The Use and Capture of Images for Computer-Based Learning II

Jane Williams*, Alan Lock, Joel Crisp and Adrian Longstaffe

Multimedia Resources Unit
Educational Technology Service
University of Bristol
Royal Fort Annexe
Tyndall Avenue
Bristol BS8 IUJ

*e-mail: J.Williams@bristol.ac.uk

http://www.ets.bris.ac.uk/

The work reported here has been funded by the Support Initiative for Multimedia Applications (SIMA).

Version one of this publication was funded by the Information Technology Training Initiative (ITTI). Initial development of the software tools available from this report was funded by the Joint Information Systems Committee under the New Technologies Initiative

Contents

Introduction

Images, both still and moving, form the core of multimedia applications and it is a commonly held view that illustrations can be used to enhance computer-based learning material (courseware) and the learning process. This view is largely based on experience rather than research, although Duchastel and Waller (1979) stated that the 'common view' was that most texts can be enhanced by the addition of illustrations. Illustrations include simple line diagrams, graphs and charts, flow diagrams or photo-realistic (representational) images.

This booklet is divided into four sections. First, we will take a brief look at the evidence supporting the view that illustrations enhance learning. The second section will discuss the capture, manipulation, storage and delivery of photo-realistic images for use in the production of computer-based learning material, although other types of illustrations will be considered where appropriate. An evaluation of several image capture cards makes up the third section. Finally, the fourth section describes some software tools developed to facilitate image conversion and manipulation and the optimisation of image palettes for the preparation of images for inclusion in computer-based learning programs. Details of how to obtain these tools are given in the relevant section.

This handbook was first published under the Information Technology Training Initiative (ITTI) and has been updated under the Support Initiative for Multimedia Applications (SIMA) to include sections 3 and 4. Under this initiative a further publication “Evaluation of Image Capture Pathways for Multimedia Application” (Steele *et al.*, 1994) has been produced. The aims of this project were to investigate the various methods and choices of image capture, the costs and quality of image obtained for each method and to determine the best approach needed depending on the type of source material available. This publication and that of Robinson (1993), Williams (1993) and Williams and Hammond (1994) should be read in conjunction with the following information.

This booklet is by no means an exhaustive account of the subject and the authors do not pretend to be educational experts. The first section is referenced and a further reading list for the remaining parts is provided, which should be read in conjunction with this handbook. For the first section the author has relied heavily upon and quoted freely from Clark (1992).

During the course of this account the words illustration, image, picture and graphic are used synonymously.

Section 1: Images and learning

Images have a direct route to long-term memory

Current studies of human memory make a functional division of memory into short-term and long-term memory. Both types store and remember information as "chunks" but there is a difference in the number of chunks that can be retained and recalled. Immediate or short-term memory can only retrieve a limited number of items at a time - roughly seven plus or minus two. Long-term memory on the other hand does not seem to be limited to a finite number of chunks or concepts that can be stored and retrieved (Miller, 1956; Gage and Berliner, 1988).

A number of experiments carried out in the 1970s showed that not only does the brain have an extraordinary capacity to imprint and recall, but that it can do so with no loss of memory. The capacity for recognition memory for pictures is limitless. Pictures have a direct route to long-term memory, each image storing its own information as a coherent "chunk" or concept (Paivio et al., 1968; Standing et al., 1970; Paivio, 1971; Standing, 1973; Paivio, 1975; Erdelyi and Stein, 1981 and references therein). However, the images or pictures must be meaningful to be retained (Freedman and Haber, 1974).

Being non-text intensive, the computer environment is ideal for the use of images to enhance learning. Pictures make use of a massive range of cortical skills: colour, form, line dimension, texture, visual rhythm and especially imagination (Buzan, 1990). Imagination comes from the Latin imaginare, meaning "to picture mentally". Images are generally more evocative than words and more precise in triggering a wide range of associations, enhancing creative thinking and memory.

Alesandrini (1984) in a survey of American commercial educational courseware found a low rate of use of graphics. There may be several reasons for this: a low level of understanding of the use of pictures among designers; designers may see graphics as an added extra and not central to the design and learning process; overemphasis on the word as the primary vehicle of information; resources of suitable images in computer useable form may be unavailable or have copyright restrictions or in the case of computer-based courseware graphic displays may not have been capable of achieving the results needed. Today, with good computer graphic capabilities, high quality photo-realistic images can be achieved.

With a more complete understanding of how the mind works we are beginning to realise that a new balance must be established between the use of images and the use of words. The brain is divided into two hemispheres, left and right. Both gather in the same sensory information but each half handles the information, or parts of the information differently. The left side, or logical left as it is known, is the analytical, verbal, sequential, symbolic, linear half. The right side allows us to have imagination, visualisation, understand metaphors and create new combinations of ideas; it is more spatial, holistic and relational (Edwards, 1982).

The computer industry makes use of this knowledge and this is reflected in the increasing development of machines that allow us to link and manipulate words and images together (Buzan, 1990). It is important, however, that any visual material is used in the correct manner (see next section).

The use of images in computer-based learning

Currently there is no extensive body of information exploring the use of illustrations in computer-based learning (Alesandrini, 1987). Few studies have investigated the use of images in CBL (Peeck, 1987). However, there is a large volume of research into the use and effects of illustrations in learning for paper-based learning materials (Levie and Lentz, 1982). Under these circumstances it is not unreasonable to conclude that pictures will aid learning.

There is considerable evidence that users find reading text from screens more difficult than from printed material (Gould et al, 1987; and references therein). The computer screen, however, is not a text-intensive medium (at least it should not be, if proper screen design guidelines are practised); thus the replacement of text, wholly or in part, by illustrations is important.

There is also evidence that text should sometimes be used to support pictures as well as the converse (Holliday, 1976; Weidenmann, 1989; Bernard, 1990). Bernard (1990) went on to consider two strategies for increasing the effectiveness of illustrations in text. Two types of caption were used:

- Descriptive - the caption repeated the contents of the picture
- Instructive - the caption included key features of the picture.

Results from experiments employing these strategies show that both caption types produced better results than when the illustration alone was used. Little difference between types was shown and there was no additive effect when both types were combined. However, when using images for screen-based material, where space is limited, it is helpful to remember that the instructive captions require far less space than descriptive ones.

In general, users prefer material which is illustrated (Levie and Lentz, 1982) and regard it as being of higher quality. Levin (1989) states "pictures interact with text to produce levels of comprehension and memory that can exceed what is produced by text alone." It may well be that many of the findings from studies of the use of illustrations in printed material are transferable to the computer screen. Below are some of the points and guidelines summarised by Levie and Lentz (1982) in an extensive review (153 experiments) of the effects of illustrated text against text alone.

