HYPERTEXT DATA BASE APPLICATIONS IN CONSTRUCTION

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ABSTRACT: Hypertext is a data base system of text and graphics that allows a reader to jump from idea to idea depending on one's interest. Hypertext can be applied to construction to provide interactive reference manuals for controlling construction operations. Other potential applications for hypertext in construction include data bases of regulatory information and as advice programs for planning and estimating. An example hypertext data base that provides advice for the construction of asphalt pavements is described. The purpose of the asphalt hypertext system is to consolidate information on the construction inspection of asphalt paving in a single data base. The prototype system was developed using the Hyperties hypertext development program. The system is implemented on an IBM-AT compatible computer. Hyperties allows drawings to be incorporated in a data base. The asphalt paving system includes drawings of the major components of the asphalt paving machine. The data base has articles of expert advice, standard specifications, and reference documents. Potentially, hypertext data bases can provide construction engineers with improved access to information about construction.

INTRODUCTION

Hypertext can be defined as a data base management system that provides connections between files of information, both textual and graphic. Hypertext is a tool for building and using associative structures. A normal document is linear, usually read from beginning to end. In contrast, a hypertext document allows the reader to jump from idea to idea, depending on one's interest (Parsaye et al. 1989).

Hypertext programs have the capability of providing interactive reference and advice programs for use on the construction site. The primary potential benefit for application of hypertext to construction is to provide better information to construction decision makers. A hypertext system can consolidate construction information from diverse sources, and allow construction field personnel to access reference information quickly.

Hypertext systems have some general characteristics that differentiate them from other programs. Hypertext documents are not separated from each other like word processing documents are. Potentially, a document in a hypertext system can be connected to any another document. Development of hypertext documents typically do not require any programming expertise. The system developer can be viewed as an editor who defines the links between documents. Hypertext systems have user customizable features that allow the developer to link documents together in any desired manner. A hypertext document can, therefore, be a free-form data base, or a highly structured hierarchy of information (Louie and Rubek 1989).

Development of hypertext systems is possible for both IBM and Apple Macintosh personal computers. Example hypertext development systems in-

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clude Hypercard for the Macintosh and Guide, which is available for both the IBM-AT and the Macintosh. Typical hypertext software has a text editor, graphics editor, data base, and browsing tool. The purpose of the browsing tool is to allow users to find their location in the network of nodes of information.

There has been considerable interest in hypertext applications for educational purposes and for use as reference manuals. Hypertext has been used to develop interactive textbooks for college courses. A hypertext system was used to provide documentation for the Apollo space program (Conklin 1987).

Hypertext Reference Manuals for Construction Operations

A primary area of application of hypertext systems is as reference manuals to aid in the control of construction operations. Construction operations can be defined as the work processes that are basic to the accomplishment of the physical components of a construction project (Halpin and Woodhead 1976). To provide high-quality construction, it is important that field agents responsible for controlling the construction operation have ready access to information so they can make correct interpretations and decisions about the conduct of the operation.

With the continued development of laptop computers, the potential exists to provide inexperienced construction field agents with quick access to reference material on the construction job site. It is impractical for many construction field engineers to carry all the required reference materials for a project in the field. Hypertext can provide an electronic notebook of important project documentation linked together in a data base.

Hypertext programs typically can incorporate existing ASCII files, so existing word processing documents already developed pertaining to an operation can be used. To incorporate existing reference manuals and standard specifications, document scanning is possible to reduce the effort in creating the system. The development of a hypertext system requires little programming expertise. Once documents are input, the system developer is required only to establish the links between documents. This makes the development of hypertext systems attractive for construction firms, which may not have personnel with extensive programming expertise.

A hypertext sytem can allow a user seeking information to access sources of information from all levels of the construction firm's hierarchy. Information could be included from main office sources describing recommended firm policy, and from expert field managers describing details on recommended techniques for performing the construction operation.

Two primary areas of information about a construction operation can typically be identified. They are reference documents and the knowledge of experienced personnel. Reference documents such as standard specifications describe the contractual requirements for construction. The inexperienced field agent may require additional information to understand the specifications and to find the best construction techniques.

Hypertext can allow reference material to be linked to documents of advice, produced by experts with experience in managing the operation. Information on the recommended techniques and practices for performing the operation can be included in the advice documents. Additionally, a hypertext system for a construction operation could include advice on how to recognize

when a construction problem is occurring and suggest corrective actions. A hypertext system can provide a way of speeding access to information in reference documents, and provide enhanced information by linking the reference material to articles of expert advice.

The U.S. Environmental Protection Agency has developed a hypertext system to give advice to tank owners and operators about the EPA's regulations for underground storage tanks (Foskett 1990). This hypertext system allows regulations written in legal and technical language to be linked to plain-English translations of the regulations. This system illustrates the potential of hypertext to link required documents with interpretive information.

