Merging Expert Systems with Multimedia Technology

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Abstract

Traditional methods of interaction with ES can be a burden to users who are forced to translate conceptualizations of problem attributes and characteristics into text form and then convert back to conceptualizations in interpreting and recommending solutions. This burden can be relieved by merging ES with multimedia technology. In addition to text, the user would be able to selectively access information with graphics, full-motion video, or animation; and hear with stereo sound, voice recording, or music. Such a combination provides a powerful interactive interface enabling the various facets of expertise to be more fully communicated to the user. This article describes multimedia expert systems and considerations for implementing them.

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Introduction

Expert systems (ES) provide expert knowledge, judgment, and support in managerial decision making. To achieve full benefits from the use of ES, it is critical that systems be built with the technological resources that provide the most comprehensive support to a particular problem domain.

It has been recognized that ES applications can be designed to interact either with other software (such as database management systems) or with other systems (such as decision support systems). The perspective on ES design must be further expanded to exploit advancing technological capabilities. Merging ES with state-of-the-art multimedia technologies provides ever-expanding possibilities. This broadened perspective of ES design enables all facets of expertise to be more fully incorporated into the system, thereby achieving the greatest benefits.

Multimedia Technology

Multimedia incorporates a combination of computer hardware, software, and other devices, such as television, video monitors, optical disk systems, or stereo systems to produce a full audio/visual presentation. This combination of technologies provides a powerful interactive platform to meet users' needs.

The variety of visual features providing text, graphics, and images includes high resolution generation of text that can be edited and superimposed (such as hypertext), sophisticated presentation graphics generation for charts and maps, high quality image digitizing, and image editing, drawing and colorization. Images can be captured and entered into the system with video cameras, video discs, videotape, film recorders, or scanners. Images can also be generated or converted from software packages incorporating digital photography. Visual output is provided through television sets, monitors, and screens.

Audio features include sound digitizing, editing, and mixing of voices and music. Microphones, compact discs, cassettes, and voice-input devices enable the capture of sound for entry into the system. Stereo speakers and voice-output devices enable audio output from the system.

Managing the configuration of audio and visual components requires an integrated set of software to capture, enter, store, retrieve, edit, and otherwise manipulate both audio and visual elements. The control and synchronization afforded by these software tools, referred to as authoring systems, enables the creation of customized interactive multimedia systems.

To date, multimedia technology has been applied to a limited extent in applications such as training (Lookatch, 1989; Majkiewicz, 1990) and marketing presentations (Miller and Howard, 1990). The potential of this advanced technology is unbounded in both business and consumer realms and deserves serious consideration.

Merging ES with Multimedia Technology

Merging ES with multimedia technology provides a comprehensive set of resources to support users' needs within a particular area of expertise. ES, combined with audio/visual facilities and related components, enhance the presentation of expertise. Indeed, "by linking computer-based information with stereo, audio, full-motion video, animation, and graphics, you get a teaching and presentation system of unparalleled impact" (Veljkov, 1990). A dramatic and informative system with full explanation capabilities can be achieved.

Traditional methods of interaction with ES can be a burden to users who are forced to translate conceptualizations of problem attributes into text form and then convert them back into conceptualizations for interpreting and recommending solutions. This burden can be relieved by merging ES with multimedia technology. Such a combination enhances user interaction through a variety of audio/visual capabilities to provide full explanatory power. In addition to text, the user is able to selectively see information and explanation about conceptually difficult problem attributes through the use of pictures, full-motion video, animation or graphics, and hear information with stereo sound, voice recordings, or music.

For example, if a physician is unfamiliar with terminology, procedures, or methodologies associated with a newly identified disorder, greater insight could be obtained by requesting indepth

definitions, explanations, or a visual example of the application of the recommended treatment. This would be particularly useful for demonstrating a deviation from standard procedures in a step-by-step manner via full-motion narrated video with text or graphics superimposed to highlight critical points.

Presentations with a mix of audio and visual accompaniments have been found to be advantageous in two studies sponsored by 3M. Undertaken by Wharton's Applied Research Center (Johnson, 1989) and the University of Minnesota's Management Information Systems Research Center (Straub and Wetherbe, 1989), these studies examined the impact of presentations supported by computer-generated visuals. Both studies found that visuals do indeed increase the effectiveness of presentations. When visuals are added, retention increases by about 10 percent and persuasiveness by 43 percent (Figure 1). Another study, done by General Telephone of California, addressed the interactive mix of these mediums and also attested to the advantages of such a combination (IBM, 1989).

