Int. J. Engng Ed. Vol. 8, No. 1, pp. 76–80, 1992
Printed in Great Britain.

0742–0269/91 $3.00+0.00

Applications of Image Databases in Engineering Education*

J. ALAM†
J. D. BAKOS, Jr.‡
J. O'LEARY§
Department of Civil Engineering, Youngstown State University, Youngstown, OH 44555, U.S.A.

Database systems have been restricted to storing and retrieving information in text format since the manipulation of pictorial information was not possible due to storage limitations of available computer hardware. Using new technology to overcome these limitations, an image database system (IDS) was assembled using separate computer components to store and retrieve pictorial information. This IDS was used to create an instructional picture database for a pavement design class. These images, digitized from conventional videotapes, were also edited and enhanced. The system is flexible, easily adaptable and user friendly. Other picture databases related to engineering education are also detailed.

INTRODUCTION

ANY CIVIL engineering (CE) curriculum is the result of a long evolutionary process. It is periodically revised to accommodate the needs of the work arena and to satisfy accreditation requirements. In addition to fundamental and specialized technical knowledge, recent CE graduates are required to possess effective communication and computer skills, along with an awareness of the social, ethical, political and environmental impact of their work. To meet these new demands, CE educators are continuously updating the curriculum by adding more courses or material to an already overburdened curriculum. Thus, there is a need to develop new and innovative ways to transmit knowledge within a constant timeframe and in an optimum number of courses.

The behavioural response to learning of the current generation of students is quite different than their predecessors. Today's students are more visually oriented with respect to the learning process due to an overexposure to television and computer video games. It is imperative that engineering educators do not underestimate the effects of visual imagery and its impact on effective communication of information. In the coming years, which are widely acclaimed as the advent of the information age, it will be essential to develop new tools for classroom instruction. These should include efficient ways of preparing and delivering instructional material.

There is a strong need to experiment with innovative new tools made available by recent advances in the areas of computer science and video technology. This is particularly important for such disciplines as engineering where more and more information has to be transmitted in a limited time interval. In order to provide CE students with more exposure to the real engineering world, professors often make use of the following: field trips to construction sites and/or treatment plants, the use of slides to demonstrate practical situations, the use of videotapes and films to demonstrate practical situations, etc. These activities, aimed at increasing the practical component of the educational process, are extremely time-consuming and often require the use of outdated visual aids. In addition, the visual aids are not always readily available and their use consumes valuable class time.

It is now possible to asemble a low-cost image database system (IDS) due in part to a decline in computer hardware cost and to the widespread availability of suitable software. By utilizing such a system, image databases (IDBs) for different topics in CE can be created. These databases can be viewed independently by the students or can be used by the instructor in a classroom setting by utilizing a video projection system.

HARDWARE AND SOFTWARE CONFIGURATION OF THE IDS

A schematic diagram of a typical IDS is shown in Fig. 1. The system utilizes an Everex 386/Step 20™ microcomputer to include a Targa16™ image capturing board, which can digitize full-colour pictures (frames) from any video source such as a videotape player or from live action images received from a camcorder. These digitized

* Paper accepted . . .
† J. Alam is Associate Professor of Civil Engineering.
‡ J. D. Bakos Jr. is Professor and Chair of Civil Engineering.
§ J. O'Leary is Graduate Assistant.

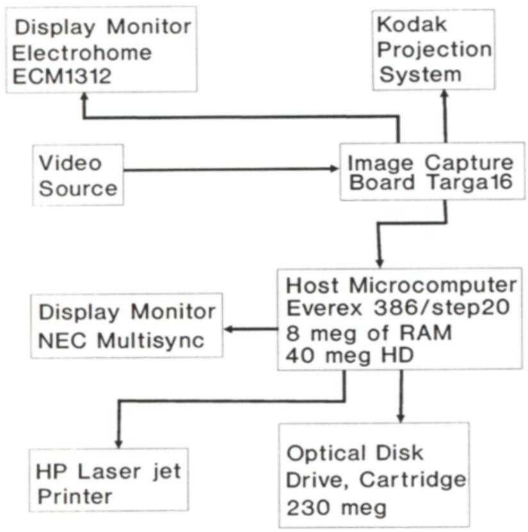

Fig. 1 Schematic configuration of the IDS.