- The presence of pictures relevant to the text will assist learning.
  Therefore, for each screen without an image, is there an image that is relevant to the information of that screen? If you can replace the text with an image, do so.
- Pictures not covered by the information in the text will not enhance the learning of the text.
  For each screen with an image what is the intended purpose of that image? If it does not have a purpose relevant to the text, remove it.
- The presence of pictures in the text will not aid the learning of the text which is not illustrated.
- Pictures can help learners to understand what they read and also to remember it.
  The memory's storing and recalling powers can be enhanced through the use of images for emphasis and association.
- Pictures can sometimes be used as substitutes for words or as producers of non-verbal information.
- Learners may fail to make full use of complex illustrations.
  Simple representations should not be discounted because they are not 'sophisticated' enough. Can the image be simplified without losing the point? If so, simplify it.
- Pictures may assist learners with poor verbal skills more than those with good verbal skills.
  By providing an additional visual explanation the holistic skills of the right side of the brain are brought into play

Representational/Photorealistic images

Instructional pictures have been classified into three types, on the basis of how they convey meaning:

- Representational - those pictures that share a physical resemblance to the concept being portrayed

- Analogical - those pictures that explain a concept by showing a similar example and applying the similarity

- Logical - those pictures that show logical representations of the physical concepts being represented. For example, flow charts, graphs and charts.

Our attention will focus on representational or photo realistic images.

Much research has evolved from the use of photorealistic images to assist learning in text-based situations. Several experiments investigating the effects of realism have been carried out (Dwyer, 1970; Dwyer and Joseph; 1984 and references therein). The results showed that the effectiveness of realism is directly proportional to the time and effort put into studying the images. Students working at their own pace (self-paced learning) took most advantage of the information provided in realistic images. However, if the time the student has for study is short and under control then line drawings (simple representations) proved to be most effective.

There is also the danger that complicated realistic images may distract the student and impede learning (Holliday and Thursby, 1977). This is an important point when teaching students who have a low aptitude for the subject.

These last points lead us to the obvious question:

What is the objective of the illustrations used?

The learning objective that the author is aiming to achieve must always be considered. Realistic images may motivate students more than line diagrams. They may gain the interest and attention of learners by adding variety or providing a focus. Myatt and Carter (1979) and Spaulding (1955) reported that students appreciated more realistic images and detailed pictures. Of more importance is the fact that photorealistic images, particularly moving ones, may help aid understanding and learning of concepts that cannot be explained verbally or for learners with a low degree of verbal understanding.

Placement of images in computer-based learning material

Bernard (1990) stresses the importance of placing the image near the text that it supports or making obvious the links between image and text. Often this is difficult if the size of the computer image is full screen. Therefore, use quarter screen images when available. Images related to text should not be put on a second "page" of the module. That is, the text and associated image must appear together (there is no reason why the image should not appear on a second monitor as occurs with two-screen videodisc programs, although this may carry an extra overhead in terms of additional software and hardware costs). If necessary place a "button" on the screen that when pressed causes the appropriate image to appear. Several images can be used in this way but this can lead to problems with colour corruption of subsequent images (see section on palettes for further details). With printed material the need to turn several pages to find the relevant diagram can be distracting (Hutchinson, 1990).

Opinions differ as to whether images should be placed to the left or right, or above or below, any text. The computer-based education section of Queensland University of Technology suggests that the illustrations should appear towards the upper left hand corner of the screen. The reasons for this are that the eye automatically scans from left to right and any image, regardless of its placement, will gain the attention of the learner (Russell and Redhead, 1991). However, preliminary observations at Bristol University have shown that users are likely to spend more time observing and analysing the images and associated text if the image appears towards the right side or below the text. The user reads some text, refers to the image, refers back to the text and so on. When images were placed to the left or above the text, users quickly passed over the image onto the text and rest of the screen without referring back to the image (personal observations made during staff development workshops).

On occasions almost the entire screen will be taken up with an illustration. In these instances the centre of the screen is not necessarily the best position for the image. Good design practice is to place the image's focal point slightly off centre.

Section 2: Image Capture

Image generation can be handled in a number of ways. Spreadsheets can be used to store data and generate graphs and charts. Line diagrams, flow charts and sophisticated graphics such as molecular models and chemical formulae can be generated using graphic design and drawing software programs. Photographs, transparencies and documents can be scanned or captured using a camera and image capture board. Alternatively, computer-ready images, for example, samples of clip art, may be imported into computer-based learning material.

This following section will focus on the capture of photorealistic images (transparencies, prints, objects, etc) for computer-based learning materials.

There are several ways of capturing images but all have one thing in common; the visual information needs to be converted into an electronic signal before it can be stored, edited and ultimately displayed. We perceive images by the light that reflects off or passes through an object. This light or optical signal is captured and converted to an electronic signal which can be stored. The electronic information or data can be stored as either an analogue or digital signal.

- Analogue: For analogue data the signals are based on the variations that occur in a continuous electronic signal. Such signals occur on cassette tape, videotape and videodisc. Such signals can contain an infinite range of shades, tones and colours and as such transparencies and prints can be referred to as analogue or continuous images.

- Digital: With digital data the electronic signal is represented as a '1' or '0', that is, on or off, logical yes or no. Digital data are stored as bits and bytes and examples are the data stored on a hard disc, floppy disc, compact disc or DAT (digital audio tape).

The process of image capture can be divided into four steps. These are:

- Capture
- Store
- Edit
- Display

Capture and store will be considered together as will edit and display. For each group the advantages and disadvantages of the analogue and digital scenarios will be discussed. Hardware and software issues will also be explored.

Image capture and storage:

The analogue model

This sort of model is not for the individual wishing to capture half a dozen or so pictures. However, it is an essential consideration when archiving material such as thousands of transparencies and prints, for example, for archiving museum specimens, works of art, medical images, etc. The hardware is expensive but in many instances, such as those referred to below, can offer a cost-effective medium.

This model has been used to produce a number of videodiscs such as the Bristol Biomedical Videodisc (Williams, 1992) and the videodiscs produced for the Wellcome Trust Tropical Diseases Videodisc Project (Longstaffe et al., 1992).

Figure 2.1 shows the recording studio for videodisc production at Bristol University.

