

THE POTENTIAL OF HYPERMEDIA TO PHOTOINTERPRETATION EDUCATION AND TRAINING

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PURPOSE:

Hypermedia is an authoring environment, an idea organizer tool or a conceptual indexing tool. A hypermedia information base consists of interlinked pieces of text, graphics, full motion video, animation and sound. The authors examine how educators teaching photointerpretation could use this technology for more effective presentation and teaching. A photointerpretation hypermedia system can help put information related to objects, attributes, their clues and recognition methods in obvious patterns so students could interactively and non-sequentially locate, browse, and understand the photointerpretation concepts and processes. The marriage of multimedia and expert systems is also inevitable. Hypermedia systems can help to build less ambiguous decision support systems and knowledge-bases and thus make expert interpretation systems more intuitive.

KEY WORDS: Photointerpretation, hypermedia, expert systems, knowledge representation hypercard, teaching

INTRODUCTION

Photointerpretation is still an art, using science for only its most basic foundations. Practice relies on the case-study method and intuitive judgement more heavily than is commonly believed. Photointerpretation relies on an imprecise combination of information gathered in different ways and processed in a largely intuitive and recursive fashion. Overall impressions are gathered and interpretations are made, but the photointerpretation process remains obscure (Argialas et al, 1999). There are few definitions and descriptions of photointerpretation objects given in the literature. And, there are even fewer explanations of the procedural or inferential framework of the interpretation process (Argialas and Narasimhan, 1988a; Narasimhan and Argialas, 1989). This may be so because of the difficulty of the problem itself, the lack of theory and technology to assist in the symbolic representation of the complex inferential process (Argialas and Narasimhan 1988b), and in the extraordinary emphasis that has been placed on the digital image processing paradigm. The last reason has contributed to our sidetracking from forming a workable photointerpretation paradigm (Ryerson, 1989). For the last two decades little attention has been paid to rigorous, visually-based image interpretation. This severely reduces our ability to effectively interpret and use the TM, SPOT, and other sensor images.

There is, therefore, a need to study methodically the process of building photointerpretation keys and to develop a systematic framework for the recognition of objects from aerial images using information specific to how objects appear on a given image as well as information available in the

mental models of expert photointerpreters. The proper application of such keys will allow a novice interpreter to tap onto the knowledge base of the individual who offered her/his knowledge for building the key. To build such keys it is necessary to have a thorough understanding of the domain specific knowledge and of the new theories and technologies in representing, managing, retrieving and formalizing knowledge (Nielsen, 1990; Shneiderman and Kearsley, 1989; Parsaye et al, 1989; Bielawski and Lewand, 1990). Advances in hardware and software has contributed to a new set of techniques for computer aided instruction and presentation systems of unparalleled impact. Hypermedia and knowledge-based expert systems can offer us the base on which to develop a workable visual image interpretation paradigm similar to the keys of the past. Argialas and Harlow (1990) have examined the potential of expert systems for image interpretation. In this paper the authors examine the potential of hypermedia for photointerpretation and present the rationale underlying the structure and design of such systems.

THE HYPERMEDIA CONCEPT

Hypertext was born of the need to devise text storage and retrieval systems capable of managing efficient large masses of information. All traditional text, whether in printed form or computer files, is sequential, that is there is a single linear sequence defining the order in which the text is read. The idea behind hypertext is to read text non-sequentially. Hypertext has departed from the sequential, linear storage and retrieval of text to a random-access, nonlinear method with many options and alternatives (nielsen, 1990). Hypertext can present several options to its readers, and each one determines which

options to follow at the time of reading the text. The author of the hypertext has to set up the alternatives for the readers to explore. Assuming the analogue of the familiar 3 x 5-inch card, hypertext provides the tool to partition our knowledge into cards, representing the knowledge content as a chunk of text, and into links, representing the associations and relations among the cards, that is the structure of our knowledge. The result is the development of hierarchical or network linkages among knowledge chunks.