still-frames in turn can be stored on a disk as binary files. The size of each of these files is approximately 250 kbytes, and thus the usual hard disk is not capable of storing the number of files needed to create a full size IDB on a specific topic in CE. To overcome this problem, an optical disk drive known as WORM (write once, read many times) drive must be added to the system in order to provide sufficient storage. The optical disk cartridge, similar in size to a conventional $5\frac{1}{4}$ in. floppy disk, is capable of storing 230 Mbytes of information. However, unlike the floppy disk, information can only be written on the optical disk cartridge once, though it can be retrieved many times. This is an inherent limitation of these drives, and thus careful preplanning of the IDB is needed before any pictures or frames are stored on the optical disk cartridge. The disk cartridges are removable from the drives, and therefore provide a very flexible environment for the creation of several different IDBs. The IDS also includes a HP LaserJet Printer for creating hard-copy prints of the pictures or frames stored in the IDB.

The system, however, requires the use of dual monitors. One conventional monitor displays program menus and computer commands, while the other, an Electrohome ECM1312™, is a special-purpose monitor that is required to display the pictures or images stored in the IDB. This latter monitor permits a flicker-free, stable display of the pictures, which is made possible by a coating of a slow, persistent phosphorous applied to the inside of the monitor screen. The output from the Targa16 board can also be directly connected to a Kodak™ projection system for classroom use of the IDS.

TIPS™ and Picturepower™ are two commercially available software packages used for capturing still pictures or frames from videotaped live sequences, image editing and for creating an IDB. TIPS is a 'paint' or an image-enhancement program, which also permits pictures to be captured from a video source. These can then be edited with the help of additional tools available in the program via a menu. Part of the captured picture or frame can be trimmed or additional graphics can be added to enhance the captured image. It can also be used to create new pictures other than those captured through a video source. Text or any other information can be added to make any picture or image self-explanatory. For example, a complete visual program, which includes text, graphics and edited still-frames from a video source, can be created with the help of this program.

Picturepower also has video frame capturing capabilities as well as some limited editing capabilities. Its main strength is its ability to create and allow access to an existing IDB through its retrieval function utility. It is also fully menu-driven. The IDB is created by capturing or creating a collection of pictures. Keyword titles are then added to these pictures to allow for a random access to any part of the IDB. The program also permits addition or deletion of pictures from the existing IDB. The pictures can be accessed sequentially or in a random fashion by various functions available in the 'retrieve menu' of the program. The main menu of the program is shown in Fig. 2. Picturepower is very easy to use and has adequate capabilities for developing an image database.

DEVELOPMENT OF IMAGE DATABASE FOR ROAD DISTRESS CONDITIONS

In recent years, the deteriorated conditions of the USA's roads and highways has drawn considerable attention to this problem as a growing part of the nation's crumbling infrastructure. The maintenance of these roads and highways is becoming a major part of any public works program. This topic is usually covered in a pavement design course included in most CE programs. In this course, most of the emphasis is usually placed on the design of pavement structures themselves, while topics on maintenance and pavement rehabilitation are neglected or downplayed due to insufficient classroom time and the lack of adequate or applicable course material. Using the IDS, an IDB of representative pavement distress conditions was created to address this problem of availability of material and time.