Other Potential Areas for Hypertext Development

A suggested area of hypertext data base development for construction is to provide quicker access to government regulatory information. Many areas of construction require adherence to government rules, such as building codes and OSHA safety regulations. The required manuals can often be voluminous and difficult to understand. Hypertext has the potential to gather the multitude of documents together in a format that can be quickly accessed by a construction user. This regulatory information, which may be difficult to interpret, can be linked to explanatory documents more easily understood by construction personnel. A prototype hypertext system has been developed that links explanations of various types of building demolition techniques to the applicable OSHA safety regulations. Potentially, a system user can more quickly receive information on safety requirements, rather than having to search through many different documents.

Another area of application of hypertext data bases is to provide an interactive data base of project planning and estimating information that could be used for bid preparation. Hypertext systems can be constructed that contain information on expected productivities, required crew sizes, and descriptions of how to modify the expected productivity based on specific site conditions. The hypertext system could be used for transferring the expert knowledge of experienced estimators to less-experienced personnel.

Hypertext System for Asphalt Paving

A prototype application was developed to provide a reference manual to help in the construction inspection of asphalt concrete pavements. The information included was developed with the assistance of New York State Department of Transportation (NYSDOT) paving experts. The hypertext system contains documents that describe the NYSDOT recommended paving practice.

The primary purpose of the system is to provide information to construction inspectors about the asphalt paving construction operation. Controlling the construction of an asphalt concrete pavement requires considerable expertise to recognize and correct paving problems. Decisions made during construction can have significant effects on the performance and durability of the pavement. Some paving inspectors do not have enough experience to decide when there is a deficiency in the paving process.

The goal of this hypertext system is to make critical information for controlling the construction operation accessible to inspectors. The data base

contains articles of advice written by a paving expert linked to NYSDOT reference documents. The system brings together information from several sources and allows a user access to specification documents and explanatory articles.

This hypertext application is possible because of the widespread use by the NYSDOT of computers in construction field offices. Potentially, the system can allow inspectors to make better informed decisions concerning the conduct of the paving operation by quickly providing advice and easier access to pertinent specifications.

Software for Hypertext System Development

The NYSDOT hypertext system was developed using Hyperties, a hypertext-development system for the IBM-PC (Cognetics Corp., University Park, Md., 1989). The metaphor used in Hyperties is an electronic book. Each Hyperties data base has a cover, preface, table of contents, articles, illustrations, and an index.

The information in the data base is contained in the articles and illustrations. Once an article is input it is possible to establish user-defined links to other articles. A link is a cross reference, an indication that more information on a topic is available. Links permit the user to browse through the articles in the data base, following paths of interest. Links are easily defined by the system developer. Any word can be chosen and then linked to any other text article or graphic in the data base.

Links in Hyperties are words or phrases that are highlighted when displayed on the cathode-ray tube (CRT) screen. The user can select highlighted words using a mouse or keyboard, and view the information contained in the linked document. To put a link in a Hyperties article, the developer puts tildes around the word or phrase to be highlighted. After editing the Hyperties article, the developer then accesses a menu to define the articles to which words and phrases are to be linked.

Hyperties contains several features that enhance its usefulness as an interactive reference system. A search capability allows the user to search for specific words or strings of words in the data base. The system user is presented with a list of articles containing the string, and can select them for viewing. An index of articles is automatically generated for each Hyperties data base. The index has an alphabetic list of articles. Any article can be selected from the index. The user can refer to this index whenever. This is particularly useful for a user who wants to access a specific article and does not want to browse through the data base. A table of contents can also be created. The table of contents presents a listing of available documents in any format chosen by the system developer.

Articles can be entered in the Hyperties data base using an editor provided with the Hyperties program. This editor allows the system developer to create articles and to establish the links between articles. The Hyperties program also allows text files in an ASCII format to be imported into the data base. This allows information from manuals to be scanned, and eliminates the need for retyping. These imported files can be edited using a conventional word processor or the editor that is provided.

Structure of Asphalt Paving Hypertext System

The asphalt paving hypertext system contains material from several dif-

ferent sources. These include an article describing recommended paving techniques by a NYSDOT expert, NYSDOT standard paving specifications (*Standard* 1981), a list of NYSDOT-approved equipment, and selections from the *Asphalt Paving Manual* (1978). The hypertext system includes required specification documents for quick reference by the inspector and descriptive articles to aid an inspector's understanding of the paving process. Fig. 1 shows an outline of the major articles included in the hypertext system, and the primary links between these articles.