Hypermedia or multimedia systems extend the linking and integrating of textual information to include all kinds of computer based information such as stereo audio, full motion video, animation, and graphics. They also provide mechanisms to control and synchronize numerous external devices, such as laser disk players, CD-ROMs, and CD-I (compact disk interactive) (Rosenthal, 1990; Veljkov, 1990). The fact that a system is multimedia-based, that is, it employs a mixture of text, graphics, animation and video is not enough in itself to characterize a system as hypermedia. Only when users interactively take control of a set of dynamic links among units of information does a system get to be hypermedia (Nielsen, 1990).

Hypertext and hypermedia systems present a style for information representation, management, and presentation around a network of multiple connected nodes allowing the user to jump easily from one topic to related or supplementary material and thus they allow diverse type of information to be linked and accessed rapidly and by association, much as a human being accesses related information. Thus, hypermedia systems provide a means to organize knowledge in easily accessible and intuitive patterns.

THE HYPERMEDIA ELEMENTS

To describe some of the specific features available in hypermedia systems, we have chosen Macintosh's Hypercard which is one of the most popular hypermedia engines. Nodes are the fundamental unit of hypermedia, and the basic node in HyperCard is represented as a card. A collection of cards is called a stack. This notation is analogous to the concept of 3x5 inch cards used for notes. Cards consist of text fields, graphics, video, sound and buttons providing the links to other cards and stacks. Graphics can be either scanned images or object-oriented pictures. Buttons are one of the methods for implementing hypercard links.

Hypercard links are pointers from one card, called departure card, to another card called the destination card. Links are implemented in Hypercard through first constructing buttons or anchors on the card and then associating a language script with them. Anchors can be either words, text strings,

buttons, or graphics. Anchoring, thus, may take the form of embedded menus where part of the primary text or graphics does double duty serving both as information and being the link anchor (Nielsen, 1990). The number of links of each card varies with its information content.

The scripting of the buttons and anchors is written in the HyperTalk programming language. HyperTalk is an object-oriented language of HyperCard that can be used for writing and passing messages among HyperCard objects, e.g., buttons, fields, cards, backgrounds, and stacks. A message is generated by (among other means) clicking the mouse, opening a card, or typing a statement into the Message box (HyperCard Stack Design Guidelines, 1989). The manner that a given object responds to a particular message depends on the object's script. It is possible to call external application programs or programs written in a traditional programming language like Pascal or C.

The hypertext structure forms a network of cards and links. The activity of moving around this network is referred to as browsing or navigating, rather than just "reading," to emphasize that users must actively determine the order in which they read the cards (Nielsen, 1990). When users follow the links around the hypermedia network, they will often have a need to return to some previously visited card. Most hypermedia systems support this through a backtrack facility. HyperCard has a menu which includes a "recent" choice, which displays up to 42 of the most recent cards seen; these cards are displayed in miniature and in sequence. Access to any of these cards is immediate upon a mouse click. Access to an individual card in any stack may be obtained by calling the card by name and/or its stack using the message box in conjunction with the "go" menu, or by searching for key words or phrases using the "find" choice in the "go" menu (Goodman, 1987).

THE HYPERMEDIA TOOLS

Authoring tool is the term used for any system that can be used for building hypermedia systems. Authoring tools are available for many platforms. They are, however, far better developed on the Macintosh platform than on the workstations and IBM PCs and clones. Macintosh's Hypercard has become the most widely used authoring tool for work concentrating on the content of the hypermedia instead of features (Nielsen, 1990). This development is probably due to Macintosh computers (1) being more widely available than the more expensive workstations, and (2) being good for prototyping graphic user interfaces through Hypertalk. This situation is slightly changing though by newly announced products for the Amiga, IBM's OS, and MSDOS/Windows. Other authoring tools

available for the Macintosh include Director from MacroMind (San Francisco, CA) and Authorware Professional from Authorware, Inc. (Minneapolis, Minn.). Guide from Owl International is an example of an authoring tool for both IBM and Macintosh computers. KMS is an authoring tool available for UNIX based workstations. There are few research prototype engines for unix stations, and even fewer commercial engines.