Different types of pavement distress conditions such as alligator and transverse cracking were located in the field and videotaped using a camcorder. The resulting videotape had multiple pictures or frames for the same type of pavement distress taken from different sites. Typical single video frames or images were captured from the videotape with the help of the image capturing board. Each of the pictures or frames were stored in the form of a binary file on the optical disk. Each was then edited and enhanced by adding appropriate text and identifying markings to make them

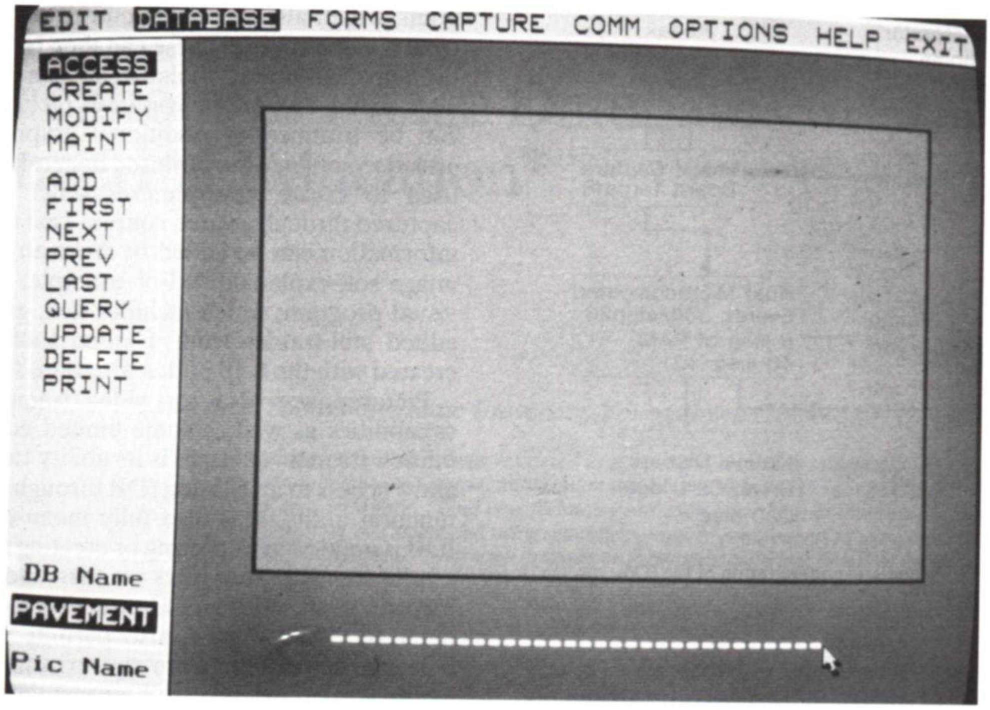

Fig. 2. The main menu of the Picturepower program.

self-explanatory. Picturepower was used to select a display format which included keyword titles for each type of pavement distress. The CREATE command of the program was used to link all the stored pictures or images in the form of a database. This whole process is entirely menu-driven and user-friendly. Linking all the pictures with appropriate keywords completes the creation of the IDB.

The IDB for pavement distress has approximately 43 pictures or enhanced still video frames. Figures 3–5 are typical examples of the still-frames placed in the pavement distress IDB. More pictures can be added by using simple commands. Accessing the pavement distress database can be accomplished using Picturepower commands in either sequential or random modes.

