Hypermedia Authoring and Contextual Modeling in Architecture and Urban Design: Collaborative Reconstructing Historical Sheffield

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Studies of historical architecture and urban contexts in preparation for contemporary design interventions are inherently rich in information, demanding versatile and efficient methods of documentation and retrieval. We report on a developing program to establish a hypermedia authoring approach to collaborative contextual modeling in architecture and urban design. The paper begins with a description of a large-scale urban history study project in which 95 students jointly built a physical model of the city center of Sheffield as it stood in 1900, at a scale of 1:500. Continuing work on the Sheffield urban study project, it appears to us desirable to adopt a digital approach to archiving the material and in making it both indexible and accessible via multiple routes. In our review of digital models of cities, some interesting yet unexplored issues were identified. Given the issues and tasks elicited, we investigated hypermedia authoring in HTML and VRML as a designer-centered modeling methodology. Conceptual clarity of the methodology was considered, intending that an individual or members of design groups with reasonable computing skills could learn to operate it quickly. The methodology shows that it is practicable to build a digital contextual databank by a group of architecture/urban designers rather than by specialized modeling teams. Contextual modeling with or without computers can be a research activity on its own. However, we intend to investigate further how hypermedia-based contextual models can be interrelated to design development and communication. We discuss three aspects that can be explored in a design education setting.

The Sheffield 1900 urban study project: a case of collaborative contextual modeling

The urban study project "Sheffield 1900" was recently launched at the Sheffield University School of Architecture. The starting point for our urban study was a consensus among the staff that context is important, and that one should always know the history of a site in order to understand how it was formed and what it means, whatever use is eventually made of that information. Allied with this is the problem of what constitutes a city, how cities might work today, and how buildings might (or might not) be integrated within them. Again, the current situation is only comprehensible with some understanding of the past, with an idea of how a city developed and how its past states contrast with the way it is today. To understand an urban context, more is needed than a peremptory glance at some old maps. On one level this is a question of developing perception and understanding, of knowing what to look for and how to look, but it is also a question of learning how to use maps and archives, and of getting familiar with the kinds of things that can be found in them.

Project objectives.

For the academic year 1998/99, the urban study was devoted to Sheffield. We considered it desirable to start some kind of database in which information could be cumulatively recorded, and which could be consulted by anyone planning a project in the city in future years. The urban study project is intended to continue taking a different aspect of the city each year. Pedagogically speaking, the study has four objectives:

• to demonstrate the importance of understanding how a place has evolved before contributing a new design;

• to show the changes that have taken place in cities during the last century;

• to teach students how to undertake historical research; and

• to build up a database about the history of Sheffield for future reference.

Project organization and team-working.

But how does one study a city systematically? We decided to try to base our work around a physical model of the whole central area as it was in 1900. This date finds Sheffield at its industrial height and the peak of its wealth, before the depredations of war, redevelopment, and the collapse of heavy industry. It is late enough for accurate maps and photography, yet early enough to show many original features missing today. Topically, it marks the passage of a century, so coincides pertinently with the millennium.

We decided to divide the 95 students taking part into groups of four or five. A consequent division of the work was needed, so we imposed on the plan of the city a north/south and east/west grid. A one in four subdivision of the current Ordnance Survey grid produced 20 squares with a side-length of 200 meters on the ground. At a scale of 1:500 this gives a piece of model 40-cm square, and a whole model 2.0 meters by 1.6. The scale of 1:500 is just large enough to show the forms of individual buildings and even chimneys, but without in most cases including such details as door and window openings [Figure 1]. The gray model of contours alone was temporarily assembled at an intermediate stage in the model's development to check for inconsistencies. It was also necessary for groups to collaborate where grid-lines passed through buildings, but the difficulty of accurate matching between one grid-square and the next was mitigated by leaving a gap of 10 mm.

Sources of research and modeling.

The initial sources of information for the model were the Ordnance Survey Maps of 1897 and 1903. The use of two editions immediately highlights the problem of a changing situation, for even if there had been a map published in 1900 it would have been out of date, having taken a year or more to prepare. Inevitably there were places that were cleared sites in 1900, and there were buildings under construction: one of our model squares actually shows one of them scaffolded. Groups with sites in transition soon found out about them, and were usually able to estab-

lish from records what was present in 1900. Things that had existed for a number of years before or after the date were usually recorded in some way, but more temporary things proved elusive.