The choice for an appropriate authoring tool for a certain application will depend on the needs of the individual building the system and the specific features required for the application. The following paragraphs outline a tentative set of features for choosing an authoring tool for building a photointerpretation information base into a hypermedia system.

The authoring tool should have hypermedia functions which will help to dynamically link text, images, graphics, video, sound or animation to additional information. These functions are not explicit in all authoring tools today. In Hypercard, for example, when the designer opens a new card or stack, finds himself with a blank card in which he needs to build each and every element of the system. All the links, except of the most trivial, need to be programmed in Hypertalk.

The authoring tool should also include an explicit representation of the network structure in its user interface. In most current systems that network is only present inside the computer and it is up to the user's imagination to picture how the entire network is structured. A dynamic overview showing the structure of this network is desirable (Nielsen, 1990). Hypercard does not embody a browser to permanently show overview diagrams of the network structure, while some of the unix based systems, like KMS, do. Such systems, though, are not as widely available and as inexpensive as Hypercard.

The authoring tool should contain the basic tools needed by any author, such as integrated word processors, spelling checker, and graphics editors for preparing the text fields or making good illustrations. Text files, graphics, and animation should also be easy to import from other applications. Multiple graphics formats should be recognized and supported. The multimedia system should also take advantage of the particular graphics hardware and it should be able to handle all the colors and resolutions of the hardware. It should also supply drivers for controlling external media such as laser disk players and other remote media peripherals.

An authoring system should also provide for integrating the output of external applications into the system and to actively and dynamically interact with an expert system environment. NexpertObject, an expert system tool available from Neuron Data,

provides an integration module for Hypercard. HyperX (from Millennium Software) is an expert system tool written in HyperTalk that integrates with Hypercard as well.

While one of the newest interactive multimedia tools is digitized sound, it does not appear that a hypermedia interpretation system will be greatly profited from digitized sound, especially if one takes in account the storage requirements. It should be mentioned though that all Macintosh II machines include a built-in sound chip that can play back digitized sound and there are external sound digitizers available from third parties. There are also boards and drivers for the MS-DOS/Windows machines as well. Single-screen interactive video, which implies showing motion video and computer information on the same screen is possible by obtaining a single-screen board from third party manufacturers.

A special hardware concern in the design of hypermedia is the storage space needed for the multimedia in hypermedia, especially if digitized images, voice, and video are used. Some writable optical disks exist and can be used to store between 550 and 650 megabytes of data. A variety of compression methods and formats are also being developed that could help alleviate the problem. Another hardware requirement is for larger screens (19-21 inches). Larger screens will allow students to see more hypermedia material at the same time and allow room for various extra user interface features such as permanently shown overview diagrams.

An authoring system used for photointerpretation training should maintain records of students who participate in the course. The records might include such things as the number of correct answers a person made, or how long it took a particular person to finish a specific section.

It should be easy to learn and use without the support of a full-time programmer or a hardware engineer. It should not require of an expert photointerpreter to learn and use a programming language to create a hypermedia application. However, it should either contain its own procedural language or offer a direct access to such a language for those who wish to program advanced or additional features. It should also offer context-sensitive help for both the developers and its users.

AUTHORING HYPERMEDIA SYSTEMS

Building a hypermedia system is often called authoring a hypermedia system. Authoring in hypermedia is different from regular text authoring in the sense that the author must provide opportunities and priorities for knowledge exploration instead of ordering users to read sequentially (Nielsen, 1990). This is accomplished by first establishing an

appropriate set of nodes and then creating the links between these various nodes.

Establishing the nodes involves dividing the unrefined, implicit photointerpretation knowledge into meaningful chunks or units of knowledge. These nodes in most cases will be card-like or scrolling windows. They can be as simple as a single word or as complex as a textbook, depending on the granularity of knowledge representation. Indeed, it is the variety of nodes that hypermedia nodes can represent that makes them so versatile. Having a single topic for each node makes it easier for the author to know what links to construct. This process of knowledge decomposition or compartmentalization will continue until all of the available information is divided into individual definable nodes.

