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Building a city advisor in a 'hypermedia' environment

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Abstract. In this paper examples are given of how modern information technology may have an impact on the way we build and use computerised models for different applications. The KBS-MEDIA (knowledge-based systems-media) group of projects is described. These projects are aimed at integrating advanced software techniques (knowledge-based systems, HyperCard from Apple Computer, etc) with new distribution and storage media. The 'hyperdocuments' which are created possess powerful man-machine interface and dynamic model-building properties. The system described forms a demonstration environment used in different applications to capture, test, and communicate ideas, so allowing fast prototyping. New tools for building and using 'hypermedia' systems have been defined, created, and tested. These tools are adapted to the needs of the people intended to use them, by means of 'friendly' interfaces. Some comments are made on the ideas behind the project, as well as on how the KBS-MEDIA environment is used in the 'City Advisor' application.

Résumé. La communication décrit et illustre comment la technologie moderne d'information peut influencer notre manière de construire et d'utiliser des modèles informatiques pour des applications différentes. Le projet 'KBS-MEDIA' (systèmes basés sur les connaissances) y est décrit. Un ensemble de projets groupés sous l'étiquette 'KBS-MEDIA' ont pour but d'intégrer des logiciels avancés (systèmes fondés sur les connaissances, HyperCard fonctionnant sur ordinateur 'Apple', etc) avec de nouveaux moyens de distribution et de stockage. Les 'hyper-documents' qui sont créés représentent un intermédiaire puissant entre l'homme et la machine et possèdent des propriétés dynamiques en ce qui concerne la construction de modèles. Le système forme un milieu démonstratif utilisé pour des applications différentes pour saisir, tester et communiquer des idées et permettant d'obtenir un prototype rapidement. De nouveaux outils pour la construction et l'emploi de systèmes à hypermedia ont été définis, créés et testés. Ces outils sont adaptés aux personnes qui sont supposées les utiliser. Les idées se rapportant au projet sont commentées et particulièrement celles concernant l'utilisation du 'KBS-MEDIA' dans un but de 'Conseil Urbain'.

1 Introduction

On the scene now we have a set of very powerful software tools which are of immediate practical use. These include object-oriented systems, induction systems, production systems, hybrid artificial intelligence systems, neural networks, optical storage media, and so on. It now becomes practical to handle, capture, store, and distribute large quantities of data in the form of colour pictures, film, sound recordings, animation sequences, drawings, etc together with computer-stored models, in so-called 'hypermedia' systems.

The systems we construct today, covering a wide spectrum of applications, are better suited to capturing information and create greater demands on the users; this in turn sets new requirements for user interfaces, model descriptions, and model-building tools. The end-user needs tools when he or she constructs and uses the computer-stored model of the application. The old programmer has become a *toolmaker.* The new tools will hopefully give us a higher quality in those products we design, produce, and maintain, as well as improving our personal work and living environments and creating better contacts between people. 'Inventions' in information technology are made from time to time. We are now in a turbulent phase of evolution, trying to see possibilities and risks in using the new technology. New concepts, ways of thinking, of doing things and of making agreements are formed only *slowly* (figure 1).

The KBS-MEDIA (knowledge-based systems-media) environment is described briefly in the next sections, both from building process and from information technology standpoints (see also Christiansson, 1988; 1989).

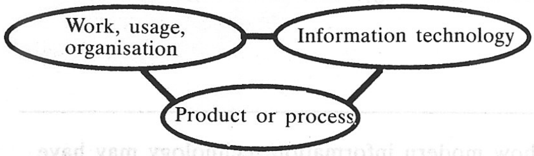

Figure 1. Evolution under mutual influence.

2 Hypertext, multimedia, hypermedia

2.1 *Short history*

The idea of 'hypertext', a nonsequential writing and reading medium built up from nodes of text chunks (and graphics) with links between them (figure 2), is not new. The pioneers in the field were Vannevar Bush in the 1940s, Douglas Engelbart in the 1950s, and 1960s, and Ted Nelson in the 1960s (Conklin, 1987). In the last two decades the essential ideas have remained, but modern information technology now lets us formulate and develop the next generation of 'hypermedia' systems.

