Modelling the city
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ABSTRACT
This paper describes the construction of a three-dimensional computer model of the City of Bath and its development into an urban information system. The hypermedia application used to structure the underlying database is described and the use of the system to consider issues of planning and conservation discussed.

INTRODUCTION
Over the past ten years or so there has been an increasing public awareness of architectural issues. The pronouncements of the Prince of Wales have given voice to a widely held view that many of the buildings constructed since the war are unsatisfactory in a number of ways. The strongest feelings often have to do with how buildings look and, in particular, how they relate to existing buildings within an historic setting. In Bath, confidence has become so low that the architectural correspondent of the local newspaper, himself an architect, has suggested that the Empire Hotel, an extravagant Victorian building which is totally out of keeping with its surroundings, be retained rather than demolished and replaced. This is not because it has any particular merit, but because of fears, based on past experience, that its replacement would be bound to be worse than the existing building. A classic case of the devil you know being better than the devil you don't.

In most historic towns, including Bath, there is particular concern about how new should relate to old. However, it is very easy for this concern to be expressed with what might be regarded as an over-zealous conservatism where no building more than a hundred years old can be demolished, no matter how inappropriate, and no new building, whatever its function, can be built in anything other than the Georgian style. That is not to say that in certain
locations a building in the Georgian manner might not be justified, but such an approach does not provide a universal solution, even for a city like Bath. Modern buildings are proposed but difficulties are often experienced in understanding what is being intended and in assessing the impact of the proposal on surrounding buildings. There is a desire for public debate but, at the moment, that debate can very easily be constrained by difficulties in understanding what is proposed, often because of problems in reading traditional architectural drawings. Bitter experience has shown that slick draughtsmanship and a carefully contrived perspective view can all too easily fool a planning committee into thinking that a proposal is appropriate only to find, when the building is complete, that it intrudes on its surroundings in ways that were never anticipated. In order to address this problem two things are required, an accurate and easily understood representation of what is being proposed in relation to the city as a whole and a presentation technique which is objective and not completely under the control of the applicant.

As computer based technology is used increasingly for architectural design it is becoming more and more common for architects to produce CAD models of buildings for presentation purposes. These models allow a building to be seen in three dimensions and animation sequences can be set up to show what it would look like when walking down an adjacent street, or even when flying overhead in a helicopter. Useful though these presentations are, they can be as deceptive as their hand-drawn counterparts. Views can be carefully selected and although adjacent buildings are often modelled to show the building in context this is usually done approximately, with the city as a whole represented only in the most general terms.

In order to provide a way of examining the visual impact of proposed changes to Bath, J Sainsbury PLC are funding the construction of a computer model of the entire city at the Centre of Advanced Studies in Architecture, Bath University. This model will be made available to the local authority and when planning permission for a new building is sought the proposal can be included within the urban model and then viewed from anywhere in the city. This will give those concerned about the future of Bath an opportunity to study the implications of the proposal without being constrained by the presentation material submitted by the applicant. They can then engage in a public debate which is properly informed with respect to the implications of what is intended.

Although the initial reason for constructing the urban model was to provide a planning tool, once the model has been created it can be used in a number of other ways. These may be summarised as follows:
• As an index to a variety of types of property-based information on the city.

• As a way of representing social and economic data by mapping it directly onto the topography of the city itself.

• As an educational tool to explain the history of Bath to a general audience.

Each of these can be used to help with the conservation of historic buildings as the availability of relevant and timely information can aid the building owner and the professional consultant when dealing with conservation, maintenance and repair. Increased education can also help when considering the merits of a specific option, or deciding on how to spend scarce resources.

THE THREE-DIMENSIONAL MODEL OF BATH

The 3D model includes the whole of the Georgian city, most commercial and business activities and a considerable portion of the city's residential fabric. Aerial photogrammetry is being employed, based on a survey carried out by Ordnance Survey in 1991, and digitised on an Adam MPS-2 stereo plotter. The model itself is being constructed using AutoCAD with the photogrammetric information being supplemented by surveys of building facades to show architectural detail at a scale equivalent to 1:500. One of the great benefits of using photogrammetry is that fieldwork is kept to a minimum thus allowing the construction of the model to proceed more rapidly than would otherwise be possible.