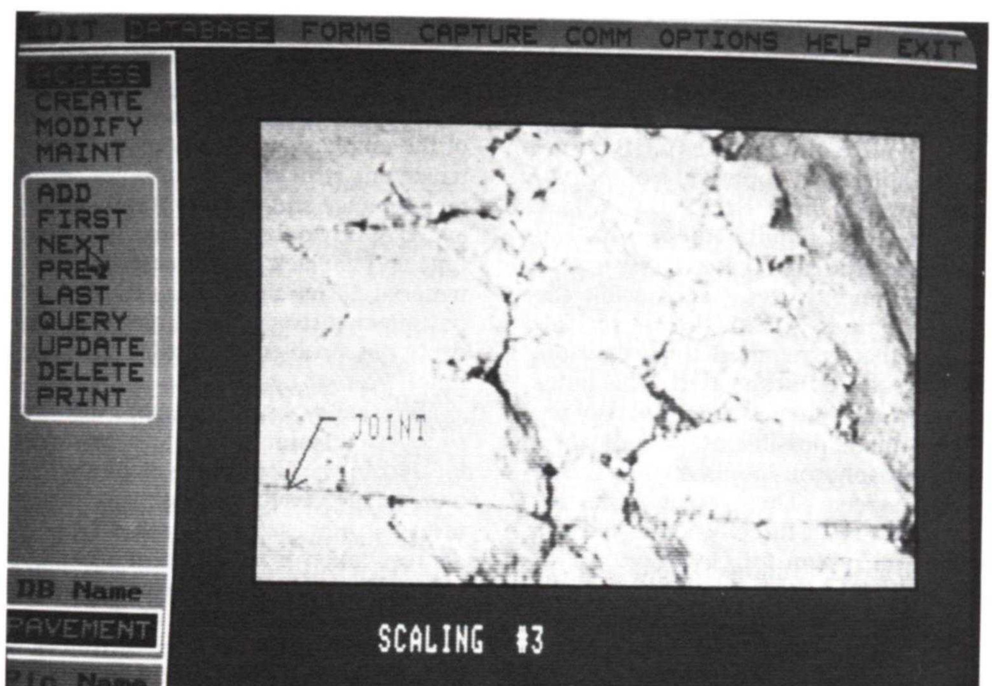

Fig. 3. Video still-frame placed in the IDB showing scaling.

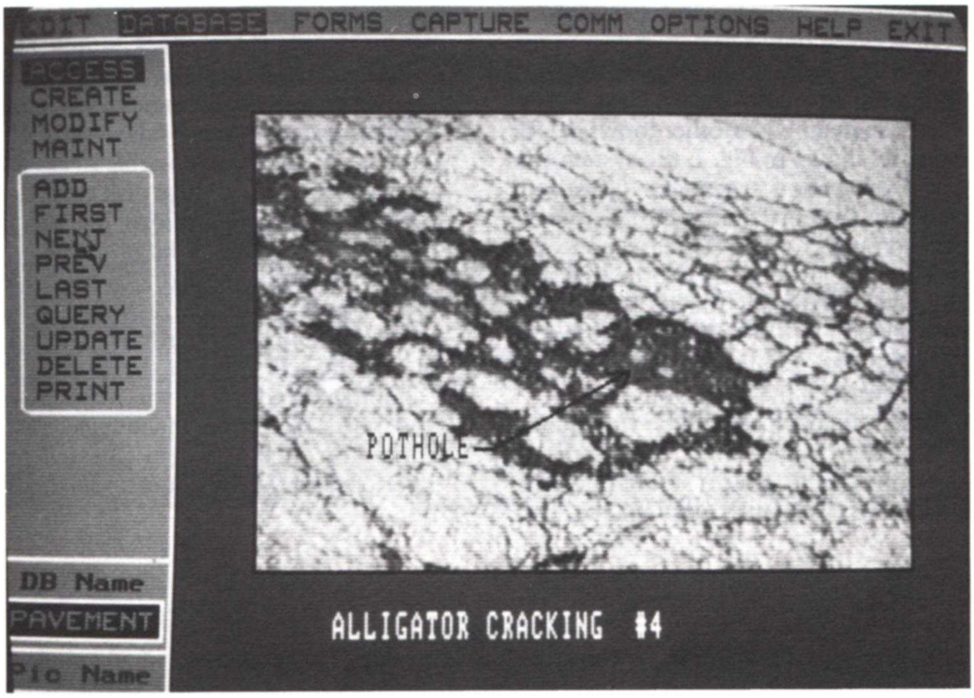

Fig. 4. Video still-frame placed in the IDB showing alligator cracking.