Combining the concept of *multimedia* (text, still pictures, moving pictures, video, sound, speech, drawings, animated graphics) with *hypertext* systems for nonsequential

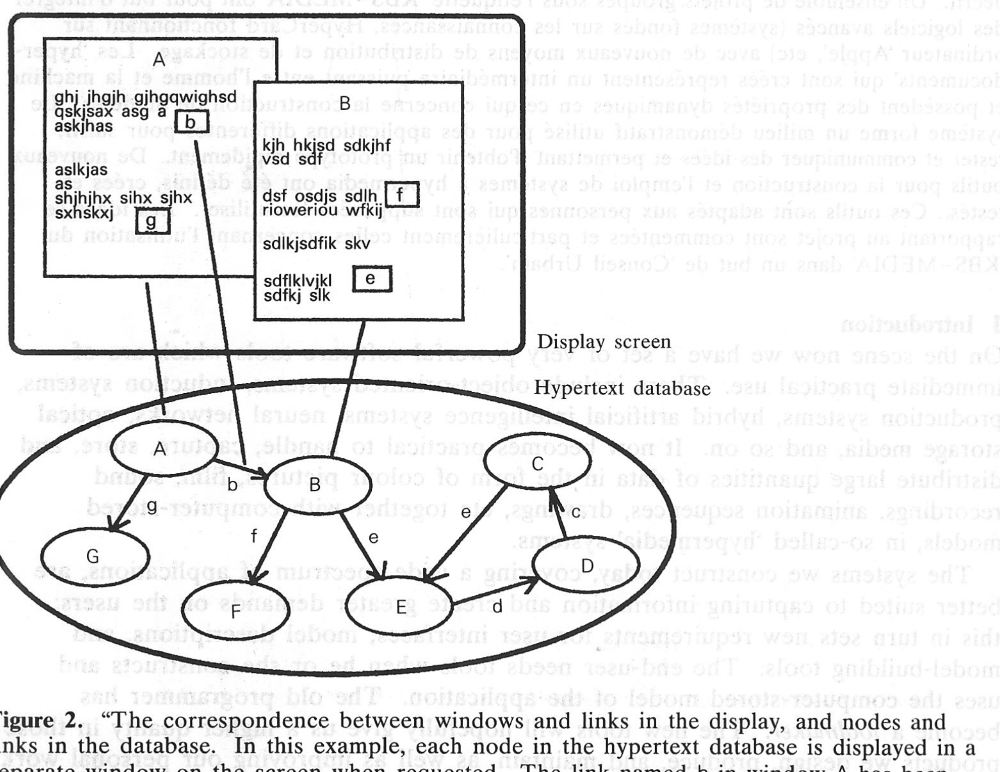

Figure 2. "The correspondence between windows and links in the display, and nodes and links in the database. In this example, each node in the hypertext database is displayed in a separate window on the screen when requested. The link named b in window A has been activated by a pointing device, causing a new window named B to be created on the screen and filled with text from node B in the database." (Source: Conklin, 1987.)

writing and reading, gives us the concept of *hypermedia*. According to the dictionary, a *medium* is either an intervening substance through which something is transmitted or carried, or an agency by means of which something is accomplished, conveyed, or transferred. In Christiansson (1988) the concept of 'hyperdocument' is defined, as something having the combined properties of model, document, and medium (for transfer or publication and storage).

What are the advantages of using 'hypermedia' systems? Our ability to create solutions to information-handling problems according to demands from user and according to application is dramatically enhanced—something which it is hoped will be shown by the worked examples and comments which follow.

2.2 *'Lost in hyperspace'*

'Hypermedia' systems give us the possibility of getting access to very large volumes of information, which will be even bigger when the systems are logically connected into the ISDN (integrated services digital networks) that are now slowly being installed. Several problems arise, however, from a lack of common definitions and standard structures for information content. The prospect arises of becoming lost in the information space—of being 'lost in hyperspace'. The user must therefore have total control over the system, and have access to powerful search, navigation, and tracking tools. He or she must be helped to associate the computerised model with his or her own view of the problem. In section 3.5 some comments are made on how these issues are solved in the KBS-MEDIA environment. When the conceptual modelling is carried out, definitions and concepts are agreed on or formulated, preferably consciously.

