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A VCR-Based Access System for Large Pictorial Databases

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We describe a Videocassette Recorder (VCR)-based information system whereby we can distribute frequently updated large pictorial databases to individual users and provide a variety of interactive video services. The four key advantages of this system are: (1) economics, (2) good picture quality, (3) capability to reach nationwide users, and (4) ability to update the database frequently (say, daily, preferably in early morning hours when many transmission facilities are unused). An experimental home terminal consisting of a VCR driven by a personal computer for random-access searches was constructed to demonstrate this concept. The pictorial database used in the demonstration includes real estate listings, vacation guides, autos and Sears-type merchandise catalogs. We also make comparisons of this system to other video services and conclude that the present approach has potential advantages in many applications.

I. INTRODUCTION

There are presently many systems under development for providing interactive visual displays.[1] For example, videotex uses the switched telephone network to send and receive digital data, which are then used by a microprocessor terminal to construct color graphics on a TV screen. Teletext is another technique whereby digital data for the same purpose are imbedded in the vertical blanking period of a video signal broadcasted to the end users. The graphics capability of these two

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methods is limited in representing those real objects, e.g., clothing and furniture, for which visual attractiveness is more important than functional appeal.

Limitations in the computer-graphic representation of real objects can be overcome by storing the pictures on an interactive videodisc (as in the "electronic book" application).[2] In such a case, hard copies of the disc have to be distributed by mail or through stores to the end users. If real-time access to a central database is really required, then the so-called frame-grabber approach is frequently suggested. In this latter system, single frames are sent to individual users, time multiplexed on a dedicated video channel.[3] The user terminal must then store the received frame so that it can be examined by the human viewer. Digital frame stores for this application are expensive, although their cost should decline eventually. Nevertheless, a multiuser computer system at a central location must manage the data requests and send different video frames to different users. Such a system can be overloaded easily, and practical solutions for giving nationwide service to thousands of users simultaneously have yet to be worked out.

Here we suggest an alternative arrangement which appears to be more economical than the videotex or frame-grabber systems. We propose that the home terminal consist of a home Videocassette Recorder (VCR) connected to a personal computer, and that a "frame-search" capability be provided whereby the home computer can specify which frame of the videocassette is displayed (in still frame) at any one time. The VCR must of course have good still-frame performance. The overall system for distributing pictorial databases from a central station to end users with such home terminals is outlined in Section II. Then we describe an experimental home terminal for demonstrating the feasibility of this idea (Section III). Finally, we make comparisons with other systems (Section IV) and conclude that our present proposal has potential applications in both the business and consumer markets.

II. DIRECT DISTRIBUTION OF PICTORIAL DATABASES TO USER VCRS

We propose the direct distribution of pictorial information to the end users' VCRs via a TV broadcasting channel, as illustrated in Fig. 1. The pictorial database is assembled in one central location, where individual color pictures (35 mm photographs or slides) are recorded onto a master videotape (one-inch type) in a frame-by-frame manner, i.e., a single color picture on a single video frame. A two-hour videotape can then store up to 216,000 single-frame pictures. In the vertical blanking period of these video pictures, we insert a frame number for identification as analogous to the page number in a book. This technique of numbering the video frames can be implemented easily with the conventional Vertical Interval Time Code (VITC). In addition,