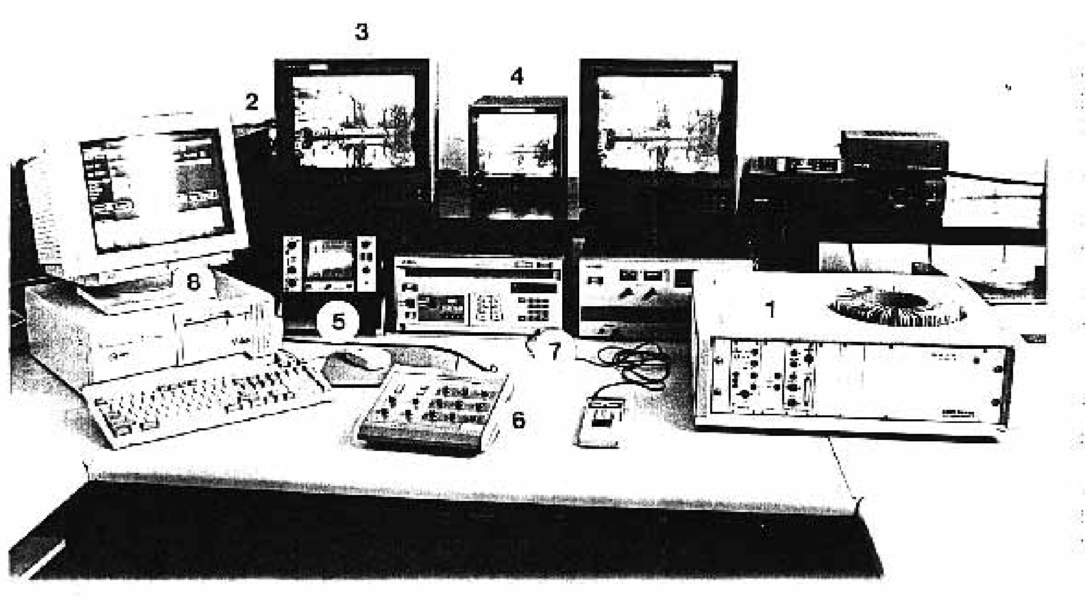

Figure 2.1 The Laser Videodisc Recording System at Bristol University. The recording line comprises: a carousel unit (1) inside which is mounted a 3-chip broadcast quality camera; the camera control unit (2); two colour monitors (3), a black and white camera (4), a wave form monitor (5); a colour balancer (6); the Sony Laser Videodisc Recorder (7) and a computer running the cataloguing software (8). The wave form monitor is used to monitor the quality of the signal and colour correction is carried out using the colour balancer. The corrected image is viewed on the second colour monitor prior to recording. The recording process is under computer control; the frame numbers are automatically inserted into the appropriate database records.

The equipment or hardware required includes:

- camera (input device)
- colour balancer (restore colour balance to images)
- wave form monitor (monitors the quality of the signal)
- colour monitors (to visualise the process)
- video tape recorder/recordable videodisc (recording device)

Not all of the above equipment need necessarily be bought. It will depend very much on what it is you want to do. It is best to take advice from a reputable dealer. However, you will need a camera and a recording device. The camera may also double up for digital image capture (see the digital model).

In addition to the above list of hardware you will also need some device to support the image that is being captured. This may simply involve projecting the image (e.g. transparency) onto a white screen and pointing a video camera at the projected image. The quality of this captured image can be improved by projecting the image directly into the camera. Figure 2.1 shows a piece of equipment known as a Kindermann Unit. This houses a normal carousel unit but the camera head has been mounted inside and the optical signal directed into the camera lens. Alternatively, the camera can be mounted on a stand (rostrum) and a light source placed above (in the case of objects and prints) or below, e.g. a light box, (in the case of transparencies). In this instance a number of different lenses are required. You may find that a lot of this equipment already exists within your institution.

It cannot be stressed strongly enough that the quality of the captured image will depend on the quality of the original. The optics and electronics of the camera will also affect quality. Video cameras contain photoreceptors known as charged couple devices (CCDs or "chips").   It is these CCDs that convert optical information into electronic data. The number, resolution and spatial luminance of these CCDs will affect the quality of the resulting image. Video cameras are typically single-chip or three-chip. Three-chip cameras are generally thought to be of higher quality, the chips separately capturing the red, green and blue parts of the light signal. However, there is much debate and many arguments for and against the purchase of three chip cameras over single chip cameras. Certainly more technical support in needed with three chip cameras; as the chips need to be kept in alignment, any spatial misalignment will show on the captured image. Good-quality images can be generated from high-resolution single-chip cameras.   Whichever choice of camera you decide upon make sure the camera has the capability of outputting an RGB signal (see section 3, results and conclusions).

Whatever camera you finally choose, it is important to remember that the better the image you start with, the better the resulting captured image.

The resulting tape or recordable videodisc containing the images can be used as a 'one-off' or alternatively be sent to a videodisc manufacturer and be mastered and replicated to produce the required number of standard read-only videodiscs.

The digital model:

To convert an analogue image (whether transparency or stored on tape/videodisc) to a digital image, a sampling process occurs that creates discrete finite picture elements and assigns to them both a location and a colour or grey value. This process is known as digital imaging or digitising.

Video capture is the process of capturing and displaying sequential images rapidly in real-time. Single frames can also be captured from video if this is your source material

There are three possibilities as far as equipment or hardware is concerned:

- Digitising board (frame grabber/video board) plus analogue input (e.g. camera, videotape)
- Scanner (hand-held, flat-bed, transparency)
- Digital camera

Digitising boards: are boards or cards that fit into the expansion slots of the computer, allowing the capture and storage of a digital file. Image capture devices that capture images via the parallel port of the computer are also available. All need an analogue input either directly from a camera or from a videotape, videodisc or other analogue storage medium. Again, the better the quality of input, the better the resulting digitised image. A variety of digitising boards are available for both PC and Apple Macintosh platforms and range from as little as £79 to £4,000. The price reflects the number of options offered and its capabilities of allowing RGB, S-video and composite inputs. The top range boards will also provide video output, allowing the recording of computer presentations and animations to tape or other analogue devices.

Some image capture boards come complete with software that allows not only image capture but also extensive image manipulation. Other boards allow capture only. Extra software is then needed to take that image and alter it further. This is important to remember if your budget is limited.

Some capture boards, known as video capture boards, allow the capture of full-motion video using a video camera or VCR . This involves a great deal of storage (2-10 MB for every 1 minute of video) and compression methods need to be employed (see sub-sections on storage and compression). The cost of video capture boards generally reflects the frame rate and size at which the video is captured.

For more details on image capture cards see Section 3.

Scanners: These range from the low-end hand-held scanners to the high-end drum scanners. Between these two extremes lie flat-bed and transparency scanners that are more commonly used for digital image capture and for Desk Top Publishing applications. Some scanners on the market today combine flatbed scanners with a transparency module, that is, they accept transparency and reflection copy (Rogers, et al., 1993). Alternatively, dedicated slide scanners are available. Scanners may be monochromatic or colour . The size of image that can be scanned varies from scanner to scanner. Some accommodate originals, from 35mm up to A4. Scanners specialising in capture of X-rays are also available. Many of the more popular computer magazines regularly include surveys and tests of the latest scanners.

However, you do not need to purchase a full-size flatbed scanner if you are not intending to use large images. Small inexpensive hand-held scanners (both monochrome and colour) are adequate for images such as clip art, small diagrams and photographs.