3 The KBS-MEDIA environment

Since the autumn of 1987 work has been going on to build a KBS-MEDIA environment at the Department of Structural Engineering at Lund University. The most powerful features of this environment (figure 3) are: clearer and more

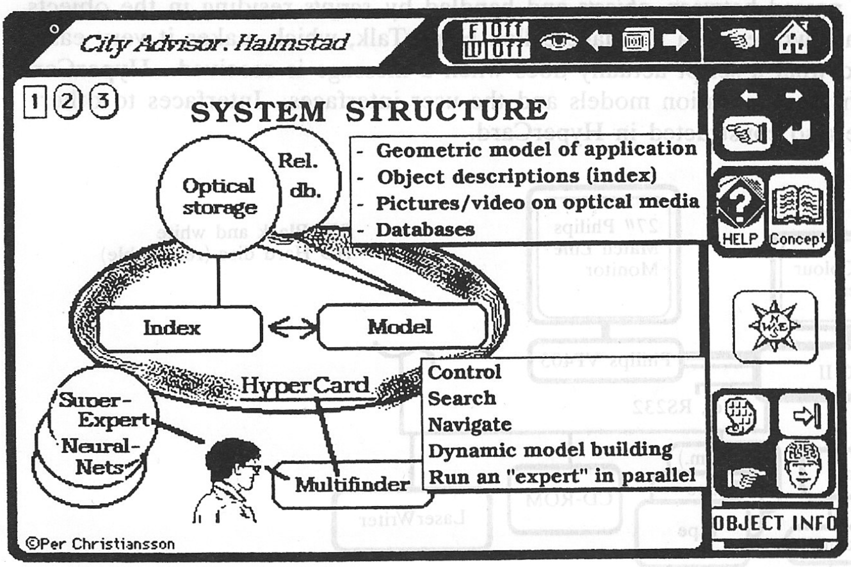

Figure 3. The KBS-MEDIA environment, showing an example from the City Advisor. HyperCard, SuperExpert, neural nets (knowledge-based systems), and optical media are integrated in this environment. (Multifinder is the operating system of Mac II from Apple Computer.) (Source: Christiansson, 1988.)

obvious connection between application and the computer-stored model; integration of advanced software tools, such as HyperCard (Apple Computer Inc., Cupertino, CA), knowledge-based systems and relational databases; simplified knowledge elicitation and dynamic growth, change, and validation of models; use of different knowledge representations and search strategies (object-oriented systems, decision trees, neural nets, relational databases, etc); provision of generic tools for problem-solving (decision support, information browsing and search, model building); design of powerful man–machine interfaces; computerised models supported by real-life pictures and sound as well as computer-generated pictures, drawings, animations, and sound; integration of optical distribution and storage media to support different computer-stored models (the same optical disc can support different models); tools for acquisition and handling of large volumes of pictures; powerful tools for knowledge transfer (training, education, and transfer of information); fast and simple prototyping, and powerful modelling tools; demonstration system for capture, test, and transfer of ideas.

3.1 *Connection between application and model*

The application models which reside in the system may be linked tightly to real-life pictures, film, and sounds. This opens up a new dimension for the user when accessing the model. It is possible to navigate through these images and sounds. Support can be gained for decisionmaking and illustrations added to different parts of the model (objects, methods, actions, etc).

3.2 *Integration of advanced software and hardware*

Part of the hardware used is indicated in figure 4. A portable Toshiba PC/AT is also available, to allow information to be collected easily outside the laboratory [partly through the use of induction systems, and learning by example (see Christiansson, 1986a)].

The HyperCard program has properties of both hypertext and object-oriented programs, although it is not a classical object-oriented programming system. *Messages* are passed between *objects* and handled by *scripts* residing in the objects. The scripts are written in a language called HyperTalk, which makes it very easy to understand what a script actually does when a message is received. HyperCard contains both the application models and the user interfaces. Interfaces to other programs are also constructed in HyperCard.