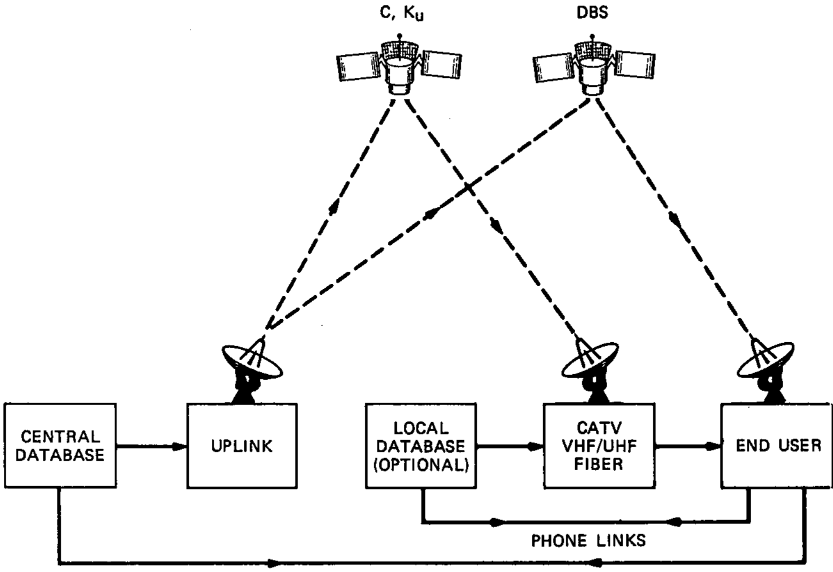

Fig. 1—Direct distribution of pictorial databases to home users.

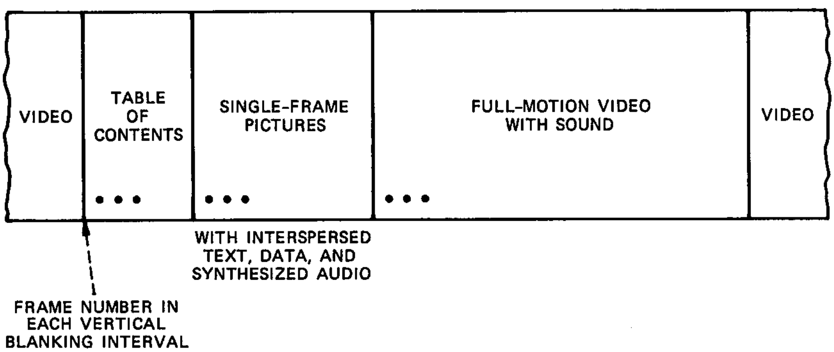

Fig. 2—A video segment showing a sample database layout.

part of the database, i.e., parts or the whole of a video frame, can be devoted to nonpictorial information such as table of contents, text, software instructions, etc. These data, although encoded digitally, can easily be incorporated in place of the normal active video. As an example, we show in Fig. 2 the layout of a database consisting of table of contents, text descriptions, synthesized audio, single-frame pictures, and full-motion video with sound.

As suggested in Fig. 1, the database from the central station can be transmitted through a satellite broadcasting system (C-, K_u-band, or DBS) whereby nationwide users can either receive the information directly or through a local broadcaster. In the latter case, the local distributor simply takes the received video signal from the satellite and retransmits it to the users via his own broadcasting system (e.g., cable TV, off-the-air VHF/UHF channels, optical fiber, etc.). Attaching additional information from a local database is optional. Since many transmission facilities and TV channels are idle in early morning hours, this operation can most conveniently be done in the middle of the night with the VCRs programmed or pretimed for unattended recording. Once the database is recorded on a videocassette, the users can assess the information at their home terminals at their leisure. Direct distribution in this manner avoids the cost of recording and shipping thousands of tapes (or discs). Moreover, the database is always up-to-date, depending on how often it is sent (once a day should be adequate for most applications). No special equipment is required at the TV station or CATV head-end for sending out the databases. Indeed with satellite transmission, nationwide distribution is possible with transmission systems already in place. For example, the Sears catalog could be sent in 4.5 minutes, assuming 1600 pages and 5 frames per page. One thousand real-estate listings could be sent in 5.5 minutes, assuming 10 frames per listing. Custom orders for still-picture or full-motion information (e.g., instruction manuals) could even be served if more transmission time were available.

With the database recorded on a videocassette, we can use the interactive home terminal suggested earlier to browse through the pictures in a random-access manner. We constructed an experimental terminal to demonstrate this idea, which is discussed in the next section. But first, we should point out that the assembly of large databases at the master station is no easy task. In fact, the production cost could be an important consideration in systems of this type. The need for automation in database production is mandatory and indeed manageable with modern production equipment.

III. AN EXPERIMENTAL VCR-BASED INTERACTIVE TERMINAL

We show in Fig. 3 the block diagram of a VCR-based interactive terminal suitable for examining stored video data from a videocassette. The solid-line portion represents what was implemented in our laboratory as an experiment to demonstrate the proposed concept, while the dashed-line part stands for an alternate approach using a remote computer (via telephone hook-up) to control the operation. They are functionally the same, but offer different kinds of user flexibility. More is discussed about their differences after we explain the terminal itself.