When users initiate a session with the system, a preface page is displayed that describes the purpose of the system. After the preface, the introductory article is displayed. In the asphalt paving system the user is presented with a list of the major documents in the data base. Each item in the list can be selected by the user for browsing. This introductory article allows experienced users to directly select a document of interest.

The first document in the introductory list is "Achieving Good Results in the Paving Operation," written by Robert C. Parks, a paving specialist with the NYSDOT. This document contains information on recommended procedures for getting a high-quality pavement. This document is divided into four Hyperties articles, which can be read in sequence by the user. The first article contains a description of how the paving machine operates. It includes links to pictures that illustrate the main components of the paving machine and the forces that act on the screed of the paver.

The Hyperties program allows graphics to be incorporated in a data base. The PC Paintbrush IV program by ZSoft Corporation was used to create the drawings. Many inexperienced paving inspectors may not be familiar with the various elements of the paving machine or the paving process written about in the text articles. Therefore, the drawings were included in the data base to provide better information to inexperienced inspectors using the system. Fig. 2 shows the drawing of the screed of the paving machine that is linked to the article.

Other Hyperties articles that comprise the advice document include an article that gives advice on recommended paving techniques such as development of construction joints and temperature control of the asphalt material. A third article describes how to set up the automatic screed controls of the paving machine. The final article describes recommended techniques for compacting the asphalt.

These articles of expert advice are linked, where appropriate, to the NYSDOT standard specifications for asphalt paving. Fig. 3 shows the link between a discussion of the paving machine in the advice article to NYSDOT standard specification section 401-3.05 (*Standard* 1981). A system user points to a highlighted word using a mouse. If the user selects the highlighted word, the article containing the specification section pertaining to the asphalt paving machine is displayed. This linkage allows the user to read easily understood information about the paving machine, and to access the detailed information contained in the specification. After reading the specification the user can choose to return to the previous advice article or continue browsing through the specifications. If a user takes a different path through the data base, such as reading the specifications, links are provided from the specifications to the advice articles. Hyperties allows extensive cross reference to be established between articles.

The advice articles that make up the document of expert advice contain

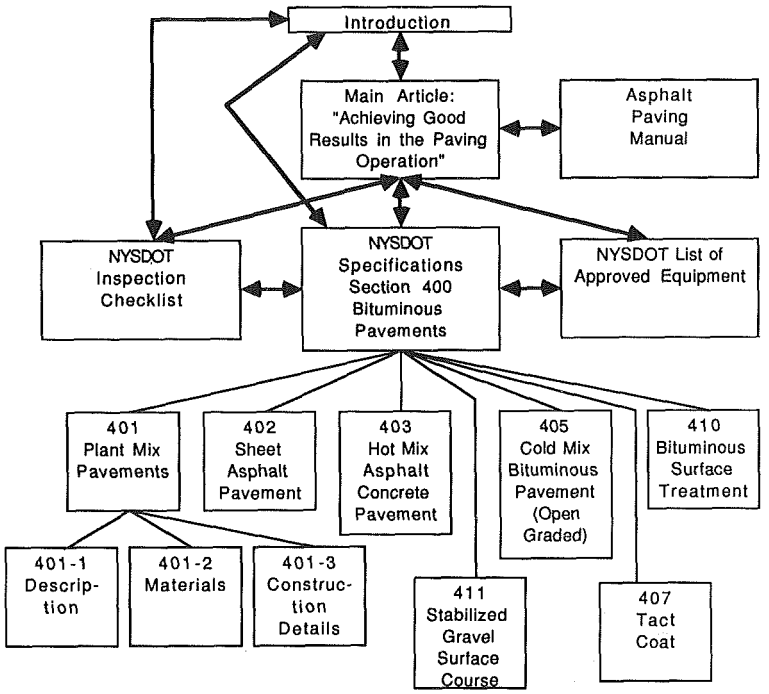

FIG. 1. Asphalt Paving Hypertext Data Base

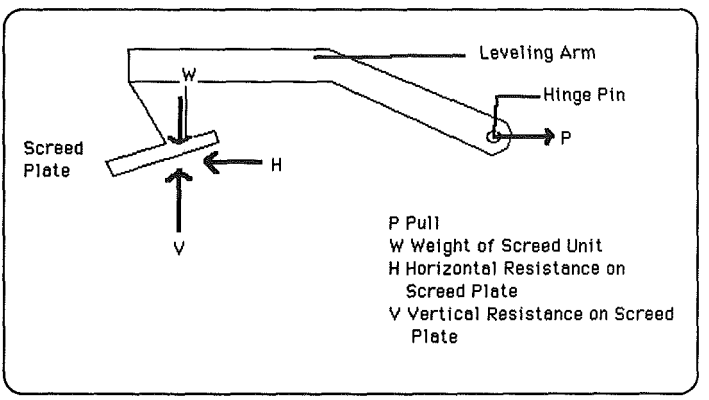

FIG. 2. Graphic of Paver Screed in Data Base

links to other reference materials required by NYSDOT inspectors. Paving inspectors are required to verify that the paving and compaction equipment used by contractors is acceptable. Therefore, the NYSDOT list of approved equipment is included in the data base. Links are provided to this list from the advice articles and the related specification sections. The NYSDOT also