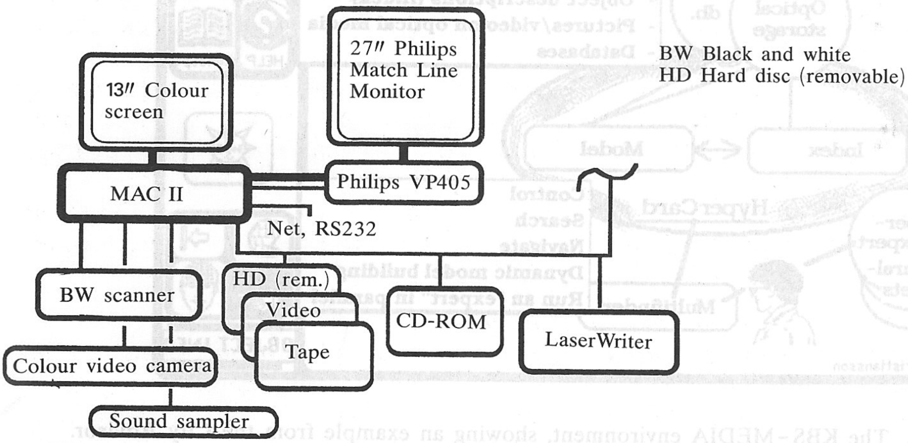

Figure 4. Physical units in the KBS–MEDIA projects.

The objects in HyperCard are of three kinds. In hierarchical order, these are *buttons* and (text) *fields* which are on the same level, and reside on *cards* with a common *background*. Cards belong to *stacks*, including the necessary *home stack*. On the highest level is *HyperCard* itself. HyperCard stacks contain documents (data) and applications (programs). When regarded as a hypertext system, HyperCard uses a file-card metaphor.

The SuperExpert induction system from Intelligent Terminals Ltd of Glasgow, Scotland and Novacast AB of Ronneby, Sweden is used to induce rules by giving examples. The decision trees so generated contain knowledge both about the application and about the KBS-MEDIA system tools (see Christiansson, 1986a; 1986b). Neural-net-type knowledge-based systems have also been implemented and are being tried out.

The following units are used as scanning devices: a black-and-white flat-bed scanner, a frame-grabber card which grabs the video signal from a video camera (Super-VHS PAL) and converts it to a digital picture, and a sound sampler which converts analogue signals from a microphone to digital form. Analogue (ROM) videodisc and CD-ROM (compact disc-read only memory) are used as mass storage devices, as well as hard discs (including removable hard discs). At present the video images and sounds from the videodisc player are displayed on a television monitor, but later they will be transferred, in real time, to the colour screen attached to the computer.

3.3 *Optical storage media*

Film sequences with sound and pictures are stored on an analogue videodisc, with 54000 frames per side, produced in 1986 together with Finnish colleages at VTT (the Technical Research Centre of Finland) in Helsinki. A new disc is now being produced at Lund University which will contain images to support some of the KBS-MEDIA projects. Pictures can also be stored digitally on hard discs or CD-ROM. In the latter case the number of stored colour pictures would be only between 1000 and 5000 approximately. We have not yet produced any CD-ROMs in the project. Images are collected initially on photographic slides or with a portable S-VHS video camera-recorder.

These optical storage media possess different qualities, influencing which should be chosen for any given application. Important factors are the type of information (stills, film, sound, etc), the size of the edition, the validity over time of the stored information, whether the disc will have multiple applications, how the information will be maintained, and how information is collected and transferred to the optical medium.

In the future, digital storage of images will become more common. This kind of storage puts heavy demands on memory and digital transfer capacity. There exist optical videodiscs which can store both analogue and digital signals. Digital images may be compressed using time-consuming compression algorithms as in the DVI (digital video interactive) technology. Also CD-audio is incorporated into the new media being developed. One emerging problem area concerns the copyright issues arising in the use of optically stored information.

3.4 *Knowledge representation, conceptual modelling, and search strategies*

These systems provide very powerful and flexible tools with which models can be built, based on different forms of representation and different search strategies. The work of conceptual modelling is extremely important. This work, which is to a great extent done manually, consists of five phases: definition of problems and subproblems, outline of problem solutions, choice and combination of knowledge representations for different problems, specification of search strategies, and dynamic building tools for the KBS–MEDIA systems. These steps are repeated, as work progresses (figure 5).