Some buildings present in 1900 are of course there still and could be photographed or surveyed in place, but the extent of survival varied greatly from one grid-square to the next. Some parts of the city had remained relatively stable, but others - notably sites of industry, slum housing and post-war ring-road development - had changed out of recognition. One group found only a single pub still intact on their site. In dealing with such areas, careful research was needed to establish the three-dimensional form of the fabric, and here the collections in the City Archive, Local Studies Centre and the Hawley Collections proved essential. The Ordnance Survey maps give accurate plot outlines and ground heights, but no information on the number of storeys or the roof-forms, while courts and light-wells are sometimes also missing. Much valuable information could be gathered from period photographs, but the unexpected major source was fire insurance plans. These not only noted the number of storeys and locations of small internal courts, but even details such as roof lights.

Figure 1. Modeling one of the grid squares (200m side-length) at 1:500 in the Sheffield Urban Study Project.

Tasks of data creation. The physical model was the focus of the research, but the student groups were also asked to provide other kinds of information. They were asked to account for the presence, shape and orientation of every street within their square, and this meant looking at earlier maps to trace the *growth pattern*. Plans in the archive show not only every detail of the layout, but even the earlier field boundaries. With such information it is possible to explain the development of nearly everything in Sheffield since the mid-18th century.

The student groups were also asked systematically to chart the uses of the buildings in 1900, and here contemporary directories were the major source. They allowed a consistent series of coded plans to be drawn showing uses across the city, and it was soon obvious that the different squares had very different characters.

Illuminated by knowledge of all these uses, the model conveys the impression of a dense city teeming with activity. Spatially it was organized in a clear hierarchical manner, with major streets giving way to minor, these leading in turn to alleyways and backcourts. The pressure for maximal land-use conflicted with the requirement for daylighting to produce a complex and irregular built pattern of yards and light-wells, a use seemingly being given to every square foot.

In addition to the work outlined above, each student within a group was asked to select a building from the grid-square in question and to examine it in detail. In some cases these could be unique buildings of declared architectural significance, such as the Cathedral and the Cutlers' Hall, but students were equally given the option of looking at an ordinary building as example of a type. A detailed report of more specific findings from the Sheffield Urban Study project will soon appear in a separate publication (reference to be added later).

The project was accompanied by a series of lectures and discussions, and one of the topics explored was the nature of building types, and whether they should be classified on a formal, functional or technological basis. We stressed that the language of building types is significant in giving a city's coherence both in terms of the repetition that establishes a type and the contrast that differentiates it from another. A further

task for the students was to identify the equivalent of their chosen building today, and to pinpoint its location in the modern city. With the later expansion and loosening of density occasioned by the motorized transport, many are located in relative isolation and more towards the periphery.

The final assembly of the model was dramatic occasion revealing a city none of us had ever seen before [Figure 2], and its riches emerged even more strikingly as the groups presented their detailed findings in turn. We were all struck by the areas of the city wholly transformed and the extraordinary damage inflicted by post-war road schemes. Also fascinating were the many layers of construction serially imposed on the original site of development. The grid system of working, initially imposed to divide the work between groups, proved an unexpectedly fruitful analytical tool. A piece of city 200 meters square is large enough to have two or three streets and a character of its own, yet small enough to get a real grasp of the life lived. The possibility of switching from the scale of the city as a whole to that of the grid-square and back allows an appreciation both of part and whole.

The Sheffield 1900 model and beyond.

As an educational vehicle the study teaches students some social and architectural history as well as how to use maps and archives. More fundamentally, exposure to the evidence of the relationship between social forms and architectural forms should make them more socially conscious as designers. Although some initially regarded the study as a distraction from the more essential activity of design, nearly all seemed by the end to acknowledge the value of their achievement and many were astonished by the sheer scope of 95 combined contributions. Never before to our knowledge had the city been looked at in this way, and never had the archive material been assembled in such form. Being able to locate the positions of photographs from Local Studies within the model, for example, gives them a fresh significance. Interest from the Director of the City Museums of Sheffield has resulted in the proposal to build an exhibition around our model, which will occur in the year 2000. The intention is to take the model as centerpiece, working outward towards a series of displays including artifacts about the city's industrial and social life. Apart from this exposure, the model will be retained within the school for reference.