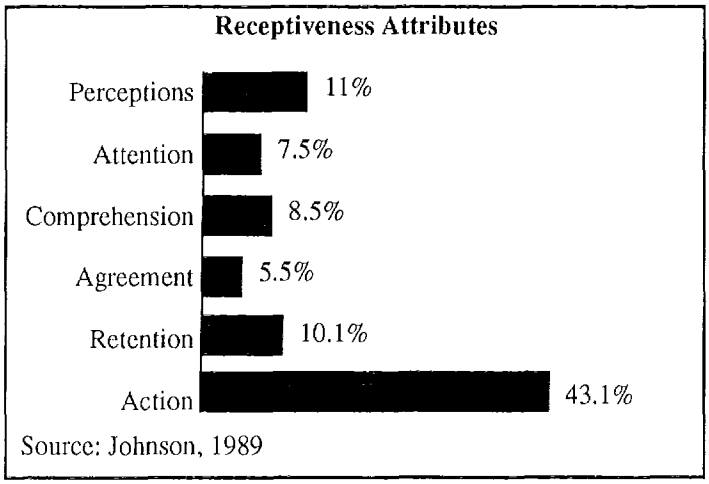

Figure 1. Percentage Increase in Audience Receptiveness s for Presentations Supported by Visuals

Components of a Multimedia Expert System

A multimedia expert system requires a multimedia platform comprised of a number of components to support the array of audio/visual interactions, including those related to the media effects and those recognized as part of a traditional expert system.

A conceptual representation of the union is provided in Figure 2. As shown, the storage repositories would include a video base, audio base, database, and model base. Within each of these would be the contents appropriate to support the particular problem domain. The multimedia management system would function as a management facility, not unlike a database management system or a model base management system. This would provide the capability to create, edit, update, and delete the contents of each of the four storage components. The multimedia management system would operate in conjunction with the integrated directory, which contains the references necessary

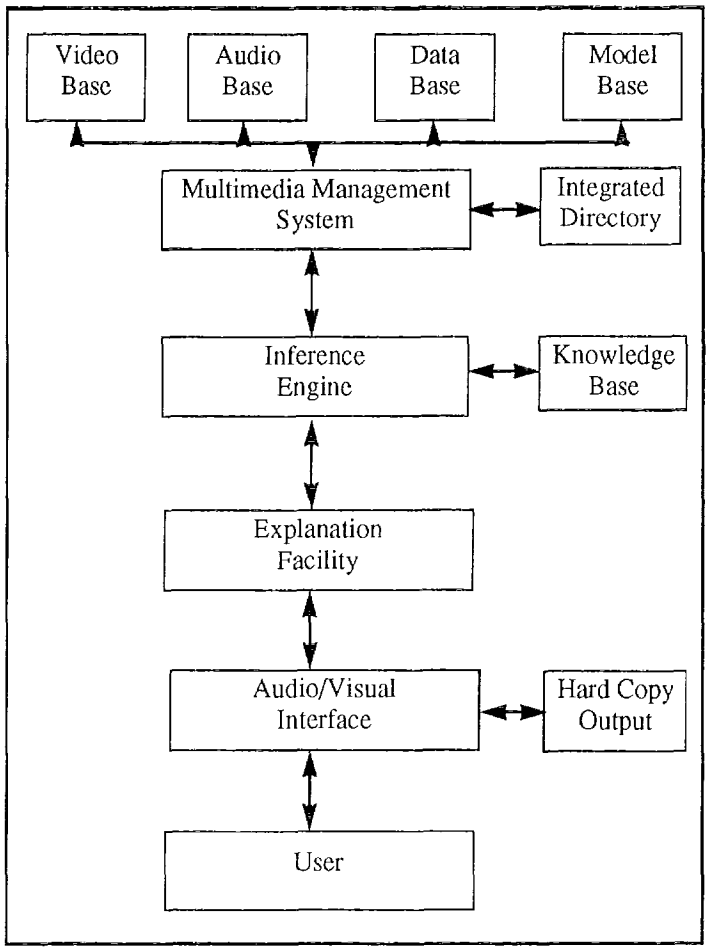

Figure 2. Components of a Multimedia Expert System

to retrieve the appropriate set of data, models, video, and/or audio features provided when using the system.

The classic ES components include the inference engine, knowledge base, and explanation facility. The explanation facility would interact with the multimedia management system to support the audio/visual interface. System prompts for user input would have text accompanied by audio cues and visual representations assisting user identification of a problematic element. The recommended solution presented would also be supported by the same mix of media, facilitating user comprehension of the solution attributes and suggested course of action.

One final step in using the system might be to obtain hard copy output of the recommendations to serve as a guide in implementing the solution in the field. Output could be obtained in the form of quality color photo documents with comments and directions superimposed on the images. Output devices that can convert information into this format include film recorders, plotters, and sophisticated printers.