In the future, systems will be developed that will 'learn' or be more open to acquiring knowledge than before (Christiansson, 1986a). This prospect demands that we do our conceptual modelling work properly. We must make appropriate definitions of model structures, objects and their relations, and model-building tools (as in the palette shown in figure 6). We must provide suitable access to the model for its construction, use, and maintenance; and we must be open to trying out completely new concepts. It is better to make a bigger effort in the early stages of designing a system, than to have to make changes later because of insufficient preparatory work.

It is very important that the work of conceptual modelling is done in close collaboration with the end-users of the system. One way to expose the system to

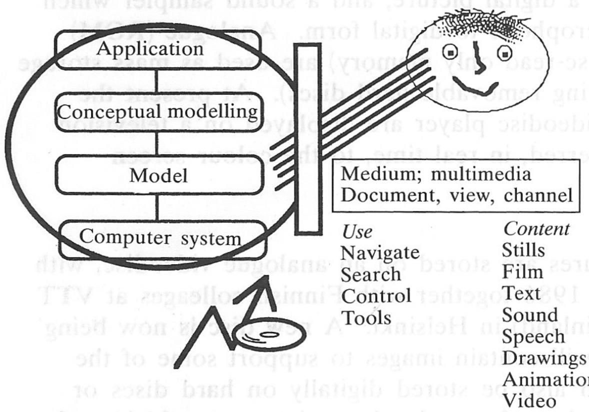

Figure 5. Conceptual modelling, the model, and the hyperdocument.

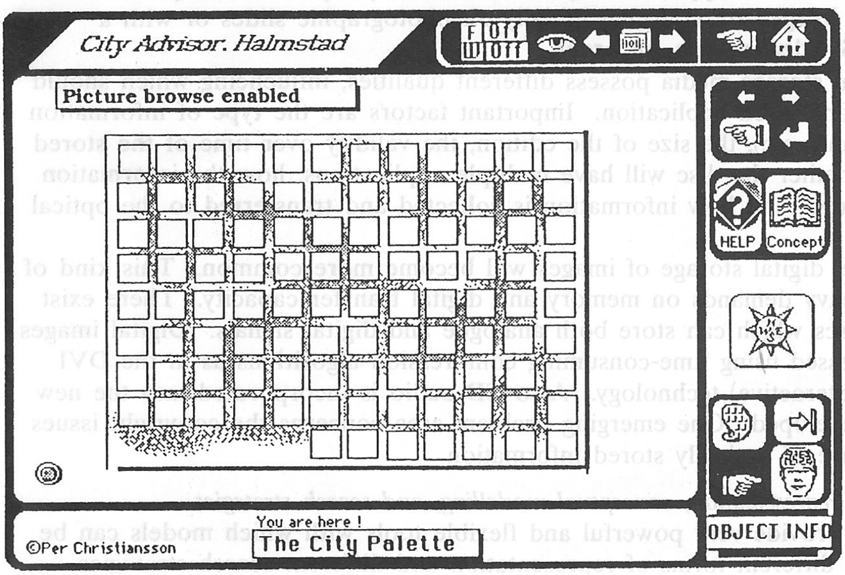

Figure 6. A palette in which to browse among pictures of objects and pick references to objects in the City Advisor. The palette in this application is created automatically from the object description stack. The palette is touch-sensitive: no clicking on the mouse is needed. (Source: Christiansson, 1988).

these users is to create a *demonstration* system (see below). This is especially important when the user interface is being worked out. Which associations does the user make, for example, when working with the problems in hand? New concepts are formulated at this stage and tried out.

3.5 *Generic tools for problem-solving: man–machine interface controlling the KBS–MEDIA system*

Mention was made earlier of how easy it is to get 'lost in hyperspace' when using 'hypermedia' systems. How can we make sure that the user is in control when he or she uses these systems? It is possible to navigate in the information space and to access information in different ways: by using *browse* tools such as the KBS–MEDIA palette shown in figure 6 and at the right of figure 7; by *searching* in text, sound, picture descriptions, etc (the search can, for example, be made as a Boolean search or a free text search); through *links* between objects in HyperCard (established with HyperTalk scripts); by using *decision-support* systems and 'intelligent' agents (background experts); by using map *analogies* (picture, drawings, etc) 'attached' to objects; by providing good *tracking* possibilities (in HyperCard, for example, the way can be marked by 'pushing' card addresses to an address stack, which is read and emptied with 'pop' commands in HyperTalk, so allowing backtracking); by making the system *flexible* to the user's intentions and current activities; by the providing *alternative* search paths and *guided* search.