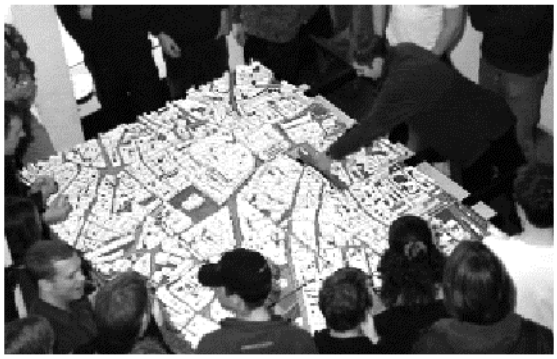

Figure 2. A scene of the final assembly of the Sheffield 1900 Model in the studio.

Until now the Sheffield 1900 database has taken the form of a paper file on each grid square and the model has been entirely physical. The use of computer modeling and digital media offers great advantages both in storing the material and in making it both indexible and accessible via multiple routes. Since the ultimate aim is to provide a physical history of every site in the city to inform new architectural interventions, it is highly desirable that the data on the three-dimensional positions of lost buildings and roads are electronically reproducible. We are therefore aspired to develop ways of recording the data electronically, both in order to relate it directly to the modern electronic survey and to make it more easily retrievable and convertible. In the long-term we should be able to make the historical information available for any site in a flexible form. We also have a box-file of paper for every grid-square, which is probably the most practical way of assembling data initially, but we intend to recreate this also in electronic form, not only to ease the access and storage problems, but to make it searchable in a diversity of ways.

Computer-based contextual modeling: purposes and issues

Our interest of extending the Sheffield 1900 project into a digital databank brought us to review some related work done in the area of computer-based urban modeling and simulation. We have looked into several examples of digital (or virtual) city models via the Internet: Bath (Day, Bourdakis et al. 1996), Glasgow (ABACUS 1998), Philadelphia (Bentley 1997), and Los Angles (Jepson and Friedman 1997). The purposes and resources invested in producing these digital city models vary from project to project. However, the impression of being a 'specialist' task done by highly technical staff is common. In our view, the virtual city models as built may well be used by designers to consider contextual issues, but the fact that contextual study is an integral part of the design processes, which is normally undertaken by designers themselves, seems not to be a central concern.

Standing from a design education and practice viewpoint, we aimed to establish a computer-based modeling methodology with which architectural designers themselves can carry out the tasks of generating and maintaining data resulting from their contextual studies. The methodology should be generic and it is operable with projects of various scales ranging from a single building site up to as large as a city. As informed by our review of the published digital models of cities, some interesting yet unexplored issues were identified as follows:

• The idea that an *accumulative open-ended* contextual databank may be created and maintained by researching design professionals collaboratively as the information modelers. A data organization strategy is required to enable an open-ended bottom-up approach to data creation and accumulation so that a wide range of digital records can be produced and organized into existing collections of contextual study at any one time.

• Contextual models may be constructed to reveal the *evolution* of a place or city development by sorting data on a chronological as well as a spatial basis. Innovative uses of visualization techniques (e.g., collage, juxtaposition, animation etc) are also required, thus allowing reconstruction of different periods to be displayed associatively, rather than fixing the model at one time.

• 3D graphic models of buildings and any portions of a city may contain embedded *hyperlinks* pointing to other types of documents such as texts, drawings, images, interviews and so on generated in various digital mediums.

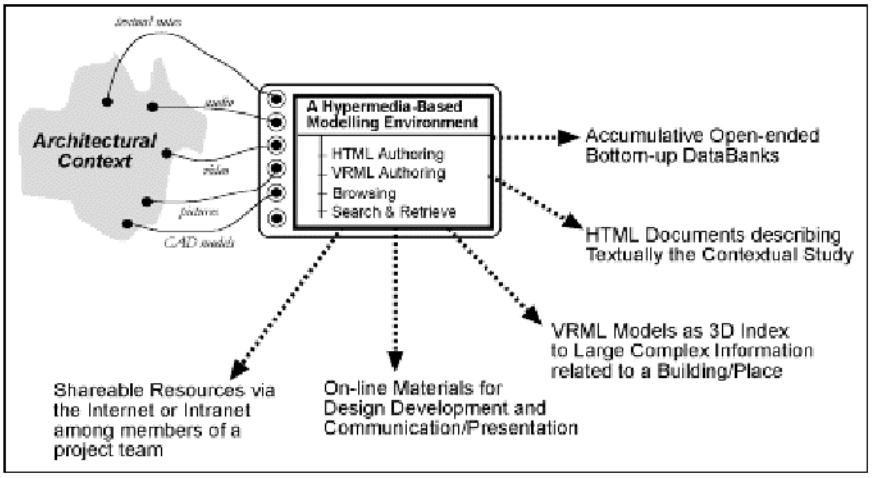

Figure 3. Purposes of contextual modeling and a hypermedia-based modeling methodology.