Again, charged couple devices are used to create an electronic signal (voltage) that is proportional to the amount of light it receives. An analogue to digital converter converts the electronic signal from the photoreceptor to digital form. The size of the CCD, its sensitivity (number of cells), the sampling rate and repeatability of the scanning motor are all important in determining the resolution and quality of the scanning process. The CCD consists of a horizontal array of cells or elements. There are CCDs with 2,400, 3,200 or 4,800 elements. It is these that determine the optical resolution (dpi - dots per inch) in the horizontal. The optical resolution in the vertical is determined by the stepper-motor. Optical resolution can be artificially increased by mathematical tricks or interpolation. That is, the resolution is increased by adding artificial dots between the dots gathered by the scanner. Interpolated data is only as good as the original information and only makes the image worse when the image is of poor quality to start with. High resolutions are only needed for those images that need enlarging, for example, transparencies, or to meet the needs of professional graphic artists. If this is needed be aware of the true dpi or resolution of the scanner before purchasing.

If purchasing a scanner for capturing images that will eventually be outputted to print then the resolution of the image should be determined by the output device. Scanning at higher resolutions will only waste valuable time and disc space. Redundant data will be disregarded by the printer and there will be no benefit in image quality. If outputting to print the majority of applications will be handled easily with 300 x 600 dpi optical resolution scanners.

The new scanners appearing on the market today are offering 36 bit colour, that is 12 bits each for the RGB components. However, very few applications currently support 36bit images.

Once the original has been mounted ready for scanning the operator can prescan the image and, depending on the software employed, can rotate, crop and resize the image, mark the highlight and shadow areas, select a specific area and sometimes perform colour correction on the image. Some scanners have plug-in software modules that drive the scanner directly from some of the more popular image processing software programs on the market. These packages provide excellent manipulation facilities and many special filters and effects. However, complex image manipulation may require an investment of time for learning.

Digital cameras: Like conventional 35mm cameras, digital cameras use optical lenses. However, rather than capturing the image to film, the image is captured with a CCD chip and stored internally either as analogue or digital signals. The images can be transmitted over networks and telephone lines, displayed on the screen and printed. The speed with which images can be produced and transmitted is of great value to people who need images fast. In instances where the images are stored as analogue, one still has to plug the camera and disc into a digitising board. The images once captured can then be altered in the appropriate way.

The first generation of digital cameras, such as the well known Xap Shot or Ion camera from Canon, do not have the resolution to compete with conventional photographs. Images are stored as analogue signals on small discs, each disc taking 50 images. Vast improvements have been made in this area; many of the major manufacturers, such as Canon, Kodak, Minolta and Nikon, are producing high resolution digital cameras based on SLR cameras. The newer digital cameras come equipped with internal hard discs or have utilised PCMCIA technology for storing images for later viewing and manipulation with a computer. The cameras can also be directly built into an imaging system and come with software plugins for the more common image manipulation packages such as Adobe Photoshop for capturing images directly. Digital cameras are expensive and the digital file is very large, up to 18 MB in some cases. The advantage of these cameras is their portability and the elimination of the need for chemical processing. For further information see Brown (1994a, b) and Robinson (1993).

PhotoCD:
PhotoCD is a digital image format and provides a mechanism for transferring photographic film or transparencies onto compact disc at very high resolutions. PhotoCD images can be manipulated further using image processing software. For further details see section on PhotoCD.

In summary, choose a digitising method that takes into consideration the source material (videotape, transparency, etc) and target display. See also section 3, Conclusions: Recommendations and Guidelines for Image Capture

Before digitising any material be sure to have read or be aware of any copyright restrictions and if necessary seek permission first.

TWAIN

TWAIN is a protocol which defines how bitmapped images from scanners and other image capture devices can be captured directly into image processing packages. For example, image manipulation software such as Aldus Photostyler, Adobe Photoshop and Micrografx PhotoMagic are TWAIN aware and can directly capture images from source. TWAIN drivers are supplied with the image capture hardware.

Cataloguing/indexing images

When capturing images and storing them on analogue or digital storage devices, one area that is often forgotten is that of cataloguing. With analogue systems, the images are often stored and referenced as time-codes or frame numbers. With digital systems one is limited to a filename of a few characters (eight letters on current IBM compatible PC's) which is often insufficient for immediate recognition.
Imagine you have several thousand images stored on a compact disc and you need access to those that illustrate a particular object or scene. Without an index, your only choice is to load each image sequentially. You may only require a few images for a tutorial but very quickly the images become unmanageable. At the very least one should keep a written record of the frame reference/file name with corresponding key words. However, once into the hundreds, it becomes essential to keep a proper database/index of the images. Information on the images that one might wish to keep, especially if coordinating an image archive involving several donors, will include sections on the details of the donors, copyright information, image subject matter (description, key words), frame number/file name, physical location (e.g. catalogue videodisc no. 2/CD-ROM no.7, subdirectory Landscapes) and anything else particularly relevant to your collection.

Again, there is much software available to help. Database tools provide a means of indexing data (still images, video, animations, graphics, audio, etc) in a form that facilitates easy retrieval. They incorporate tools that allow the user to create, update, interrogate, relate and build temporary image sets from the main database.

One might choose to use a relational database or cataloguing software that specialises in search and retrieval. The advantage of the latter is that searches of the database can be carried out on any word or piece of data. However, the drawback is that the image you require may be there but the data or word on which the search was performed is not present. To help overcome this many people catalogue using a classification system. In addition guidelines for writing details of the description and key-words should be provided if your images are coming from a number of people. Different people will describe the same image differently. A well designed database will accommodate all these views. Depending on the size of your project, for example if creating a resource of images, and your access to programming expertise, several search and retrieval mechanisms can be employed to assist in searching such as providing a list of headings (this may be generated from any classification system used), or key words available, spell checking, synonym lists, context based searching, etc.

Within the Educational Technology Service of Bristol University, two different databases are used for cataloguing image based resources; an administrative database based on the relational database model and a delivery database using search and retrieval mechanisms. By using the relational model for administering images, details such as the donor and institution, for example, need only be stored once for a large number of images. Only information needed by the users is then delivered with the images via the search and retrieval programme (Williams and Hammond, 1994).

In the case of digital images and other digital files, modern database software allows a record to be linked with the corresponding image file. Some software will display a series of the indexed images the size of a postage stamp. A number of commercial specialist image database software packages are now available on the market which will display your images as 'thumbnail sketches' and provide space for key words. Kodak and Aldus have developed such archive management software, 'ShoeBox' and 'Fetch' respectively. Both have facilities for tagging each image with numerous keywords and descriptions and are extremely easy to use.

For videodisc resources, some database software will communicate with the videodisc player provided the appropriate drivers are available to display the image on a second screen or, if using an overlay board, on the same screen as the computer data.

Editing and displaying images:

Analogue model

Once recorded, analogue images cannot be edited; if the wrong image has been recorded the only alternative is to re-record. With tape, certain frames can be erased but with recordable videodisc the technology employed is "Write Once Read Many" (WORM) or "Analogue Write Once" (AWO) technology and in this case the images cannot be deleted. The standard videodiscs are read only. In some cases the cataloguing software can be programmed not to access particular images. The capacity of tape and videodisc is large and the loss of a few frames is not disastrous. However, re-writable videodisc technology is now available; although the original recorded image cannot be edited, it can be erased and re-recorded.