The terminal consists of three major components: the computer, which serves as a controller for the entire system; the VCR/computer

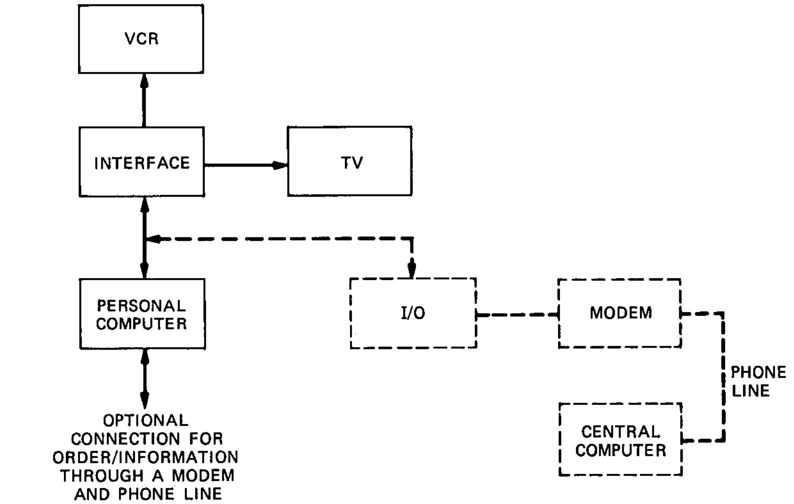

Fig. 3—A VCR-based user terminal.

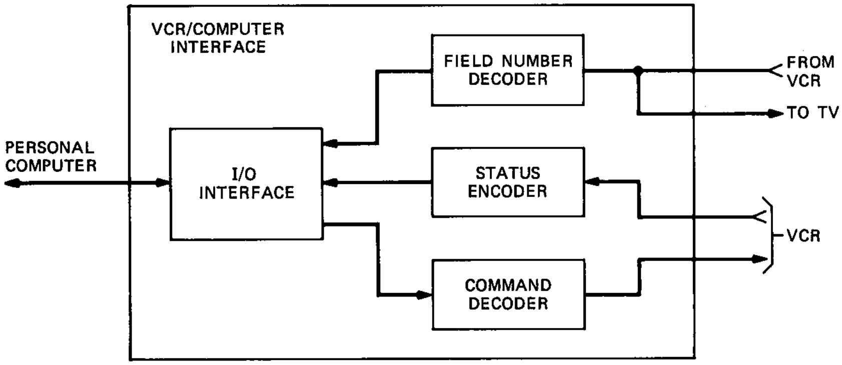

Fig. 4—VCR/computer interface.

interface; and the VCR* (with TV) itself. The video signal from the VCR is passed through the VCR/computer interface before being displayed on the TV. Inside the interface (Fig. 4), a field number decoder is used to examine the video frame identification number (VITC) recorded in the vertical blanking interval. This information should be made available to the computer at all times, i.e. when the tape is in still frame or in motion. But for simplicity, it is sufficient to provide valid frame numbers for tape motions from still-frame to play speed (30 frames/second). For higher tape speeds, the computer can

* Both the VHS and the Betamax formats would work as long as the VCR has good still-frame performance. We used VHS in our terminal.

use calculated estimates based on the initial known tape location, the current known tape speed, and the measured elapsed time plus some precalibrated adjustments. As an adjunct, the status encoder monitors the current operational status of the VCR (such as stop, fast forward, play, etc.) and conveys it to the computer. The command decoder, on the other hand, receives commands from the computer and translates them into actual instructions to the recorder, i.e., emulating a human pushing buttons to control the VCR. This was done simply by wiring up computer-driven electronic switches over the contact points of the pushbuttons on the remote control unit of the recorder.

Although the field number decoder is designed to detect VITC for frame identification, it is easy to extend the idea for decoding digital data recorded in all or part of an active TV field. Thus, part of the database can be devoted to digital information such as table of contents, programming or search instructions, synthesized audio, etc. They can be copied directly to the computer memory for use.