• A contextual databank is *searchable* so that contents can be searched and retrieved effectively according to the end-users' queries.

In response to the issues and tasks elicited above, we chose to investigate hypermedia authoring in HTML and VRML as a designer-centered methodology for contextual modeling. The diagram in Figure 3 serves to consolidate the purposes, issues and concepts as described, leading to a methodological framework for further elaboration. We looked for conceptual clarity of the methodology, intending that designers with reasonable computing skills could learn to operate it quickly as an individual or a team. Based on a range of authoring/ modeling tools and data sets, the current methodology consists of five components explained in the next section.

Hypermedia authoring as a methodology for collaborative contextual modeling

Use of the ordinance survey (OS) digital maps

Under the scheme "Superplan Data," the OS has made several kinds of digital mapping data commercially available in the United Kingdom. Among others, the "Urban Data Source" (1:1250 scale) is particularly relevant to our purpose of urban contextual modeling. A fair amount of information is provided in a Superplan data file (in Autodesk's DXF format), containing drawings and descriptions of a chosen plot in 59 layers. The data sets can be read by most CAD packages such as AutoCAD or MicroStation, and this is considered as the basic 2-dimensional footprint of the site. Data such as the locations and datum of benchmarks, outlines of buildings, street blocks, roads etc., can be processed to establish accurately updated the ground conditions of the plot, which in tern are the inputs for 3-dimensional CAD modeling.

3-Dimensional CAD modeling

The heights of buildings are not provided in the Superplan data source. Information of heights of buildings and outlines of "roof-scape" of the site will have to be acquired via field survey by the investigators. For contextual modeling purpose, a surface-based modeling of the buildings or any other objects/spaces is appropriate. As buildings and spaces are not defined in single volumes or blocks, surfaces created in 3D modeling can be later identified for the purpose of VRML modeling in which several other operations are performed to produce hypermedia-based contextual models.

HTML and VRML authoring

The Hyper-Text Markup Language (HTML) is a programming language that one can generate formatted documents containing texts, pictures, and hyperlinks with other documents of various mediums such as texts, photo images, audio/video clips etc. To the architectural design professions, learning the computer language and producing HTML documents readable by HTML browsers is no a small matter (Graham 1997). However, many user-friendly HTML editors have been developed over the years, and some of them are now widely available on the Internet as shareware or "careware". These HTML editors provide authoring and editing interfaces in a way similar to those of ordinary word processors, saving end-users from actual coding in the HTML language. Using an HTML editor, one can produce not only hypertextual descriptions of contextual study but also *designs* of "pages" to be viewed with HTML browsers.

With hypertext authoring, hypertext documents can be generated with embedded textual or graphical "nodes" (or "anchors") that enable "hyperlink" based information retrievals. One can simply describe or transcribe ones own contextual study in natural languages and establish links among any numbers of other documents in various file formats following ones lines of narration.

As a graphic counterpart of HTML, the Virtual Reality Modeling Language (VRML) is a programming language for generating 3-dimenional graphical models containing hyperlinks with documents of various mediums. Learning to program in VRML is even harder (Ames, Nadeau et al. 1997). However, a specialist kind of software has been developed to enable VRML modeling without programming: the VRML World Builders. To our knowledge, no free VRML world builders