Issues specific to Multimedia Expert Systems

A number of issues must be recognized in successfully merging ES with multimedia technologies, including: cost

considerations, identification of appropriate areas of application, technical know-how, development considerations, an understanding of the current state-of-the-art technologies, and compatibility issues.

Cost Considerations

Costs associated with multimedia expert systems are quite high due to both sophisticated equipment needs and the skilled personnel necessary to design and develop these systems. Vast amounts of storage, computing power, and memory, as well as design and programming of specialized software, are necessary to produce the audio/visual effects. This translates into a substantial investment in resources.

As with any system development effort, the costs must be weighed against the benefits. The potential benefits realizable include fostering a progressive, leading-edge company image, increased efficiency in personnel performance resulting from readily available and understandable expert advice and management of critical expertise, among others (Sipior and Garrity, 1990). These benefits may be found to contribute to the achievement of competitive advantage by the corporation, thus proving the worth of the multimedia expert system.

Identification of Appropriate Areas of Application

Identification of appropriate areas of application is essential to the development of successful ES. This is particularly critical for multimedia expert systems due to the vast resource outlay necessary for the multimedia platform. A corporation simply cannot afford a system that is never completed, never functions properly, or is never used.

The characteristics of the application must warrant the use of multimedia. Employing the technology for the sake of novelty or hype is certainly not worth the considerable cash outlay. Corporations must beware that the excitement and enthusiasm associated with employing leading-edge technologies not distract from the selection of a worthy problem area. The characteristics of particular importance in assessing the appropriateness of an application for multimedia support are shown in Table 1.

Table 1. Characteristics of Appropriate Problem Domains

1. Words are not sufficient to easily and adequately describe the problem attributes and solutions.
2. The problem domain is narrow and well defined.
3. The size of the knowledge base is limited to 100 rules or less.
4. The problem domain is relatively static over time.
5. Test cases are available to assess the functionality of the system.

First, it is necessary to ascertain whether the problem domain is suitable for the development of a multimedia expert system. One means is by determining how easily the problem attributes and solutions can be communicated. If the attributes and solutions cannot be readily communicated over the telephone, it is likely to be a good candidate. Alternatively, if written documentation concerning the problem domain exists, this can be examined to assess communicability. The presence of diagrams, charts, and other representations is a good indication of a suitable application. Finally, highly complex or technical problems, replete with technical jargon that tends to obfuscate comprehension, should be considered for multimedia representation. If the terminology can be readily clarified with a simple diagram, it is likely to be an appropriate application. In all these instances, words are not sufficient to adequately describe problem attributes and recommended solutions, suggesting the necessity of additional media support.

The problem domain should be narrow and well-defined. Considerable time and effort must be directed toward integration of the various media to effectively utilize these resources. By selecting a more focused domain, design efforts are less likely to become too cumbersome to solve.

The size and scope of the knowledge base should be carefully considered. As a rule of thumb, the first application should be limited to 100 rules or less. The manageable size of the knowledge base serves to minimize the complexity associated with coordinating the design and integration of the various media components.

The problem domain should be relatively static over time. Numerous and frequent changes and updates to the domain would result in extensive repercussions on the integrated system components. This would make maintenance prohibitively costly, both in terms of time and expense.

Test cases should be available to evaluate the functionality of the system. The technological complexity requires extensive testing to validate the recommended solutions and to assess the comprehensiveness of the solutions presented.

Technical Know-How

Merging ES with multimedia technology requires extensive technological know-how across a spectrum of disciplines to both configure the components and design, develop, and implement the system. The configuration of the components requires technicians with knowledge of both computer and audio/visual equipment. Complicating this undertaking is the absence of standards within and across the computer and consumer electronics industry.

To design, develop, and implement the system, developers must not only be skilled in the knowledge engineering process, but must also be astute in the exacting programming and media editing techniques necessary to produce a presentation which fosters user comprehension. This implies two individuals, a knowledge engineer and a professional audio/visual editor, who work closely together to integrate the processes of knowledge engineering with media production. Eventually, a hybrid class of knowledge engineers possessing visionary skills in both areas may emerge.

Development Considerations

Since multimedia expert systems combine such a vast array of elements, development efforts can become complex and technologically intensive. The project planning process must anticipate the implications this has for staying on schedule and within budget, while still remaining responsive to user needs. More time may be devoted to development efforts than initially anticipated, resulting in budget increases that, in turn, preclude

anticipated, resulting in budget increases that, in turn, preclude the ability to respond to all user requirements. These factors should be taken into account in planning the development process.