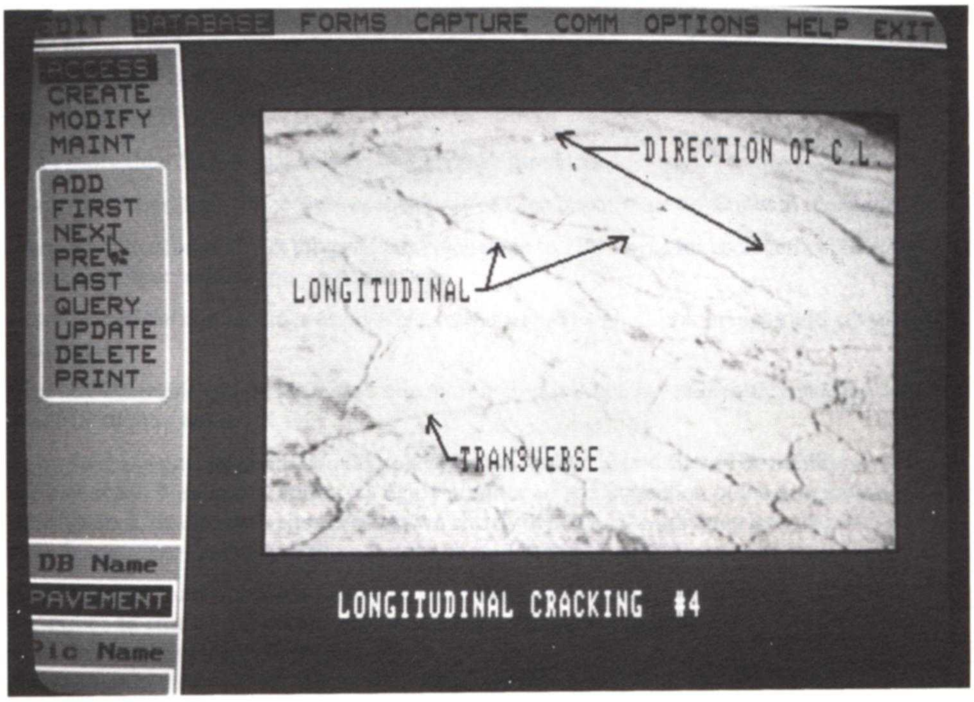

Fig. 5. Video still-frame placed in the IDB showing longitudinal cracking.

CONCLUSIONS AND RECOMMENDATIONS

The IDB described herein has been successfully used in an existing pavement design class. The students viewed different pictures or still-frames in an enhanced mode contained in the IDB. Students found this approach to be more informative than the few pictures available to them in the textbook.

The whole process seems to be equivalent to creating a slide program. However, it is much more flexible in many respects. The pictures are captured from a standard videotape, and the system therefore alleviates the need for processing a negative, which does not allow for any editing of the resulting slides. In this system, a picture can be edited/ enhanced to make it more informative. Its quality can also be improved with the help of the image processing techniques. The random access mode also allows one to view only a selective part of the IDB. The use of the system has been effectively demonstrated in the pavement design class. Additional IDBs are also planned for other topics in CE.

Furthermore, as shown in Fig. 1, the system can be hooked to a projection system for classroom presentations. The system could also be used to replace overhead projectors. In this case, concepts or images usually displayed using overhead transparencies can be created using the TIPS software. They can be placed in an IDB and then shown to students by using the sequential mode of the Picturepower software in the classroom.

As stated earlier, field trips could be videotaped and significant video frames could be captured, enhanced and stored in the IDB for students to view outside the classroom as lecture supplements. This approach is not only effective since it uses only selected applicable frames, but it also saves the students' time in that they need not view the entire tape, which is probably amateurish in nature at best.

The present system is based on a WORM drive, and it is not therefore possible to erase undesirable picture files on the optical disk cartridge. However, in future IDS configurations, this limitation will be overcome by using a large capacity, read/write laser drive. While these drives are currently expensive, it is anticipated that, as with past hardware, the cost of this and other hardware needed to optimize this system will drop in the coming years. These technological advances will make a system of this type more affordable. Meanwhile, any experimentation with such a system will provide necessary experience for future educational deployment.

REFERENCES

1. M. A. White, Imagery as the New Language of the Information Age, paper presented at National Educational Computing Conference, New York (1987).
2. J. S. Bruner, *Beyond the Information Given*, Norton, New York (1973).
3. M. C. Wittrock, *Handbook of Research on Teaching* 3rd edn, Macmillan, New York (1986).