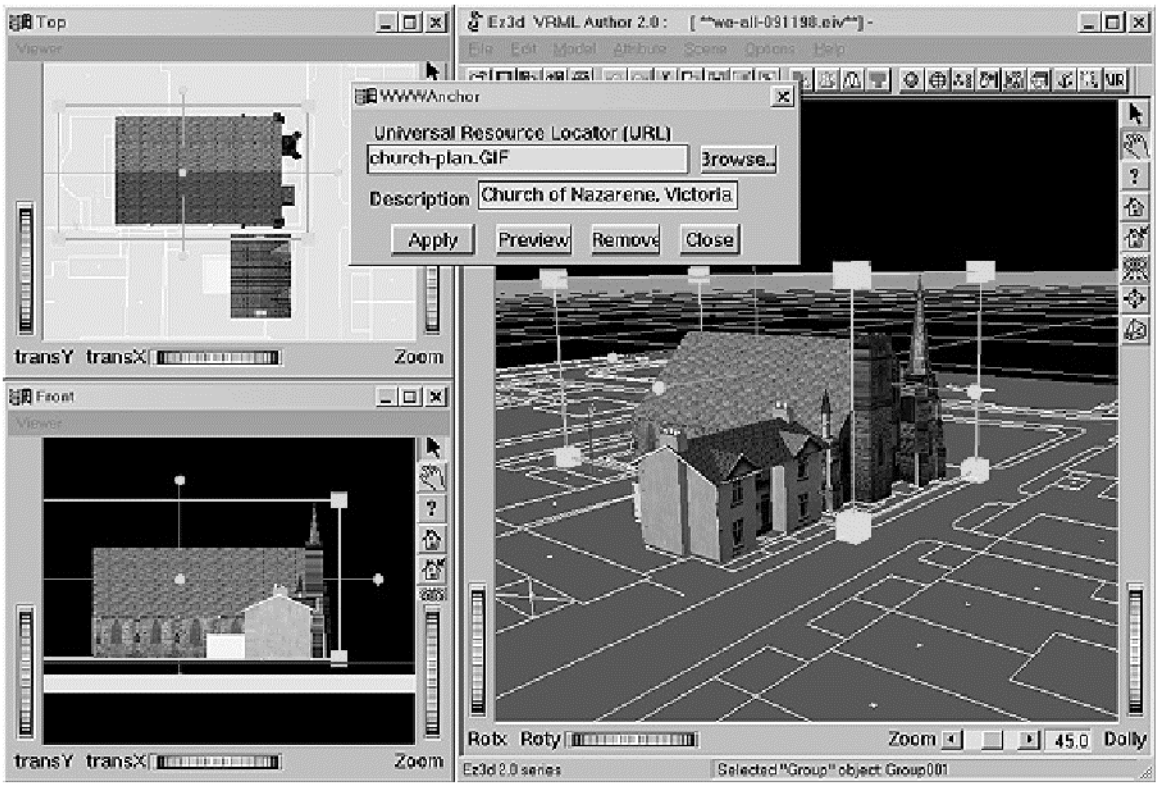

Figure 4. An example of VRML authoring. [Software used: Ez3d Author of Radiance Software International]

have been offered so far [for a list of commercially available VRML 2.0 world builders, see (Web3D 1998)]. Notably, all of these builders were developed for making interactive 3D objects or worlds into World Wide Web (WWW) pages deliverable on the Internet. Sophisticated 3D geometrical modeling, as demanded by serious architectural modeling, is not supported by the current VRML builders. However, some builders, such as the Ez3D Author (Ez3d 1998), can import a CAD file of the DXF format and preserve the definitions of the model. One the basis of CAD models imported, an author can create and incorporate further features of the models such as texture mapping and hyper-linking within a VRML world builder [Figure 4].

With VRML authoring, VRML models can be produced as 3-dimensional graphical models with embedded graphical nodes or anchors that can be further linked up with other documents of various formats. The doorway of a house modeled in VRML, for instance, can be linked to a 2D detailed elevation or sectional drawing of the doorway recorded in a separate file. With VRML modeling, one achieves not only 3D visualization of buildings or spaces but also 3D graphical indexes to a potentially vast amount of contextual information, reflecting the investigator's perception and interpretation of the places studied.

Browsing and navigation

Once generated, HTML documents and VRML models can be viewed by the "Browser" software of which the Microsoft's Internet Explorer and the Netscape's Navigator are the most popular ones. Browsers provide end-users with interfaces for interacting with parts of the document or model under viewing. When clicked, embed-