We cannot yet search explicitly for patterns in pictures or sounds, but this possibility will surely be available 'soon'. Our senses of sight and hearing capture the output from the system, including speech output from both computer and videodisc. The user's input to the system is in the form of text or by means of pointing devices. As research in pattern recognition progresses we will be able to allow other more sophisticated forms of input to the system.

In the KBS–MEDIA systems we use the notions of *context* and *status* to describe different states of the objects relating to the application or different states of the users [whether working in system learn or navigate mode (Christiansson, 1988), viewing information, etc].

Figure 7. Top level of the 'map' geographical model. the map palette is temporarily called up (at the right).

3.6 *Demonstration system*
Demonstrations are built up in the KBS-MEDIA environment. These demonstrations are used to *capture*, *test*, and *communicate* ideas in the different projects which use the systems. Prototyping is made fast and simple in a demonstration system. It is extremely important to expose the ongoing work to end-users and experts from domains other than the building field, in order to get valuable feedback. When groups larger than ten people are involved, a wall-projection unit is used instead of the computer screen. The system then also becomes a very powerful tool for the transfer of knowledge to groups of people.

4 Using and building the City Advisor
4.1 *Structure and control of the model*
Some comments are given below on how a hyperdocument might be used and also expanded by users who are knowledgeable about the application area. Figure 8 shows the main entry point to the City Advisor, which provides information to planners and tourists about the city of Halmstad in Sweden. The MAP and Halmstad object index buttons transfer control to different parts of the model containing: the geometric model or 'map' of the city (scanned maps, drawings, digitally stored images, recorded sound, etc) and the 'Halmstad object index' (also called 'object stack', although not stored in a separate stack) with descriptions of objects in the city linked with pictures and video films on videodisc (figure 9). An object such as a house or a street may be described on many cards in the object index. Each card in the index has a unique connection to an image on the videodisc.

In figure 8 we also see:
Select mode: navigate or learn. In learn mode the model-building tools are available and made visible. That is, the system is accessed on different levels depending on the user's knowledge about the application. Audio (speech) warnings are delivered when select mode and the users' intentions do not coincide.
The 'compass card' icon which makes the *map palette* appear (see the right-hand side of figure 7 where the palette is activated).
Entry to the 'experts', allowing a background expert or agent to be called up.

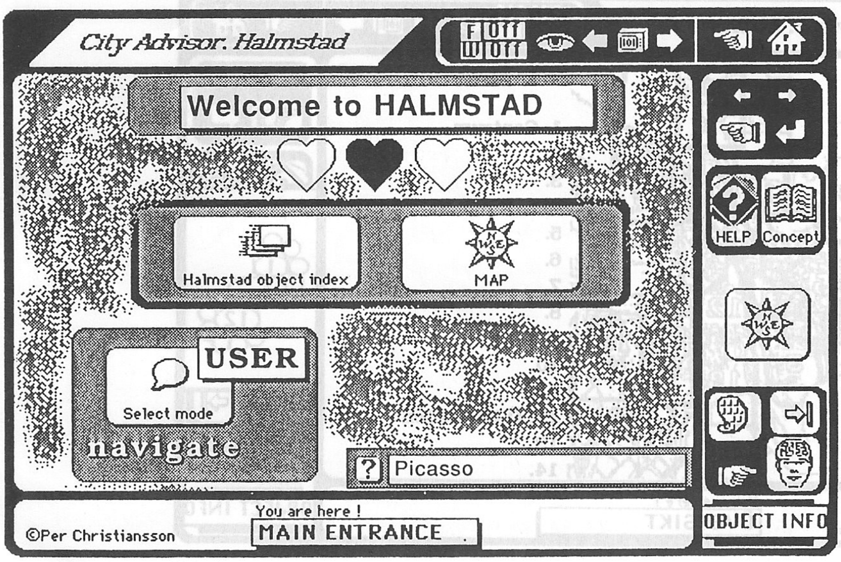

Figure 8. The main entry point to the City Advisor hyperdocument.