Interactive video may be a one-screen or two-screen system. In the case of the latter a second display device is required to display the video image. Some videodisc players possess a character-generating set, allowing arrows, for example, to be drawn on the videodisc image. For more powerful interaction a one-screen system is needed but this necessitates an extra piece of hardware: an overlay card. The overlay card or board combines the incoming analogue signal and digital information from the computer and displays the information on one screen. There are a few overlay cards available on the market, the price ranging from £200 to approximately £1,000 depending on additional functions required. The majority of overlay cards work by digitising the incoming analogue signal, allowing manipulation of the video image. Commands and routines, or in some cases interfaces, are supplied with these boards, enabling capture and storage of the digitised video signal, the boards doubling up as a frame grabber/digitising board.

To include video images in computer-based learning material, drivers will be needed to control the videodisc player from the computer. In some instances the drivers will be supplied with the authoring software. If not, the videodisc player manufacturers should be able to supply the appropriate driver. For Windows development, the drivers can also be obtained from the relevant electronic bulletin boards.

	Analogue	Digital
Advantages	Very high quality, unlimited palette Large storage capacity Full-screen, full motion, high-quality video Highly developed technology	Can be edited and manipulated at any time Multiple copying without loss of quality Workstations much cheaper and common
Disadvantages	Difficult to edit or manipulate (although sequence in which images appear can be) Copying results in loss of quality Workstations can be expensive and therefore delivery machines rarer	Quality loss on initial digitisation in some instances large files - reduced storage capacity Full-screen, full-motion video, currently available only with hardware assisted playback Standards for moving video remain in conflict

Table 2.1. outlining the advantages and disadvantages of analogue and digital images

Digital model:

When the images have been captured, using the appropriate hardware, they are not necessarily ready for importing directly into computer-based learning authoring software. The employment of image processing software may be needed for further image manipulation.

With digital images three issues need to be addressed:

- Image formats
- Resolution
- Number of colours

Image processing software provides the means to change the format, resolution and number of colours of the captured image, as well as a variety of other complex features. Packages vary in cost depending on the complexity of the package. Adobe Photoshop is now regarded as being the industry standard but remains one of the most complex and expensive packages around. A cheaper package may provide all the functions and more besides that you require.

Image File Formats:

What image file formats does my authoring software recognise?

Computer graphics (including images) come in two different forms: vector based (also called object-oriented) graphics and bit-mapped (also called raster based) graphics. Vector based images are described by formulae. They look smooth on a display and because of the way the information about the image or graphic is stored they are rendered evenly at any size or orientation. The mathematical formula that describes the file contains specifications about both the dimension and direction that is associated with them. Thus the images can be scaled or resized without distorting the object. Software systems that allow the creation of vector graphics are called draw programs. Typical examples of vector based images are technical illustrations, floor plans, maps, diagrams and charts.

For photorealistic images we are really concerned with bit-mapped images. Bit-mapped images are made up of a number of pixels to form a mosaic. When enlarged, the individual pixels themselves are enlarged and hence they reveal stepped edges often referred to as "jaggies". Each pixel or picture element has a value, made up of 1's and 0's, that is stored. For this reason, bit-mapped images can become very large in terms of file size (see also section on compression). The advantage of bit-mapped images is that the individual picture elements can be manipulated and controlled. However, this requires considerable processing power. Software programs that manipulate bit maps are known as paint programs. Applications include imaging, photo retouching and other art based techniques.

Simple paint programs are ineffective for manipulating digital images because they do not contain the tools necessary to manipulate images globally or to work with a region of the image. Colour image processing software has a wide variety of tools for extensive image editing. This must be taken into consideration before purchasing software and your choice will depend on the functions you require. As previously mentioned, quite sophisticated image processing software may be provided or come bundled with capture boards and scanners.

Image (graphic) file formats abound, each one having evolved for a reason. Fortunately there are many common file formats and the majority of software (image processing and authoring software) recognise the common formats. In some instances the software that drives and enables image capture from your scanner or video board may allow you to save the image as one of the more common file formats directly.

Other hardware may capture an image as a proprietary format. In these cases software should be supplied as part of the package that converts the proprietary format to one of the more common formats.

There is a third class of digital files that accommodates both vector and bitmapped information. These are called metafiles, although both types of information are rarely written into a metafile.
The most common formats include:

- **Windows BMP:** Windows native bitmap format. This format came into use with Windows 3.0. It is an uncompressed format so file sizes can be quite large and therefore seldom the choice for large high-resolution images. However, it has widespread support in the Windows world.

- **PCX:** One of the oldest and most common raster formats for PCs (PC Paintbrush format) using RLE (run-length encoding) for compression. It is starting to be replaced by other, newer formats.

- **TIF(PC)/TIFF(MAC):** Tagged Image File Format, a general purpose multi-platform raster format developed by Aldus and Microsoft designed specifically to provide a basis for importing scanned images into DTP packages. Comes in various versions and may be compressed using LZW compression. Both PC and MAC

- **TGA:** TARGA file format. The first popular format for high-resolution images. No compression methods or tags are employed and hence TGA files are large. A PC format.

- **GIF:** Graphics Interchange format, owned and used by Compuserve. A sophisticated format, providing amongst other capabilities LZW compression, allowing small files to be created that can easily be transferred over networks. Software packages' support for GIF is increasing and several shareware viewers/converters are available. One of the standards for the World Wide Web network information system.

- **PICT:** Macintosh format. All Macintosh programs save and read PICT files.

- **EPS:** Encapsulated post script developed by Adobe Systems Inc. Metafile, supporting both vector and raster information. Multi-platform. EPS files can be easily converted to other formats but the reverse is not so easy. EPS was developed to enable images to be sent to a printer supporting Postscript.

- **CGM:** Computer Graphics Metafile, one of the most widely supported metafile formats created by the ANSI in order to provide a common ground for graphical information interchange. Supports both vector and bitmapped information.

- **WMF:** Windows Metafile. A vector format allowing images to be resized proportionately on screen. Not commonly used and support for the format outside Windows is limited.

- **JPEG:** Joint Photographic Expert Group. Designed for maximal image compression. JPEG uses a new kind of compression called "lossy" compression - information is lost on decompression but in such a way that the human eye won't miss it. Lossy is not to be confused with lousy! JPEG images may also degrade further if manipulated further and saved. Make sure that compressing the image as a JPEG image happens last after all manipulation or keep the original as a lossless format.

- **RIFF:** Resource Interchange File Format. A family of file structures rather than a single file format supporting multimedia. Developed by Microsoft and IBM. Includes PAL (Palette file format), WAV (Waveform Audio format), MID (MIDI format) and DIB files (see next format).

