Glasgow being honoured as European Cultural Capital in 1990, demands for extension and elaboration of the existing database can be anticipated. What is not yet clear is the serious use to which architects, planners and developers will put the facility. A crucial development is the link between the geometry database and an expanding alphanumeric database of archive information on the buildings of interest in Glasgow.

By and large, the experiment in modelling the city centre of Glasgow on the Iris has been judged by those who have seen the outcome[4] as a success. If it is a success, then it is due to the Rutherford and Appleton Laboratory, to Glasgow Action and to the students who built the database.

REFERENCES

1 Maver, T W, Purdie, C and Stearn D 'Visual impact analysis – modeliing and viewing the natural and built environment' *Computing and Graphics* Vol 9 No 2 (1985) pp 117–124

2 Sasada, T T Video recordings of the Interlab work in a variety of VCR formats are available (for the cost of the tape and packaging) Osaka University, Suita, Osaka 565, Japan

3 Silicon Graphics Inc *Geometry Partners Directory* Silicon Graphics Inc, 2011 Stierlen Road, Mountain View, CA 94043, USA

4 Abacus 'The Glasgow experience' VHS cassette is available on loan from Abacus, Dept. of Architectur and Building Science, University of Strathclyde, 131 Rottenrow, Glasgow G4 0NG, UK

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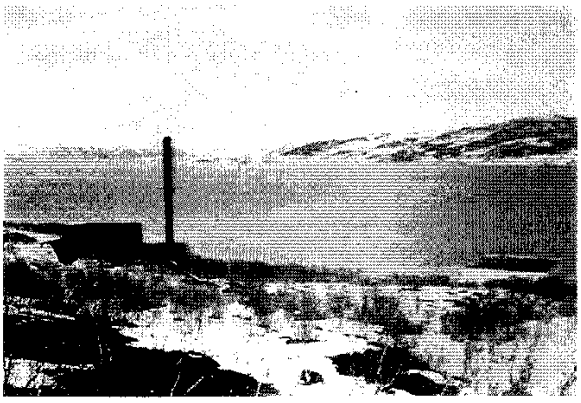
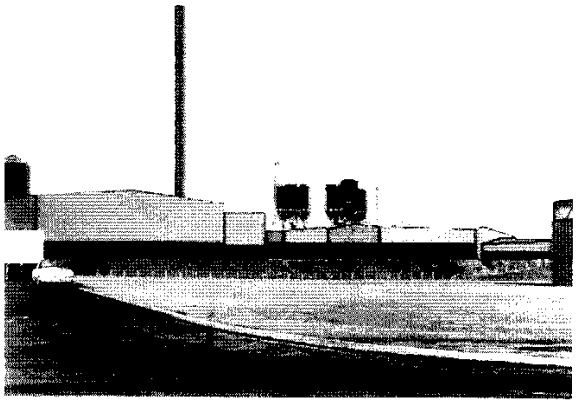


Colour Plate 1. Example of photomontage



Colour Plate 2. Example of photomontage