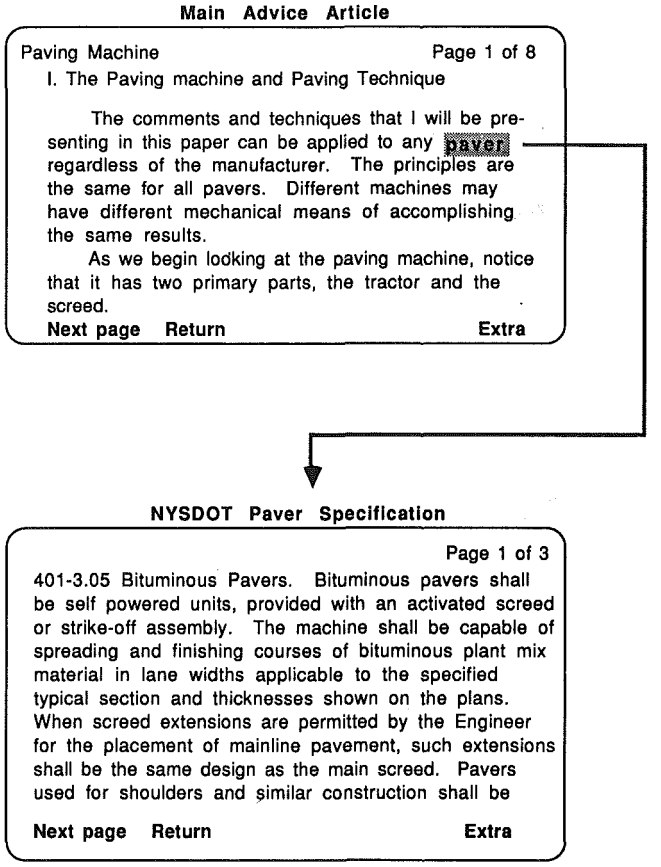

FIG. 3. Illustration of Links between Articles

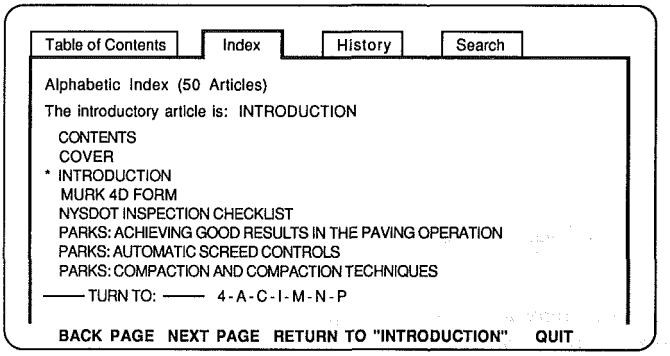

FIG. 4. Index for Asphalt Paving Data Base

issues a paving checklist. This checklist provides a list of recommended procedures for the asphalt paving process. Links are provided from this document to applicable sections in the specifications and the list of approved equipment. Links are provided from the expert advice articles to this checklist. This allows inexperienced inspectors to receive explanatory information and to then view their required tasks in a list format.

Many links have been provided between documents in the data base to allow a user to browse for information through many different paths. Yet, a system user may sometimes wish to view a specific article directly without browsing through the data base. Fig. 4 shows a facsimile of a portion of the index automatically created by the Hyperties program. This index can be viewed by a system user whenever desired during a user session. It allows direct access to topics of interest. Articles that have already been read are marked with an asterisk.

Conclusions

The development of the prototype hypertext system for asphalt paving shows that hypertext can have many useful functions when applied to construction. Hypertext can be useful as a way of providing quick access to construction information by bringing many reference documents together in a single user-friendly data base. Additionally, hypertext provides a way of linking construction documents, which may be difficult for inexperienced personnel to understand, to articles of descriptive information and advice. If expert information from senior field personnel can be obtained as text articles, a hypertext system can serve the purpose of transferring information to less-experienced personnel.

With the availability of hypertext-development programs on microcomputer, there is potential to develop construction hypertext systems to help in the management of field operations and as an aid in project planning and bid preparation. Hypertext has the potential to provide construction managers with improved information for decision making.

Acknowledgments

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