- **DIB:** Device Independent Bitmap. Popularised by Windows. Files saved in this format can be displayed on a variety of devices. Similar to BMP images and can be opened in some packages, although not offering DIB as a choice, by setting the file type to BMP. Used mostly by programmers who need to worry about displaying images on a variety of devices.

- **PhotoCD:** A proprietary format developed by Kodak. See subsection on PhotoCD.

Note: The GIF format incorporates LZW compression technology developed by the Unisys Corporation. In early 1993 Compuserve were notified by Unisys of patent rights granted to "LZW". Compuserve have negotiated licenses for themselves and the software developers who work with them. However, this situation won't immediately affect users in higher education. Unisys have recently issued a statement saying that they don't require licensing, or fees to be paid, for non-commercial, non-profit GIF-based applications, including those for use on on-line services. Concerning developers of software for the Internet, the same principle applies. Unisys will not be pursuing previous inadvertent infringement by developers producing versions of software products prior to 1995.

Compuserve are now co-ordinating the development of GIF24 - a 24-bit lossless compression format with an open specification available without cost.

Screen resolution

What screen resolution will the computers on which I will be delivering the learning material be running at?

Bitmapped images are defined spatially by how many dots (pixels) they contain horizontally or vertically and how many colours the image contains. For example, a VGA screen is 640 dots across by 480 dots in height. This is known as screen resolution. The number of colours is referred to as colour depth and is dealt with in the next subsection.

The majority of images captured will have a greater number of pixels in width and height than can be displayed on the screen. Thus they will need resizing to a resolution suitable for inclusion in the learning material. The graphic capabilities of the delivery hardware must be taken into consideration when carrying out this process (see table 2.2).

Graphics card	Pixels (screen resolution)	No. of colours	Comments
EGA	640 x 350	64	No longer recommended
VGA	320 x 200	256	Majority of computers are VGA
VGA	640 x 480	16	
SVGA, Level 1	640 x 480	256	Now standard recommendation. minimum level 1
SVGA, Level 2	800 x 600	256	
SVGA, Level 3	1024 x 768	256	

Table 2.2 showing various graphic cards and the resolution and number of colours obtainable by each

Whether the graphics capabilities are CGA, EGA, VGA, or one of the SVGA levels, it is essential that illustrations be always of the highest possible standard. This is of particular importance in higher or adult education where students might take the material less seriously if illustrations are of poor quality. It is also important not to confuse quality of image with complexity.

Finally, there may be occasions when you wish to enlarge a particular section of an image. Enlarging or zooming in on a bit-mapped image is not successful as the individual pixels are enlarged, giving the image a blocky appearance. In these instances it is far better to zoom in on the image before it is captured. With a camera you will need the appropriate lenses. If scanning, scan at a high resolution. The required area can then be re-sized to the appropriate screen resolution.

Number of Colours

How many colours can be displayed at any one time on the computers on which I will be delivering the learning material?

Again, this will depend on the type of graphics card in the delivery machines. Table 2.2 shows the number of colours available, depending on the graphics card and the screen resolution used.

As we already know, bit-mapped images are represented by a number of pixels. These pixels are given a colour (or grey) value. Images may sometimes be referred to as 8 bit images, or 256 colour images. But what does this mean?

A 1 bit image, that is, an image represented by one bit per pixel, will have two values or colours per pixel; 0 or 1, off or on, black or white. A 2 bit image will have 2 values or colours per pixel; 0,1; 1,0; 0,0; 1,1. That is four combinations of the values 0 and 1 or 22 = 4 colours. A 4 bit image will thus be 2 4 = 16 colours and so on, as shown in Table 2.3.

For photorealistic images, 256 colours per pixel must be available. Furthermore, if images larger than 320 by 200 pixels are required then a minimum of SVGA, level 1, is needed, which will mean ensuring that all delivery machines have SVGA graphic capabilities. New machines are now supplied with SVGA graphic cards installed, often as part of the computer motherboard.

No. of bits per pixel	No. of colours
1 bit	$1^2 = 2$
2 bit	$2^2 = 4$
4 bit	$2^4 = 16$
8 bit	$2^8 = 256$
16 bit	$2^{16} = 65,500$
24 bit	$2^{24} = 16.7$ million

Table 2.3 showing the relationship between number of bits and number of colours

Colour Reduction and Diffusion

For images captured at 24 bit (that is, containing 16.7 million colours) to be displayed properly on machines capable of only displaying 256 colours, the number of colours per image has to be reduced to 256. This process is carried out using image processing software. During this process a palette is created containing the best 256 colours from the 16.7 million available (see next section also). The resultant 256 colour images may often be referred to as indexed colour images. However, sometimes the image shows distinct borders between one colour and the next, giving a blocky appearance. By processing the image further, by applying a complex process known as diffusion (also referred to as dithering), the colour content of neighbouring pixels is taken into account when deciding what colour to assign to any given pixel in the diffused file. Although the results are good (smoother), resolution and hence detail are sacrificed.

Palettes

Palettes are something that only needs to be dealt with when using 256 (8 bit) colour displays. The palette of one image will be different to that of another and problems arise when trying to display more than one image on the same screen because only 256 distinct colours can be displayed at any one time. Thus, if one image uses palette A, to display another image with palette B, the current palette colours must change. After the change, image B will look fine, but image A will be shown with palette B and hence will appear corrupted. This is because the graphics card can only accommodate one palette at a time in the memory (video RAM) contained on the graphics card.

Palettes only work if displaying one image at a time on different screens and even then you will get palette flash as palettes are swapped in and out of the video RAM. This is the primary limitation of working with 8 bit colour displays. If this situation is not acceptable and there is a large requirement for displaying more than one image at the same time, then 16 bit graphic cards are needed and users should be encouraged to purchase these. These are now being supplied as standard in new PCs and Macs.

Another way around the problem is to make a common palette for all your images. Some of the more sophisticated image processing software allows palette manipulation and often provide a number of palettes which you can apply. Two such programs for the PC are Windows PalEdit and BitEdit. These tools are included as part of Microsoft's Multimedia Developers Kit. PalEdit will save a palette associated with one image to a file; BitEdit can then be used to apply the palette file to a range of images. These tools can also be used to create a common palette from a number of images with differing palettes.

Here are a few guidelines that can be given when designing courseware with images for use 8 bit graphic displays:-

- Always display important images singly to make full use of the palette. In these instances, the palette can be optimised manually to gain maximum quality.

- Try to use images without areas of unwanted colour. For example, remove background information and borders - use only the object, photograph objects on a plain background, avoid mixing different types of material on the same image.

- Avoid sequences which require the changing of palettes while images are on screen. Palette flashing does not look very professional although it may be acceptable under some circumstances.

- Mask the image to black before bringing in a second image to prevent palette flash.