We have used OS spot heights on 1:1250 maps as control points and each city block is treated as a separate CAD model which is referenced according to the National Grid. Depending on its size and complexity, each block takes about four days for a skilled operator to construct and we have experienced no significant inaccuracies when the blocks are assembled into the complete urban model. Each block is constructed as a wire frame and 3D faces are then added. Windows and doors are included as surface elements for all listed buildings and, with the important monuments full 3D facade models are constructed. In some instances we have even built interior models so that it is possible to move from the street into a building. A 3D terrain model has been constructed which shows the countryside for ten kilometres around Bath to ensure that any view taken from the city centre will include the rural skyline which is so important to Bath's setting.
USING THE MODEL AS AN INDEX TO OTHER INFORMATION

Although the primary purpose of the Sainsbury model is for visual impact assessment, once it exists it can be developed and used in other ways. Cities generate huge quantities of information, much of which relates directly to the physical layout of the city itself. At the moment this information exists, as far as Bath is concerned, in a variety of different places and in a number of different formats. There is information about property condition and housing occupancy, drawings held by the planning department which show the existing and proposed layout of properties, and historical records which include the original architects' drawings. In addition, there are case studies outlining the remedial work that has been carried out to specific properties and information on the constructional techniques used. Our intention is to create an electronic database containing all this information and to link it directly to the model so that the model itself becomes the way of accessing property-based information.

In many ways what we are proposing is similar to a Geographic Information System where spatially related data is organised around a map. Although maps work well in rural and suburban areas, where the density of development is low, they are less appropriate in urban situations where neither the buildings nor the complexities of land use can be shown two-dimensionally without considerable abstraction. By using a 3D model instead of map urban form can be properly represented and it becomes possible to navigate through the information in the way that one moves through a city. The model thus provides a much richer metaphor than is possible through the use of the map. In order to store what are potentially huge quantities of information, held in a variety of formats, we are using a recently developed open hypermedia system, Microcosm. This has been developed at the Department of Electronics and Computer Science at the University of Southampton and can store documents in their native format while allowing a relatively unskilled user to search and access these documents in an extremely flexible way.

When this work is complete the user will be able view the 3D model interactively and then select any building in order to access all the information available on that property. In initial experiments these links were made using AutoCAD's facilities for exporting information about specified elements to external applications. However, the disadvantage of this approach is that one has to be running AutoCAD in order to make the link and, with a large 3D model, there are considerable problems with real-time navigation. An alternative strategy is therefore being developed which will allow the user to carry out rapid pans and zooms around the model without the need for expensive graphics processing hardware. The system being developed has the great advantage that inexpensive machines, using a standard Windows interface, can be utilised with all the data storage and processing being carried out centrally.
THE RELATED HYPERMEDIA APPLICATION - MICRO COSM

Microcosm, (Davis et al¹), (Fountain et al²), is an open hypermedia system designed to allow the user to browse through large bodies of multimedia material by following links from one place to another. It differs from other offerings in that it is an open system, running under Windows, which allows a number of autonomous processes to communicate with one another through a system of link passing. These links exist independently of the documents to which they refer and so there is no mark-up of the kind usually associated with traditional hypermedia applications, such as Hypercard. Rather there is a link database held separately from the material being accessed which contains information about the source anchor, or button, the destination anchor, and any attribute of the link itself.

In most systems the source anchors have to be individually specified but this is not so in Microcosm. Source anchors can be generalised and so a completely new document, which is entered into the system without any mark-up, can have access to all the links that have already been defined for elements within that document. One key feature of Microcosm is that documents can be stored, searched or retrieved in their original format as there is no requirement for data to be formatted in any particular way. Provided there is an appropriate Microcosm viewer, a document can be imported into the system and then accessed directly. Traditional SQL type queries may be used but Microcosm also supports other ways of retrieving information which involve the user in moving from one document to another and, if necessary, making new links as required.

By providing a link service rather than storing documents using its own format Microcosm is rather like a traditional library catalogue, but with some very powerful features. In a library any book can be stored and subsequently accessed, no matter its size or the kind of illustrations it contains, provided some very basic information, such as a title and the author's name, is available. A catalogue search will then bring up the title of the book which can be retrieved for consultation. Microcosm offers an electronic version of this service. However, not only can it search for the title and retrieve the document it can also search for any word, or combination of words within the text. When a new document is entered onto the system, any words in that document which are the subject of links within any other documents will have these links made available automatically. Of course, in this context, the term document is used very loosely and can refer to any kind of digital information.
DEVELOPING AN URBAN INFORMATION SYSTEM