A sample video database was put together for the experimental demonstration of the terminal. It consists of four sections: (a) real estate listings; (b) automobiles; (c) a vacation package; and (d) merchandise catalogs. The interactive access to these data is done via a touch-sensitive screen on which menus are printed to prompt the user. The choices are all self-explanatory and are available to the user as touch-sensitive buttons on the personal computer. Instructions have been kept to a minimum, and the operation is so user friendly that a user manual is seldom needed. The majority of the material in the demonstration database is still-frame pictures. However, the full-motion video segments (with sound too) in the Hawaii Vacation Guide and also in a merchandise catalog on how to use the riding lawn mower consume much more recording time than the still-frame pictures. Note that our use of the personal computer with a touch-sensitive screen was merely a choice for experimental convenience. Any other user interface may be substituted to serve the same purpose in an actual system.

In addition to the user-prompting menu, 16 additional touch-sensitive buttons are always available in the bottom of the computer screen (see Table I). As an example, if one selects the button for real estate listings, then a table of choices for different towns appears on the touch-sensitive screen (Fig. 5). Touching one of these choices would bring up the next menu for specific price ranges. After that we have one more menu selection for specific house types, e.g., two-story colonial, log home, etc. The computer then fetches the text listing of the house selected from its memory and displays it on the touch-sensitive screen. Meanwhile, the search routine to locate the picture for the house is executed to the VCR. Therefore, the user sees the

Table I—List of 16 touch-sensitive buttons always available to a user

Name	Description
Autos	Brings up a new car catalog.
Vacation Package	Brings up the Hawaii Vacation Guide consisting of "Map of the Hawaii Islands," "Scenes From Hawaii," "The Polynesian Culture Center," and "The Sea Life Park," all of which (except the map) are full-motion video with sound.
Real Estate	Brings up the real estate listings: still pictures of the houses from the VCR and their corresponding text descriptions on the touch-sensitive screen.
Sears Catalog J. C. Penney Montgomery Ward	Brings up the merchandise catalogs: still pictures of individual items plus full-motion-and-sound segments of merchandise demonstrations.
Menu	Returns to the previous menu.
Order/Contact	Allows user to place an order or obtain order information.
Help	Brings up function definitions.
Compare	Compares prices of same item from different catalogs, if available.
Single Frame≫	Single-frame advance in the forward direction.
Single Frame≪	Single-frame advance in the reverse direction.
Browse≫	Causes video to move forward with momentary pause at each still-frame picture for browsing.
Browse≪	Causes video to move backward with momentary pause at each still-frame picture for browsing.
Pause	Pauses for still-frame viewing and brings up text description of current item.
Exit	Terminates the viewing session and returns to beginning.

color picture of the house on the TV and has the text listing simultaneously from the computer. The 16 buttons at the bottom of the screen provide plenty of choices and flexibility for the next step.

The search algorithm implemented in our software is designed to perform random access on the VCR in the most expedient manner. It

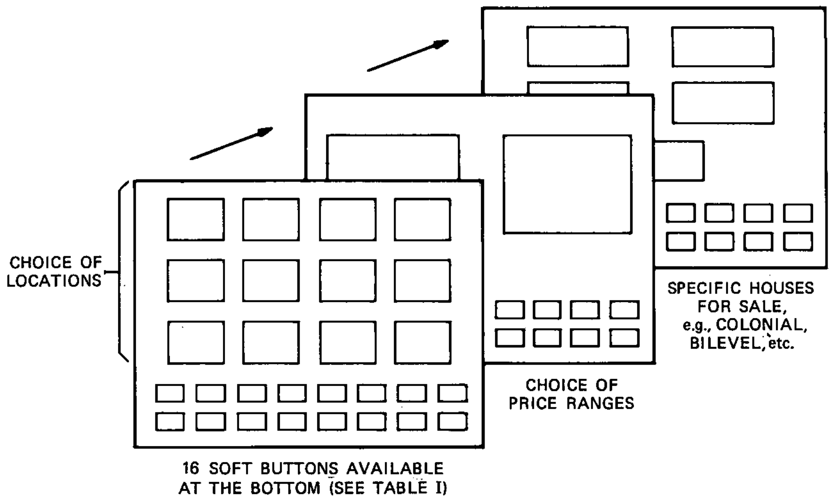

Fig. 5—Three successive menus for real estate selections.