- Use delivery machines with 24 bit display capabilities if the above are unavoidable

Displaying Images

Images, especially colour reduced ones, will not always look the same when displayed on a variety of monitors. This is due to different phosphors, colour temperatures and variations in the RGB guns. Another factor affecting the display of an image is lighting. Daylight tubes should be fitted in rooms housing imaging workstations or CBL labs. Some computer software may also hog the colour palette.

Monitors can be calibrated in hardware and software. Companies such as KODAK and AGFA produce calibration packages and light sensors are available to read the light output of a monitor.

Photo CD

If you require image capture for a few images (not thousands) PhotoCD may be the answer. PhotoCD provides a mechanism for transferring your normal photographic film or 35mm transparencies onto compact disc at very high resolutions. The more familiar high street film processing outlets will transfer your film for as little as £12.99 for 24 exposures or £16.99 for 36 exposures plus a single payment of £5.00 for the CD. Additional films may be added at a later date, the CD holding up to 100 images. Each image (or image pack) comprises 5 levels of resolution, the highest being 3072 by 2048 pixels. The CD also comes with the equivalent of a photographic contact sheet, showing a tiny print or "thumbnail sketch" of each of your images. PhotoCDs can be read in dedicated PhotoCD players that plug into standard television sets. They can also be read in CD-ROM drives but the drive needs to be XA compatible to read them. If you intend to add more images at a later date to create a multisession disc, the drive must also be multisession compliant. The majority of the common image processing programs are now capable of reading the PhotoCD format. Alternatively, Kodak have their own software, PhotoCD Access, which will access the images at any of the five resolutions and allow you to convert them into the common formats for inclusion in your authoring software.

A professional version of PhotoCD, Pro PhotoCD, allows the scanning of 5 x 4” transparencies. The CD is able to hold up to 27 of these images with 6 levels of resolution, the highest being some 3000 x 4000 pixels.

Archiving and Storage

Images should be archived at the highest reasonable resolution possible after taking into consideration the amount of storage space that can be afforded (see section on PhotoCD also). Several types of media for archiving exist; DAT (up to 8 GB compressed data), recordable CD (660 MB only but the data is incorruptible), re-writable optical discs (up to 1.2 GB).

For archiving purposes, colour images should be stored at 24 bit colour or in the case of grey-scale images at 256 levels of grey. Although the eye cannot recognise distinct colours or shades of grey beyond these numbers the computer will need these numbers from which to select the best possible colours when performing colour reduction. Some image formats, however, do not accommodate 24 bit colour and therefore the format chosen for archiving may also determine the colour depth at which the image can be stored.

A back-up strategy will also be required for the images once they have been converted to the desired format, resolution and number of colours.

Summary:

To summarise the basic steps once the image has been captured and archived/stored:

- Re-size the image to the required screen resolution for delivery
- Convert to the number of colours or shades of grey as required
- Save the file in the appropriate format

Make sure any manipulation is carried out before the steps above are followed. For further guidelines on the practical aspects of image capture see Section 3, Conclusions.

The choices made in the above three steps will be determined by the lowest technical specification of machine available to your audience or end users.

Storage Capacity and Compression

In an analogue system, storage capacity is much less restrictive than digital. A videodisc has a capacity of 54,000 still images per side. Digital imaging, however, makes significant demands on RAM and disc storage space. Typically, a 640 by 480 image with 256 colours will take up roughly 250KB (1/4 of a MByte) of disc space. Although disc storage is becoming cheaper and capacity of the "standard" hard disc is increasing, in practice space is usually limited. To counter this, data compression techniques are used to reduce the volume of data in order to minimise the demands made on storage and processing power and improve time taken to load or save files. Compression is achieved using algorithms (mathematical formulae), which identify the information that needs to be recorded and store it. It is then 'reconstructed' during decompression.

There are two types of compression:

- lossless, in which all the data is preserved and typically will compress images 2:1
- lossy, in which the data is degraded, the more so the greater the compression ratio used.

Lossless techniques are mainly used for text-based data where compression rates are quite high due to common letter groupings, etc. For images, techniques such as run length encoding are employed within some image formats such as PCX and BMP to reduce file size. Run-length encoding takes stretches of pixels sharing the same colour and stores the information for these pixels in just two bytes; one for the colour and the other for the number of adjacent pixels. Ratios of typically 2 or 3:1 can be achieved with this technique.

Many of the lossy compression techniques seek a compromise between quality and quantity and rely on human ability to compensate for losses, exploiting the way we perceive. However, there are some subject areas where the use of lossy techniques demands serious attention and research, particularly in the medical field. Many of these techniques are designed to compress moving video as well as still images. Such techniques include JPEG/MPEG, Fractal compression (still and video), Video for windows and Apple Quicktime. It is not within the scope of this document to provide any great detail of video compression as this area demands its own publication. However, all these terms will be explained in the following paragraphs.

JPEG: As with image formats, the widespread need for compression methods has resulted in the emergence of a plethora of techniques. Consequently the International Standards Organisation (ISO) set up two groups, the Joint Photographic Expert Group and the Motion Picture Expert Group (MPEG) to establish international standards for the compression/decompression of still and moving video and associated audio.

A number of capture cards will save the image as a JPEG format although this can be performed in software alone; many of the image processing programs offer this facility and JPEG is now commonly recognised as another file format. JPEG also comes in two flavours, JPEG for still images and motion JPEG. Motion JPEG is a modified version of standard JPEG that calculates the differences between frames instead of storing every frame. A whole key frame is stored every 8th frame. JPEG can offer still image compression ratios of 25:1. MJPEG capture boards are available but beware; there are various non-compatible versions of MJPEG around.

MPEG: Already we have two standards for MPEG - these are MPEG I (a sub-set of which has been defined for VideoCD/White Book CD and CD-I) and MPEG II. MPEG II is designed to offer higher quality at a bandwidth of 1.2 Mbit/second at 704 x 480 pixels and 30 frames per second (fps) and is used for images of high definition TV size. MPEG I has been developed to fit into a bandwidth of 1.5 Mbit/second to allow data retrieval from single speed CD-ROMs at 320 x 240 pixels at 30 fps. Compression ratios from 30:1 to 200:1 are obtainable.

MPEG is even more advanced that Motion JPEG and uses a process called predictive calculation. Information in the current frame is used to predict the information in following frames. A further standard, MPEG IV (combining MPEG III) is under development. Algorithms for playing MPEG I movies in software alone are available for use under Video for Windows and Apple's Quicktime but will suffer the same scalar problems (see Video for Windows section). Boards for providing hardware-assisted playback are also available, allowing full-screen, full-motion video. However, MPEG is still not mainstream technology and several computer magazines are reporting on incompatibility problems between computer, CD-ROM drive and MPEG playback cards.

One of the drawbacks of MPEG is that a great deal of processing power needs to be applied to perform the compression in the first place. Traditionally this has meant expensive, dedicated MPEG editing systems, or paying a lot of money to a bureau to do it for you, although now relatively low-cost expansion cards are beginning to emerge which claim to do the job for you.