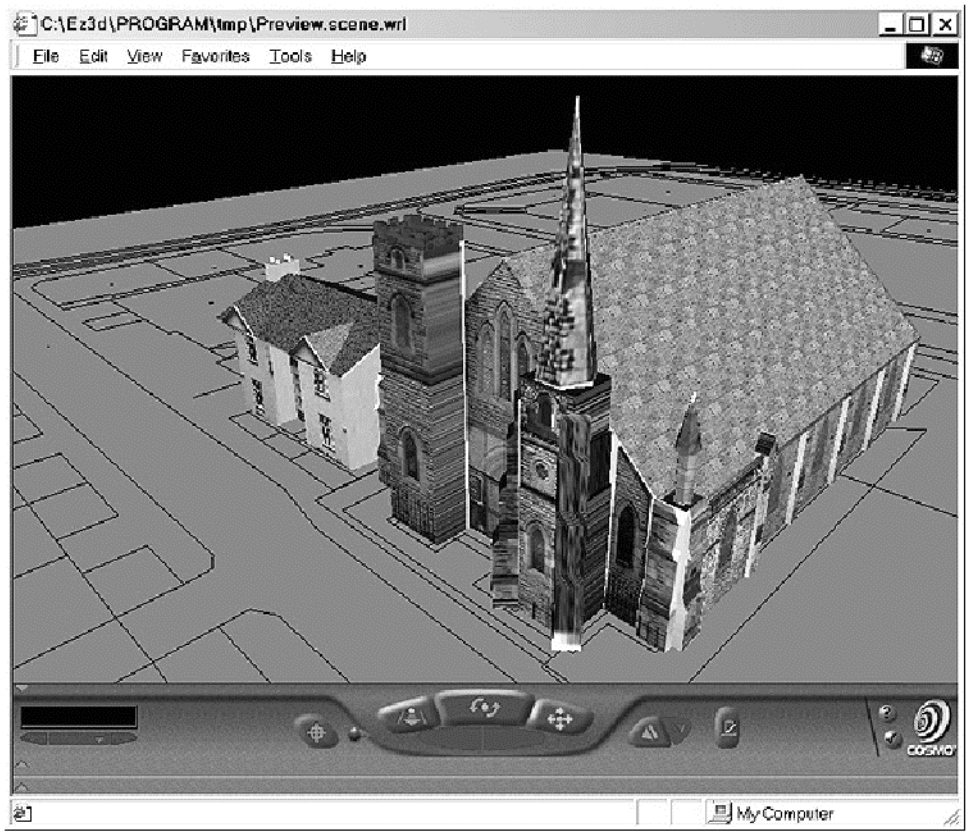

Figure 5. An example of VRML world browsing and navigation [Software used: CosmoPlayer 2.1 of Platinum Technology Inc. as a plug-in of Microsoft's Internet Explorer 5.0]

ded hyperlinks will be activated to retrieve the documents at the addresses specified. The software component for viewing VRML worlds has been developed as "plug-ins" of HTML browsers. Therefore, with the same hyper-linking mechanism, VRML models can be called upon within an HTML document under viewing and vice versa.

Navigation among HTML and VRML contents is mainly supported by the user interface elements of the browsing software so that a reader is able to know constantly what parts have been through, the current location, and where to look for next. Figure 5 shows a snap shot of the interface provided in the ComoPlayer (as a plug-in of Microsoft's Internet Explorer) in which the end-user can operate a set of buttons and cursors for moving around and manipulating the model. However, it should be noted that navigation could be an interesting and important aspect of the authoring process as implementation of certain strategies of navigation is an integral part of HTML documents and VRML models.

Resources search and sharing

HTML-based documents can be searched and retrieved by applying another specialist software called "Search Engines". The simplest way of searching and retrieving is by typing keyword(s) into a general-purpose search engine that will return documents containing word(s) matched. Figure 6 shows an example of HTML document retrieval system (LIKSE 1998). With a stand-alone search engine like LIKSE, an end-user will be able to search HTML-based