should not be a surprise, however, that the VCR access time is considerably slow compared to that of a device truly capable of random access, e.g., a videodisc player. It takes a VCR typically 3 to 5 minutes to rewind a standard T120 (2/4/6-hour) cassette, and this would be the worst-case waiting time for getting to a picture from one end of the tape to another. Such a long access time is probably unsuitable for many applications. To circumvent this inconvenience, we propose that the whole database be divided into segments of, say, 1000 pictures each. Then the search within each segment is quite fast. As an illustration, if a 10 times play (10X) speed is used for the search, i.e., 300 frames/second, the maximum access time within such a segment is only 3.3 seconds. In our experimentation, we found that the speed search feature of the VCR was the most appropriate function to use for random access (i.e., fast visual search with 10X, 5X, 2X, etc.) because the video heads did not have to be disengaged and then reengaged during the process, and the continuous display of fast motions on the TV helped to make the waiting time less objectionable. In the event that the desired TV frame is very far away from the current position, the normal fast forward or rewind might have to be used. The optimization process is based on information previously obtained by an automatic calibration program which sizes the start and stop times, the video head engage/disengage intervals, and so on for each specific VCR. In short, we have developed an automatic calibration process that can characterize the access performance of a VCR, and the random-access software is intelligent enough to use this information for optimal control.

Laying out the database in segments of 1000 frames each requires intelligent partition of the overall source into groups of "humanly correlated" materials. For example, we don't want to put the listings of all different tires in one segment as in a conventional merchandise catalog. Instead we want to group all the accessories of a specific car model together. The situation is analogous to that of a large library where the books are carefully categorized and authored in such a way that most of the information desired for a subject is confined to a book of 1000 pages. The user can browse through each book very quickly, but probably does not mind spending more time in looking for another book. The assumption here is that most readers would spend some time reading a specific book of interest rather than reading pages of uncorrelated materials from different books in a random manner. We recognize that such an idea needs much more research before it can be put into practice. Nevertheless, recent experience from the videotex experiments seems to suggest evidence supporting the validity of this concept.

It is clear from the foregoing discussion that software plays a key role in this system. In our experimental setup, all the software resides in the personal computer (Fig. 3), and the user has complete control. The dashed-line portion in the figure indicates the other alternative of having the controlling software in a remote computer, and the user interacts with the system via a key pad connected to a modem. This latter approach has the advantage that more powerful software can be used at the expense of less user control as well as less privacy. The basic idea remains, however, that very intelligent software is needed in managing the enormous database made possible by a simple consumer-type VCR.

Finally, let us point out that the VCR system can be used as a high-density digital storage unit, which can provide digital high-fidelity music as well as synthesized voice and text data.

IV. APPLICATIONS AND COMPARISONS

The VCR-based information system has the same applications as other interactive video services. Some of the generic examples include real estate listings, vacation/entertainment guides, merchandise catalogs, product demonstrations, and service/instruction manuals.

We summarize in Table II a comparison with videotex and the videodisc-based system. It should be emphasized before we discuss these results that there is no single criterion possible for judging the relative merits or shortcomings of any approach. Instead, most systems tend to be application oriented. In other words, each individual video service tends to appeal more for the application it is intended for, and there is probably no single system that is universally "better" than all

Table II—Comparison of pictorial information systems

	VCR Based	Disc Based	Videotex
Video quality	Good	Good	Graphic
Database creation	Automatic photo-to-tape	Automatic photo-to-tape	Manual photo-to-graphic
Distribution	VHF/UHF, CATV, DBS, fiber, etc.	By mail or through stores	Telephone
Number of hard copies	1	100,000+	100+
Frequent updates	Yes	No	Yes
Real-time interaction with data suppliers	Limited	Limited	Yes
Response time	Slow	Fast	Depends on number of users

others. With this in mind, let us proceed with the comparison item by item.

4.1 Video quality

The picture performance of VCRs is usually designed to be compatible with the characteristics of other devices they are connected to in most home use, e.g. resolution is similar to that of a popular consumer TV (without comb filtering) and signal-to-noise ratio is comparable to most cable TV systems. In any event, their picture quality in our subjective viewing was found to be remarkably close to that of cable TV, while the videotex picture tends to be cartoon-like. The videodisc is potentially capable of noticeably better quality than the VCR although this is usually not so in practice.