Compartmentalization of knowledge can take place either in a top-down fashion or in a bottom-up approach. If one is trying to convert an existing textbook or photointerpretation manual to a hypermedia system then it would make sense to start in a top-down fashion. In this case decomposition of knowledge can take advantage of the existing structure in the textbook or manual. On the other hand, if one is writing a new interpretation guide, it will make sense to compose it by building it from the bottom up.

Once we have partitioned the specific photointerpretation knowledge into a set of nodes, it is necessary to define their interactions and decide how they are related to each other. This involves determining the linkage among these nodes, that is, to decide not only which nodes are related to others, but also the exact nature of the relationship. To do so we need to identify explicitly the various types of links between the nodes of the information base so that to capture the semantic relationships (associations) of the photointerpretation domain (Argialas, 1989a). Semantic relationships can define organizational or conceptual links. There are several types of links (relations or associations) that can be identified, such as *is-a*, *is-a kind-of*, *contains*, *is contained-in*, *is adjacent to*, *refers to*, *consists of*, *implies*, *is-related-to*, *precludes*, *is more general than*, *leads to*, *is similar to*, *precedes*, *follows*, *is-an-example-of*, *is-a-simplification-of*, *supports*, *data*, and others (Bielawski, 1990).

Most photointerpretation textbooks/manuals have relative extensive, explicit or implicit, implications, relationships and cross-references among photointerpretation objects, elements, clues, and methods which can be used as the basis for identifying proper links. Good links should provide the means of organizing information within the hypermedia framework in patterns that may not be immediately discernable to students without the help of the navigational tools offered by the links. Indeed, good links could help to categorize photointerpretation concepts/techniques into semantically related

units or chunks which will be linked and accessed by association, much as a human being accesses related information. In this sense their definition and implementation within a system is critical to its success. The challenge in choosing nodes and links is to structure the photointerpretation knowledge in a way that supports the mental models that students may create when they use such a system.

The variety of interpretations of links can add to the flexibility of the hypermedia information base but it may also contribute to a chaotic hyperspace. It is important to use photointerpretation related names for the links or destination nodes in order for students to be able to understand their navigation options. The number of links should depend on the content of each node. Every extra link is an additional burden on the student who has to determine whether or not to follow it so we should add only those links that are truly important and relevant. It is suggested that a good hypermedia design should tell the user why the destination for a link was an interesting place to jump to by relating it to the point of departure (Nielsen, 1990).

When hypermedia system nodes and links are defined in a conceptual or organizational way, they are capable of forming semantic networks, that is a graphical representation of objects or concepts formed into nodes that are linked together in an associative way. Semantic networks are an expert system representation method and, thus, establishing conceptual links between hypermedia nodes provides the basis for a subsequent representation in an expert system environment.

The above outlined guidelines for partitioning the photointerpretation knowledge in a set of nodes and links has assumed that the knowledge lies somewhere ready to be distributed into nodes and semantic links. This was a simplistic perspective. Indeed, there is a natural tendency to underestimate the difficulty of conceptualizing implicit knowledge. In place knowledge (textbooks, manuals, expertise) does not appear in some form that neatly fits abstract symbolic categories and explicit relations and associations like those used in computers (languages, databases, expert systems, hypermedia systems). Lying like an unmined and unrefined substance, implicit knowledge somehow enables the expert interpreter to recognize objects appearing directly on aerial images or to infer objects indirectly. Photointerpretation knowledge consist of a substantial number of concepts, facts, beliefs descriptions, relationships, dependencies, constraints, empirical associations, and procedures or decision rules for manipulating these descriptions and relationships in order to reason and draw conclusions. A hypermedia information base, needs to embody the right type, level, and amount of this knowledge in order to assist or teach students the photointerpretation approach.

Acquiring, elucidating and conceptualizing such knowledge is the central task in building intelligent systems. Intelligent conceptualization is intellectually hard work, and it best comes about through an incremental and iterative process.

While this paper argues in support of hypermedia, it is written in a linear, sequential manner. It will be an erroneous hypothesis to assume that the process of decomposing knowledge takes place in a series of successive steps. We, somehow, are doing many steps in parallel, while their implementation is normally taken place in a serial manner. Hence, the actual process of knowledge conceptualization is extremely hard.