This is done by pressing the icon of the little man with the 'brain', in the lower right corner. This is a menu-driven call.
Tools to search the 'map' (the right-pointing arrow icon at lower right in figure 8) for an object which has been found while browsing objects on the palette (figure 6) or by navigation in the object stack. A flashing arrow on the map indicates the point from which the object was reproduced.
The *palette* (figure 6) which is reached by pressing the 'palette' icon (just above the hand in figure 8). The palette is touch-sensitive and needs no clicking on the mouse.
Tools to search the object index for the occurrences of specified text in the descriptions: the relevant object cards and connected video images are then displayed. Search is initiated and can be continued using the 'hand' icon.
Means to obtain information about the object displayed by pressing the OBJECT INFO button in the map stack, which passes control to the object index stack (lower right in figure 8).

The geographical model of the city has a hierarchical structure which can be traversed both horizontally and vertically. The sections which follow give an idea of how the City Advisor hyperdocument can be developed and used. We can control, search, navigate, and build a rich information space dynamically. We can navigate and search along many paths through different channels—text, graphics, and so on. We can add new knowledge to the document, and can get information from the document as to how to use it.

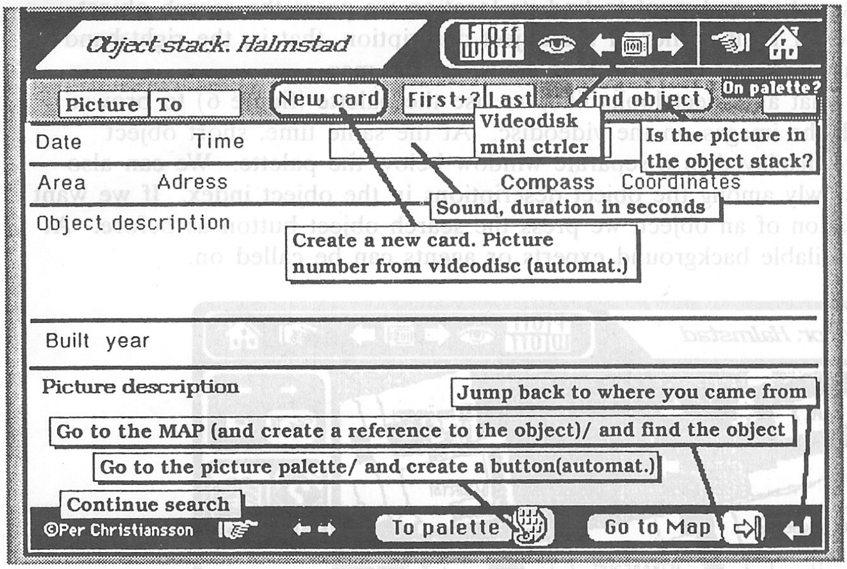

Figure 9. Layout of object descriptions with tools to build, search, and navigate.

4.2 *Background experts*
The 'background experts' are called up to give support to the user in making decisions in different situations. These experts may be knowledgeable about either the actual application area, or about how to use the tools available in the system. They will also be available in a more transparent way later and will to some extent converse directly with the rest of the model; for example, to get access to data relating to a situation or context. The experts are currently reached via the icon of the man with the brain.

4.3 *Using the model*

In this section I describe how to use the City Advisor. After entering the City Advisor hyperdocument we can walk around in the city and at any time press an arrow like those shown on the map in figure 10. A videodisc image is then displayed, showing the object in the position where the arrow is placed. At the same time the Latest object! text field on the map is updated. The name of the current part of the map is displayed in the You are here! window. If we are familiar with the different details of the map of the city we can call the special map palette (to the right of figure 7). When the cursor is moved over the palette, different parts of the map are shown. If the mouse is pressed, the map is frozen and the palette hidden.

If we want to get a more detailed description of the object, we can press the OBJECT INFO button (lower right corner in figure 8) and a more detailed description is displayed, as the layout in figure 9 shows. We return to the map by pressing the 'jump back' arrow. The model knows which was the last object we looked at. This means that we are free to do other things and then return to that object by pressing the 'search object' icon immediately to the right of the palette icon, or navigate back through the map.