The system that is being developed will concentrate on information relating to the history and conservation of Bath. It will contain all the information required by the planners and conservation architects to manage the city's historic building stock and will include textual information, current and previous planning applications, scanned images of drawings, CAD produced photogrammetric surveys, maps, photographs and historical documents of all kinds. Sound and digital video can also be incorporated if required. The core of the system will be the 3D computer model of the city which will be used as a key index to all the other information within the database. A traditional map will also be indexed to allow the selection of entities using this method, along with addresses and post codes. The model and associated information will constitute a considerable quantity of data which will be held on a central fileserver and accessed by terminals running Windows with Microcosm and associated viewers. Once operational, the fileserver will be kept current by staff with the skill necessary to use specialist CAD software and the system will provide ways for the relatively unskilled user to set up accurate perspective views of a particular area or to initiate a data search. Along with ease of use this approach has the considerable advantage of removing the requirement for expensive software running on all the terminals as this need only run on the fileserver which can then export its output in a standard format.

The system is being used to map 1991 census data onto the urban model in order to make the information more accessible to the residents of Bath. The buildings within the model have been classified according to their enumeration district and the model simplified so that it only retains those key features necessary for navigation. The buildings are then extruded vertically and height, colour and texture used to represent variables. This provides a very simple and effective way of simultaneously mapping three variables, with additional ones being possible through the application of geometric transformations to the building extrusions. This technique is particularly appropriate for representing variables relating to housing condition and use.

EDUCATIONAL OPPORTUNITIES

Twenty five years ago the Bath Preservation Trust commissioned a wooden model of Bath as an aid to explaining the development of the city, and as a vehicle for considering the implications of new developments. The intention was to alter the model in order to show change, but the difficulties of such an operation meant that it was never used in this way. However, for many years it was kept in the entrance foyer of the planning department and became extremely popular with visitors who found it to be extremely useful for understanding the layout of the city. Following restoration, the model has now found a new home in the Building of Bath Museum where it is used, once again, to explain the
historical development of the city. On the front of the model there are a series of buttons which the visitor can press in order to have various parts of the city illuminated by a series of sharply focused spotlights.

Given its limitations, the wooden model has been surprisingly successful and is extremely popular with residents and visitors alike. However it has a major limitation. It can only represent the city at a single point in time and cannot easily show how it has grown in the past or how it might change in the future. The computer model, on the other hand, can be copied and changed very easily and is therefore not constrained to representing only the present. As has already been discussed, possible futures can be illustrated as can past growth and development. It is this dynamic quality that makes computer models so interesting and it is possible to use the system described here to explain the history of the city in new ways. Multimedia technology is now sufficiently well developed for it to be used to create interactive displays which allow a user to work their way through large amounts of information at a pace, and in a way, that suits their needs. By providing such an opportunity it means that complex ideas can be communicated and a richer understanding of the past achieved. It is also possible to provide a number of different levels of explanation and thus offer something which is as interesting to the schoolchild as it is to the local historian.

CONCLUSION

One of the great delights of visiting any city is to explore its streets and buildings and gradually uncover what goes on beneath the surface. So with the Bath Urban Information System. As well as viewing the urban model from above, one can move right in and gain access to layers of information which are directly related to particular parts of the city, or even to individual properties. By using Microcosm's features links can be made from one piece of information to another and thus a highly complex database is rendered accessible. The urban model becomes an index to all kinds of information, from text and pictures to social statistics or film clips. Rather than having to use a traditional indexing system, which can be obscure and difficult to use, one can use a model of the city itself and have an interface which accurately reflects the complexity and sophistication of the information being stored. The system can be used in a number of very different ways. It can help when considering the implications of a new building, or, it can be used to provide a highly stuctured route through information on the history of Bath designed for the first-time visitor. Anyone can use it to browse through a wealth of documents relating to the city and the researcher can follow a particular thread in a highly focused and effective way.

In a democracy the decisions about how a city should develop must be made by its residents operating on the basis of informed choice. To date too many decisions have been made by minorities simply because there was no effective public debate and little of the information necessary for making judgements was
readily available. Any techniques which can make such a debate more open are to be welcomed. Those that have been described here do just that by using new technology to bring information together and by using the power of computers to represent change in a way that makes it intelligible to non-specialists. Although such techniques will not, of themselves, ensure that the buildings of the future are better than those of the past they will at least ensure that the tools required to facilitate a more open debate are publicly available.

REFERENCES