IMPLEMENTING A HYPERMEDIA SYSTEM

Once we have partitioned the specific photointerpretation knowledge into a set of nodes and links the next step is the implementation of the information base in a hypermedia system. A certain hypermedia environment is selected and the sets of nodes and links are formally represented and programmed. Assuming that a Hypercard-like system is selected, one needs to determine the nature of the stack(s) to be designed. The previously designed partition of the knowledge into selected nodes and links together with the need for easy and efficient navigation can help determine each stack's structure. Hypercard supports single-frame, linear, tree, network, and combination stack structures (HyperCard Stack Design Guidelines, 1989). Given the complexity of the photointerpretation process, it is speculated that a network or combination stack structure might be most appropriate. A network stack structure is one in which students can explore in many different ways (e.g., visiting other cards or stacks). Navigation in network stacks may be by reference points (or hubs), stack maps or menus.

Depending on the specific subject matter one may choose to include various levels of image interpretation tasks for the most significant aspects of general photointerpretation in one stack. Additional stacks may be required for advanced interpretation tasks and for specialized tasks, such as interpretation of specific geologic formations or specific tree species. Hypermedia systems permit and encourage one to build a system incrementally, creating new nodes/concepts and links as desired, one at a time. Indeed, building a hypermedia system is a cyclic, repetitive process. It is likely that the design of the stacks, cards, fields, buttons, etc will change significantly in the beginning. One approach that could help to cope with this iterative process is to think of several solutions, design all of them to a certain point, and then choose one for further development.

Some general guidelines for good stack design are outlined in the following (HyperCard Stack Design Guidelines, 1989). The system should exhibit a well organized, orderly, and well structured arrangement of cards, fields, graphics, and buttons so that students will be quickly able to learn, understand, and use the system structure, the most basic commands and the navigation options to locate needed information (Nielsen, 1990). The hypermedia cards can include as much text or graphical elements as appropriate, but screen-sized chunks of information should be mostly used because attaching more lengthy information to a hypermedia node that must be scrolled through on successive screens can be disorienting to the student.

The hypermedia design should take advantage of the hypermedia functions of the selected authoring software system. It should put information in obvious and intuitive patterns so students can more easily locate, browse, and understand the photointerpretation knowledge. Good links should relate concepts (not words), provide minimum keystroke access to these concepts, and help students to see the relationships between concepts.

Card and background layouts should be consistent for related cards. Navigation buttons should be on every card, grouped by function, and in the same place throughout the stack perhaps on the edges of the screen. The overall design should help the student to control the navigation. The students student should be able to find a certain piece of information quickly or soon discover that it is not in the information base within a minimum number of keystrokes. The stack's navigation must make use of menus, maps, textual reminders, you-are-here indicators, travel buttons, and progress indicators. The stack should also have a title card, a proper introduction describing the stack's purpose and organization including the stack's size and general layout, the stack's rules, and their options. Topical menus, tables of contents, and alphabetical listings should be explained. A button of "Help" or "How to use this stack" should be included on all cards. The system should also offer context-sensitive help.

The photointerpretation hypermedia system should include a great number of aerial, oblique, and ground photos as well as a lot of illustrative diagrams such as cross sections, profiles, and block diagrams. The stimulus for seeking to include diagrams and photographs comes from the inherent complexity of the photointerpretation process. Incorporating photographic images will serve to illustrate conditions that are too complex for verbal explanation alone. The photographic images reduce the potential for confusion and misinterpretation by illustrating objects and conditions that might be misunderstood if only descriptive text were used. All potential uses of photos

need to be investigated as well as the options by which they need to be accessed by the students.