The 'search text' icon (the hand) lets us immediately search the objects for the occurrence of a certain text string. If we want to update the text search, we can enter new text in the Picasso field (see figure 8) which is automatically in the right position to do this. The hand icon can be used from anywhere. If we reach a new object description and want to find its location we press the search object button in the lower right corner of the object description, that is, the right-hand arrow. We must look out for a flashing arrow on the map.

If we know what an object looks like, we use the palette (figure 6) to browse quickly through the images on the videodisc. At the same time, short object descriptions are displayed in a separate window below the palette. We can also browse more slowly among the object descriptions in the object index. If we want to find the location of an object, we press the search object button as before. At any time the available background experts or agents can be called on.

Figure 10. When the system is in learn mode the New button tool appears (lower left). A reference is picked either from the palette (figure 6) or from the object descriptions (figure 9).

4.4 *Building the object index and palette*

In order for a user to add knowledge to the model, the system must be in learn mode. This is indicated on the entry point to the City Advisor and also as a verbal message when the help button (the questionmark icon) is pressed.

New object or picture descriptions are created using two different tools. The videodisc minicontroller (upper right in figure 9) is used to find an image on the videodisc which describes the object in question. If it is known that this image is unused, the New card button must be pressed. A new card is created which can be filled with information about the object and picture. The process can be repeated. If the system is in navigate mode, a verbal warning is given and the New card button is inactive. It is possible to check if an image found on the videodisc already has a corresponding object or picture card by pressing the Find object button (see figure 9).

If it is required that the object or picture description should have a corresponding touch-sensitive spot on the palette (figure 6), the palette icon at the bottom of the card must be pressed. If such a reference already exists on the palette, or the system is not in learn mode, a suitable verbal message is given.

4.5 *Creating references to objects on the map*

The system must again be in learn mode for references to be created to objects. In learn mode the New button icon is visible and active. Once a view of an object has been picked from the object index (figure 9) or from the palette (figure 6), it is then necessary to navigate to the appropriate part of the map and press New button. A button will appear which must be dragged and placed on the map. This button will, like the palette button, have a script or message handler which makes the correct calls to control the videodisc when activated.

5 Projects in the KBS-MEDIA environment

The following building applications are at the moment the subject of research. (a) The City Advisor hyperdocument for Halmstad, as already described. A smaller similar document is being produced for Lund. (b) A Window Renovation Advisor. This is a system which supports designers and maintenance people in diagnosing damage to windows and giving guidance on renovation. (c) The Advanced Information Technology in Building Maintenance Support system (the Delphi project). This is a project carried out in collaboration with the Lund Academic Society (a housing foundation) and the Swedish Building Regulation authorities. The end-users are tenants and people involved in building maintenance. (d) The Advanced Material and Vendor Information system. This is a new generation of vendor information system or 'hypercatalogue' of building materials which is being developed and demonstrated. The project is carried out together with the Swedish Building Centre. The catalogue will possess qualities and contain information not available in today's systems. Other projects are planned or in their initial phases. Some projects are concerned with the transfer of knowledge in the context of education or communication between people using hypermedia technology.

6 The future

After a few relatively calm years we can now expect a rather turbulent period of evolution in computerised tools such as hypermedia systems—although that concept is several decades old. Many different solutions to the problems will be formulated, tested, and hopefully compared, so adding to our experience and knowledge. Information technology must become adapted on a higher level to demands from users in different domains. We will have a less technology-driven development of the new tools. There will be no shortage of challenges and work to be done.

Integration will be achieved on a higher level than before, in more loosely linked models, and with great emphasis on styles of communication and the way we describe work, products, and so on. More hypermedia or hyperdocuments will be developed and will become common. They will also function as interfaces and supports to other systems, such as manuals, databases, calculation programs, networks, etc. Research on knowledge representation and knowledge acquisition will be intensified. Machine-learning mechanisms and rules will again be important as a subject for study. The transfer of knowledge and communication between peoples and cultures will be intensified. It is to be hoped that cross-fertilisation and collaboration will increase between different interest groups and 'experts', that minds will be open, and creativity will flow.

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