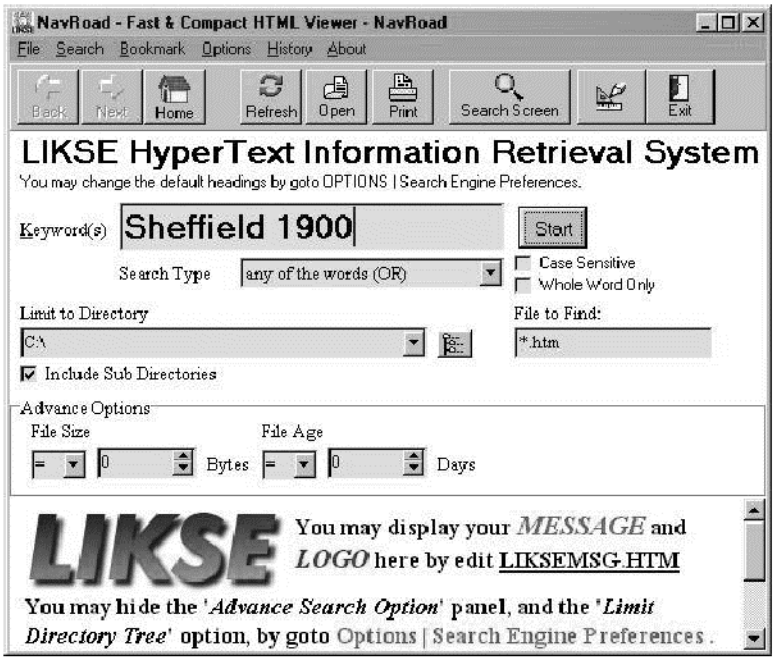

Figure 6. An example of searching HTML documents using a stand-alone search engine. [Software used: LIKSE of FAICO Information Solutions]

resources stored in local machines dedicated to the contextual database. The fact that HTML documents are "searchable" and the availability of hypertext retrieval systems is highly relevant to contextual modeling in architecture. One can envisage the cumulating of contextual studies over years into a considerable amount of resources, and any parts of them may be reusable in later occasions if the documents can be identified and retrieved effectively.

VRML models are currently not searchable and general-purpose mechanisms for graphics or image-based search and retrieval have yet to be developed. Nevertheless, as shown before, VRML models can be hyper-linked within HTML documents such that graphic models with proper naming or annotations can be searched and retrieved indirectly via an HTML-based search engine. To work in this way, writing about contextual studies in HTML plays an important role in terms of building an organization into potentially a vast volume of contextual information. Finally, HTML and VRML resources are intrinsically "shareable" when they are ported onto an Intranet or the Internet. With all the various types of software mentioned above installed, members of a project team can contribute, search, retrieve, and view any parts of contextual resources maintained by a computer network.

Uses of contextual models in design development and communication

The methodology described above remains largely at its research stage. So far among the 95 students took part in the Sheffield 1900 urban study project, only a limited number of them were introduced the hypermedia authoring approach. However, initial attempts of creating 2-dimensional graphical HTML pages containing scanned maps, CAD drawings, and photographs by a group of students have shown some encouraging results [Figure 7]. We could say confidently that the conceptual complexity as demanded by the current authoring methodology seems not putting off students with computing skills of an average standard.

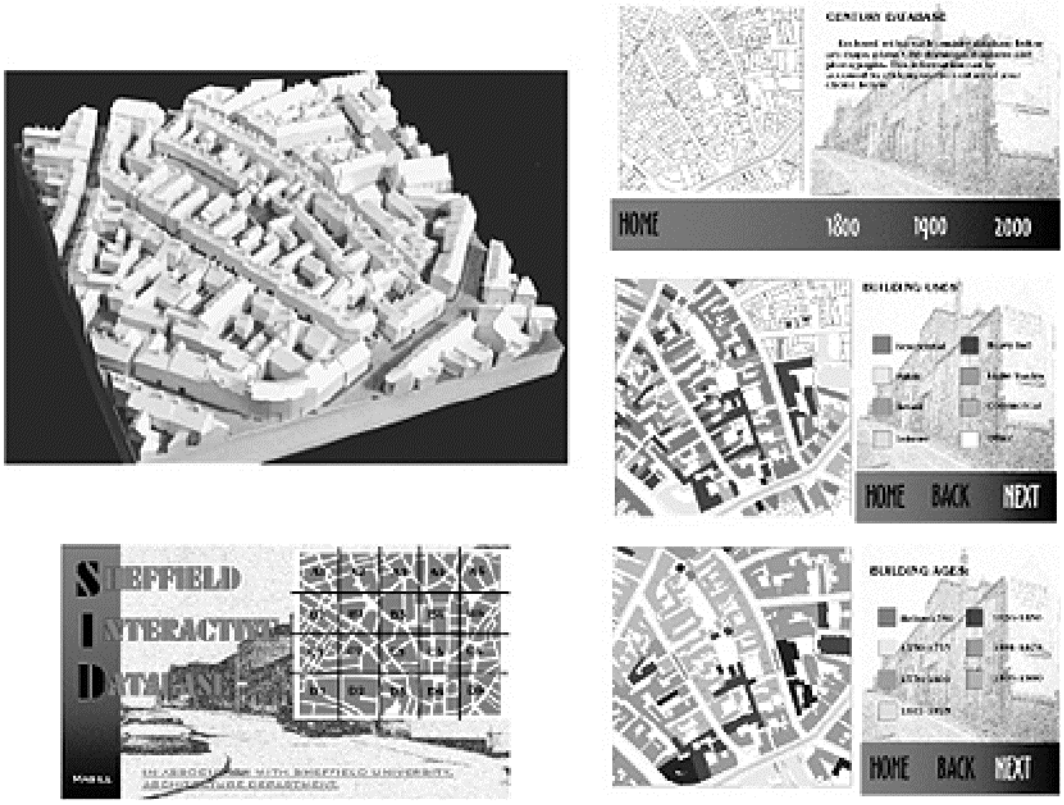

Figure 7. Some graphical HTML pages created by the students who made the model for the 'A5' Square.