It is important to focus strictly on the application itself, not the technology. By envisioning the system as it will function, a determination of the appropriate software and hardware features can be made. Thus, it is necessary to recognize exactly what capabilities best meet user needs.

The power of the multimedia platform available to the developer presents the temptation to dazzle the user with components, such as multiple screens and synthesizers or special effects such as split-screens, fade in/out and sound effects. The technology should be employed only to the extent that the user is not overwhelmed by the system components or distracted by the special effects.

The user interface should provide the classic expert system support through system prompts and a query facility, recommended problem solutions, and providing how/why explanations. Incorporating the multimedia enhancements should be done in a manner that keeps the user's attention directed toward critical aspects of the area of expertise while providing the greatest degree of interactive flexibility.

Flexibility is extremely important to system use since different users may require different degrees of support. Experienced users may access the system for confirmation of their own solutions; novice users may seek to gain expertise. Hypermedia linking provides a mechanism whereby novice users operating in a training setting can get expanded explanations and interfaces at their disposal. This additional support would be provided on demand. Excursion branching, implemented via hypermedia links, enables a user to pursue a related side issue in greater depth.

Linking can also accomplish launch and return features that transport the user to other applications, such as decision support systems or database management systems that run as submodules. This submodule could either function as an information-yielding presentation providing more detailed information, or serve as a forum for hands-on experience to apply the knowledge gained from the ES. The latter may be accomplished, for example, by accessing a decision support system submodule that allows the user to develop a model according to what has been recommended by the ES and then return to the ES to obtain further insights for developing the model.

The Current State of Multimedia Technology

Both Apple Computer, Inc. and IBM Corporation currently offer desktop video computers and are engaged in continual development. Hypermedia emerged in commercial product form in August 1987 with the introduction of Apple's Hypercard as a standard feature on the Macintosh. Other devices, such as a television set or video monitor, or an optical disk system or stereo system, connected to the computer without a separate video card provide the additional media. IBM announced the availability of the Audio Visual Connection (AVC) software and video adapter card in September 1989. Used in conjunction with PS/2 and Video Capture Adapter/A, this system enables the creation of customized audio/visual programs and presentations by capturing images from video camera, videotape, videodisc, or the monitor, converting them from analog to digital representation, compressing, and storing them on a hard disk and displaying them on a video graphics array (VGA) monitor.

Other companies in the computer industry are contributing to advances in multimedia technology. Intel Corporation, in association with Microsoft Corporation, is developing a PC system for IBM that incorporates color graphics, stereo sound, and optical disk storage, and costing less than $3,000. Intel is also developing digital video interactive (DVI) hardware and software to provide interactive editing by storing audio, video, still pictures, and graphics in a digitally compressed form (Glass, 1989).

A number of authoring systems (the software that enables users to produce multimedia systems) have recently been introduced. For IBM and compatibles, IBM developed LinkWay, ASYS offers Propi, and Allen Communications provides Quest. The Macintosh environment has Mentor/MacVideo from Edudisc, Course of Action from Authorware, and Video Builder from TeleRobotics International. All of these enable the creation of sophisticated multimedia applications.

The consumer electronics industry is also involved in technological developments by integrating computing power into the television, stereo, and other home appliances. Among the companies targeting the home market—Sony, Fujitsu, and Frox.

Several technological hurdles remain before the full capabilities of multimedia technologies are realized. Video compression, a process by which complex mathematical formulas and high-powered processors reduce the amount of raw data needed to produce video images, is still being refined. Without this process, neither high capacity compact discs nor most PC memories can support video imaging due to high storage requirements. An alternative is the use of television monitors, which do not require conversion of data into digital form; however, interactive editing would then not be possible.

Compatibility Issues

Compatibility is a particularly critical issue for multimedia expert systems. A multitude of components are available to capture, store, modify, and present both audio and video output. A heightened need for compatibility is evident, due to the highly complex nature of merging both the hardware and software required to meet the needs of users.

Multimedia technologies are the product of multiple industries, and this can be problematic. No standards currently exist either within or across the computer and television industries. With the blending of technologies inherent in this undertaking, agreements on standardization must be encouraged.

Conclusion

It has been recognized that "special-purpose hadware and software often place expert systems outside the mainstream IS environment, reducing their use in organizations," (Watson and Mann, 1988). However, as the marketplace becomes increasingly competitive, particularly intensified by the impending unification of the European Community, new ways of gaining competitive advantage cannot fall along the wayside.

Multimedia expert systems provide a comprehensive means of capturing, documenting, and disseminating expertise, an important corporate resource. The potential gains of this combination of state-of-the-art technology must be recognized and exploited to greatest advantage.

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