Scanners are available to capture images from photographs, slides or videotape frames. Scanning technology has yielded an increase in the format (A to E size), type (flatbed and drum), gray level value (0 to 255), and resolution (75 to 1000 dots per inch) that can be obtained from commercially available scanners. The common output from a scanner is a file that contains one or three bands of digital data that represent the image being scanned. This file is a two-dimensional array made up of pixels (picture elements), each of which has a recorded spectral value between 0 and 255 in each of one to three bands. Images from videotape and still video cameras that generate a National Television Systems Committee (NTSC) standard signal can also be grabbed using an appropriate frame grabber and image processing software. Software is available to convert these images to that they can be displayed on a microcomputer or workstation. Finally, Hypercard or external commands can display the images at appropriate windows during the interaction between the user and the hypermedia system.

The final phases of system design is testing and evaluation. Testing should involve frequent checks during the design and development of the hypermedia information base for such things as navigation and use of stacks, buttons, text fields, visual effects, and sound. Once the network has been constructed, one must trace all its paths to verify that it actually captures the relationships among all of its objects. Depending upon its completeness and accuracy, it may be necessary to refine the stack structure or even repeat the process one or more times to obtain an exact model. Evaluation can take place by watching and listening to testers and reviewers carefully. The stacks should also be checked on all intended machines with all possible memory configurations.

HYPERMEDIA AND EXPERT SYSTEMS

The marriage of multimedia and expert systems is inevitable for two important reasons: (1) hypermedia can provide context sensitive help for expert systems, and (2) hypermedia can be used as the initial step for conceptualization of the photointerpretation knowledge which subsequently will be represented in an expert system tool (Parsaye et al, 1989; Shafer, 1990).

While, the ability to provide context-sensitive help has become a standard in many commercial applications software packages, it is uncommon in most expert systems including expert interpretation systems (Argialas and Narasimhan, 1988, Argialas and Harlow, 1990). A hypermedia information base is needed to assist the novice analysts of expert photointerpretation

systems to understand those terms of the knowledge base that are ambiguous or hard. A hypermedia system may allow us to communicate with an expert system more effectively and efficiently. Representing key terms within a hypermedia system can make the expert system more intuitive to the users and provide the foundation on which a more comprehensive and less ambiguous knowledge base can be built.

Incorporating photographic images in expert systems through a hypermedia system may serve to illustrate conditions that are too complex for verbal explanation alone. The student would have a visual aid to enable him to understand the knowledge base terminology and have a more consistent approach to visualizing photointerpretation objects and attributes. Definitions, descriptions, diagrams and photographic images may reduce the potential for confusion and misinterpretation by relying on the intrinsic perceptual intelligence of the user and so tend to avoid misunderstandings that could result if only descriptive text were used. Hypermedia can be used to offer users not only a single piece of explanatory text or a visual aid but also a doorway into the entire photointerpretation knowledge through links active from that particular node.

Hypermedia can also be used to assist us in the development of expert photo interpretation systems. A photointerpretation hypermedia system could help to outline the photointerpretation knowledge base. While hypermedia by itself is not capable of creating intelligent applications, it can help to delineate the overall photointerpretation-related domain by revealing how certain components or objects are related to each other and to the clues for their recognition.

Building a hypermedia information base could help us, relying on our own natural intelligence, to acquire, conceptualize, organize, structure and represent the structure of photointerpretation knowledge in a semantic network which consequently can be implemented in an expert system formalism. Using hypermedia in this capacity it may also reveal the highly complementary nature of hypermedia and expert system technologies.

AN OUTLOOK

A photointerpretation hypermedia system will allow students to interactively and non-sequentially locate, browse, and learn photointerpretation concepts and processes. To the degree that the photointerpretation hypermedia system will emphasize the relationship between concepts and ideas instead of words, it might make photointerpretation easier to learn. The associations provided by links in the hypermedia system will facilitate remembering relationships between ideas, concept formation, and understanding. The greater sense of control over the reading process may produce involvement and desire

to read more. The challenge is to structure the photo interpretation knowledge in a way that supports the mental models that students may create when they use the photointerpretation hypermedia system.

Progress in representing photointerpretation knowledge in hypermedia and knowledge bases will be parallel to progress made in many closely related scientific and technical fields such as knowledge-based spatial data handling systems, distributed knowledge-based interactive blackboards, fuzzy computer system architectures, parallel computer system architectures, graphic user interfaces, visualization, 3-D graphics, and natural languages.

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