Contextual modeling can be solely a research activity on its own. However, seeing the output from the Sheffield 1900 urban study project, a great potential offered by our urban study is the preparation of contemporary design intervention in response to the memory of a site and the geometrical traces that it carries. On one hand we can be too constrained and limited by the forms of the past and the habits implicitly carried by them. On the other hand, one can free oneself too much: what is needed surely is a balance between the memory of past forms and current needs. At a time when building materials, design fashions and typologies are increasingly generalized and international, with the same kind of nowheresville of architectural objects and landscaped voids springing up around every city, a uniqueness of relationship to site and place is urgently needed. It is something well-educated architects could offer as their particular and special expertise. We therefore feel appropriate to investigate further how hypermedia-based contextual models can be correlated with design development and communication. In our view, at least three aspects can be explored in a design education program.

• On-line Accessibility of Contextual Data

Once created contextual databases can be made accessible online via networking facilities and contain hyper-linked design resources other than 3D models. The question is, can HTML/VRML support intuitive and effective ways of retrieving information so that making cross references to specific points of contextual findings can be performed in a more spontaneous and precise

manner? The effects can be observed and analyzed in students' performing design communication and presentation in relation to their concurrent uses of contextual data.

• Extending and Updating of Contextual Models

Unlike physical modeling, digital contextual models can be extended or updated far more conveniently and timely, especially if the databank is connected with the Internet. Will the ease of data management encourage more active interactions between contextual study and design development? A comparison can be made between early and end stages of a contextual database built for a design project lasting for several months. Interviews with students can be conducted to elicit how the design activity actually deepens one's discovery and understanding of context; and how hypermedia-based contextual modeling might have been conducive to such efforts.

• Sharing Contextual Models and Collaborative Design

For a group of designers to develop a design scheme collaboratively, the sharing of a common site model is essential. In the case of physically modeling, collaboration has to center on a particular workspace where the physical model is located. Working with digital site models and database has no such constraint as long as group members' design environments are connected with the network where the contextual databank is deposited. But how would a design group exploit the medium of network hypermedia space in sustaining collaborative design? Also, given the ease of extending contextual models, how would the team organized themselves in order to preserve the 'sharability' and integrity of the contextual database during a project's lifetime?

Acknowledgement

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References

ABACUS (1998). 'Virtual Glasgow'. http://iris.abacus.strath.ac.uk/new/vrml1.htm, maintained by ABACUS, Department of Architecture & Building Science, University of Strathclyde.

Ames, A. L., D. R. Nadeau, et al. (1997). *The VRML 2.0 Sourcebook*. Wiley, New York.

Bentley (1997). 'ModelCity Philadelphia'. http://www.bentley.com/modelcity/, maintained by Bentley Systems Inc.

Day, A., V. Bourdakis, et al. (1996). 'Living with a virtual city', *Architectural research Quarterly*, vol. 2, no. 1, pp. 84-91.

Ez3d (1998). 'Ez3d VR Pro: VRML authoring made easy...'. http://www.radiance.com/Ez3d-VRPro.html, maintained by Radiance Software International Inc, Berkerley, California.

Jepson, W. and Friedman, S. (1997). '*A Real-Time Visulization System for Large Scale Urban Environments*'. http://www.aud.ucla.edu/~bill/UST.html, maintained by UCLA Urban Simulation Team, Los Angeles, California.

Graham, I. S. (1997). *HTML Sourcebook*. John Wiley & Sons, Inc., New York.

LIKSE (1998). 'Standalone browser - LIKSE off-line browser with off-line search engine, off-line html browser, off-line viewer'. http://www.faico.net/likse/index.html, maintained by FAICO Information Solutions.

Web3D (1998). 'The VRML Repository'. http://www.web3d.org/vrml/vrml.htm, maintained by Wed3D Consortium.