4.2 Database creation

The database creation process for the VCR and the videodisc is almost the same. In both systems, the original material (e.g., photos or slides) is recorded on a one-inch video tape serving as the master, and the difference between the two cases is that the videodisc requires further processing in transferring the tape material onto a master disc before mass duplication. As for videotex, the original material has to be recreated in the computer (with computer-aided tools) as a graphic representation of the real object.

4.3 Distribution

The VCR system uses the TV broadcasting for distribution. Videotex uses the phone lines to connect customers to a central computer, while videodiscs have to be distributed via mailing or store sale.

4.4 Number of hard copies

Only one master copy of the database needs to be maintained nationwide in the VCR system. Videotex service requires a hard copy at each computer center, and hundreds are thus needed nationwide. The videodiscs are, of course, hard copies of the master, and a national market would require hundreds of thousands of them.

4.5 Frequent updates

The VCR database can be updated as often as possible because only one master copy is involved, and the user copies can be updated as often as transmission time permits. Similarly, videotex data can also be kept up to date. On the contrary, videodiscs cannot be changed easily, and current rewritable disc systems are prohibitively expensive for most applications.

4.6 Real-time interaction with data supplier

Because the database resides in the user terminal, real-time interaction with the data supplier tends to be limited in both the VCR and videodisc systems. On the other hand, videotex users enjoy continuous real-time interactive picture transmissions with the central computer.

4.7 Response time

The VCR access time is considerably slow compared to the videodisc, as discussed earlier. The videotex response time depends mainly on the number of simultaneous users and is probably slow (tens of seconds) for a fair size of simultaneous accesses (say thousands).

4.8 Cost

The VCR approach could become extremely economical if there was a mass availability of VCRs and personal computers, both of which have tremendous appeal in their own right and are gaining popularity among businesses and consumers. The custom interface necessary to connect the VCR to the personal computer is so simple that it can easily be incorporated into either the VCR or the computer. In any case, its cost should only constitute a small fraction of that for the total user terminal. Videodisc players capable of true random-access search are fairly expensive, and their popularity with consumers seems to be on the decline. Videotex terminals are also quite expensive, but their cost could decrease dramatically if more large-scale integration were employed.

V. CONCLUSIONS

We have proposed a system for distributing large pictorial databases to home videocassette recorders (VCRs). Distribution is done by broadcasting from a master station where the picture information has been assembled in a frame-by-frame manner, i.e., one picture per video frame, resulting in 30 independent pictures in a 1-second video segment. The broadcasting medium could be a combination of direct broadcast satellites, cable TV, conventional VHF/UHF TV channels, or custom fiber systems. The main idea is that this can take place in the middle of the night when many transmission facilities become vacant, and the home VCRs can easily be pretimed for unattended recording. In fact, distribution or updating is possible as often as transmission time permits, but once a day is probably adequate for most applications.

With the complete database stored in a videocassette, an end user can retrieve the data of his particular interest at his leisure with the aid of a simple home terminal. We constructed such a terminal comprising a VCR capable of good still-frame performance, a personal computer serving as a controller for random access, and a custom interface connecting them together. The VCR/computer interface translates digital commands from the computer into actual operational instructions to the VCR, i.e., emulating a human pushing the control buttons on the recorder. It also feeds back the operational status of the VCR to the computer. Most important of all, it examines the video signal and decodes a frame number previously recorded in the vertical blanking interval during data assembly. This frame number is the "page number" of the electronic book and is supplied to the computer so that it knows which video frame or picture is being displayed on the TV. Software on the computer was implemented to do random-access search through the database, and the interface to the user is in the form of a touch-sensitive screen with menu-driven selections. The capability of this experimental terminal was demonstrated with a sample database consisting of real estate listings, new car models, vacation packages, and merchandise catalogs.

The main attraction of our proposal is its potential economics. That is, it takes advantage of other potentially low-cost and widely available terminal equipments, namely, the personal computer and the VCR, both of which have consumer appeal in their own right. Distribution requires only a single database plus transmission facilities that are already in place. Thus, a service supplier need only provide a hardware interface plus software, a networker need only supply a satellite or a TV station plus a video production unit, and purveyors of information need only furnish color photos and text.

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