Video for Windows: Developed by Microsoft, this sets a standard for incorporating digital video under Windows. For many, Video for Windows is confusing; however, Video for Windows is more of a container for new technologies. Video for Windows created a new file standard called AVI (Audio Video Interleaved). The AVI format merely defines how the video and audio will be stored on your hard disc, that is, interleaved with the audio for frame 1 followed by the video for frame 1, the same for frame 2 and so on. This may appear simple but is important, as without interleaving, programs would have to jump from place to place on your hard disc to find the next bit in the sequence. This slows things down and so anything that reduces the demands made on the hard disc by video is important. What AVI doesn't do, however, is define how the video will be captured, compressed or played back. This means that as new technology for video is introduced, it can be incorporated into Video for Windows. AVI files are played using the Media Player supplied with Windows 3.1.

Video CODECs are software compression/decompression algorithms that define how the video is captured, compressed and played back. A number of these exist for Video for Windows and include Indeo 3 (Intel), Cinepak (licensed by Microsoft from SuperMac), Microsoft Video 1, offering compression ratios of up to 50 to 60:1.

> **Indeo:** One of the most important advantages of Indeo is that it can be used for real-time compression but needs dedicated hardware such at Intel's Smart Video Recorder (specifically Intel's I-750 chip) to perform the compression, although decompression is in software only. That is, the video is compressed as the data is captured. However, if the video requires extensive editing, real-time compression should not be used. Indeo is a 24 bit CODEC and dithers well to 256 colours when displayed on an 8 bit display; there is no need to reduce the

number of colours as the CODEC copes by itself. Needless to say, to reap the benefits, Indeo video should be played on 16 bit or higher displays. Compression ratios of 10:1 are obtainable. The latest version of the CODEC is 3.2.

Cinepak: As with Indeo, Cinepak also offers very good image quality and is capable of higher compression ratios than Indeo. It is best used for high action sequences. Decompression of Cinepak, however, is not as good, taking 4 to 10 times slower than Indeo when using software playback alone, that is without a hardware board to assist playback. Both compression and decompression are performed in software. Compression ratios of 10-20:1 are obtainable. Cinepak was originally developed by SuperMac for integration into Apple's Quicktime (see below) but has been licensed to Microsoft for Video for Windows.

Microsoft Video 1: Is not in the same league as Indeo and Cinepak but can be used as a straight 8 bit CODEC; the advantage is in reducing file size. Only to be used when hardware is limited.

Quicktime Apple have provided their own video-plus-audio file format equivalent to Video for Windows, called Quicktime. Quicktime provides a basic set of software schemes that meet a range of compression needs for still images, animation and video. Quicktime provides support for both Cinepak and Indeo video. A CODEC for playing Quicktime movies is available for Video for Windows (although Quicktime movies play back slower on PCs than AVI files) as is a converter for Quicktime to the AVI and MPEG formats. Quicktime 2.0 will capture movies at 30fps and quarter screen resolution (320 x 240). If 15 fps is acceptable you can show movies at full screen but performance will depend on the power of your MAC.

AVI and Quicktime files are played back in software alone and because of this the speed of playback and the size of the video window will depend on the power of the processor and graphic capability of the machine and the video will be scaled accordingly. A clip that looks perfectly acceptable on a Pentium 90 system may be barely recognisable as a piece of video on a 20mhz 386. On a Pentium Cinepak and Indeo can achieve 30 fps at 320 x 240 pixels and can be enlarged to 640 x 480 using graphics acceleration.

Fractal Compression Developed by Iterated Systems, it offers greater compression using algorithms based on fractal transforms. Still images can be compressed by up to 100:1. For video Iterated Systems have developed "Softvideo," providing full screen colour video at 30 frames per second on a PC using software alone. However it takes 15 hours to compress one minute but decompression is fast. The movies are also scaleable, as with still images, the video's resolution being independent of the size of the window. Fractal compression is a proprietary format and standard image processing software will not read this format.

Copyright

It is not within the scope of this document to discuss copyright in any great depth. However, with the great advances that have been made with technology it is extremely easy to breach copyright. Here are a few helpful tips to avoid this:

- Ideally, only capture material of which you are the copyright holder, or for which the copyright holder is known such that permission can easily be sought.

- The 1988 Copyright Act states that where a copyright work has been produced by someone 'in the course of his employment, his employer is the first owner of any copyright in the work subject to any agreement to the contrary.. Your images may therefore be the copyright of your institution. There are some instances where the institution has given back these rights to the individual employees. Check your own situation.

- Do not scan images from books and other published work. Even if it is for in-house educational use only, you are still breaking the law. If you are the author you may still need to check with the publishers whether you hold copyright.

- In this country all work is automatically copyrighted even if it does not bear the copyright symbol.

- If you do wish to use one or two images from a book containing thousands, it is worth contacting the publisher. Some publishers will give reproduction rights for one or two images for non-profit educational projects for an agreed use. Check with publishers first.

- Always gain copyright/reproduction rights before you embark on image capture. This could avoid needless expenditure of time and money at a later date.

Section 3: Evaluation of Image Capture Cards

Introduction

Pick up virtually any PC computer magazine and you will be presented with a bewildering choice of cards offering combined facilities such as video capture and playback, enhanced graphic display capabilities, windows acceleration, TV tuning, and amongst other things, still image capture. This, coupled with the development of other bus architectures, PCI (Peripheral Component Interconnect) and VL (Video/Vesa Local), has led to some confusion for the teacher who simply wants to purchase a card for still image capture.

This section takes a look at a number of cards available for still image capture including the more traditional cards and those where still image capture is one of a number of options offered. There is a concern that the quality of images obtained with the newer, cheaper, multifunctional cards will be inferior to that from the "standard" image capture cards, many of which will shortly be no longer available.

The cards evaluated are primarily for the PC, as the majority of academic institutions support the PC platform for delivering electronic teaching and learning materials. However, Apple MAC options are detailed where appropriate and the evaluation includes one image capture card for the Apple MAC.

Bus Architecture; ISA vs PCI vs VL

The ISA (Industries Standard Architecture) Bus (also known as the AT bus) is found in any AT type computer. However the data transfer rate across the ISA bus is limited and is restrictive for applications needing high data transfer rates such as those involving moving video. The PCI bus not only provides greater bandwidth but is also processor independent. This is probably one of the PCI bus' greatest assets and because of this is likely to become the future standard for bus architecture. Thus any PCI card can be installed into any PCI based computer whether a PC, PowerMac, DEC, Alpha, etc. At the moment the data bus width of the PCI bus is 32 bits and as long as appropriate drivers are available will probably be developed further to support 64 bits. The VL bus, while offering higher bandwidth, is unfortunately a PC dependent architecture and is therefore less likely to develop much further.

At the time of writing few PCI cards are available supporting still image capture. This situation is likely to change rapidly.

Vesa Media Channel

The Vesa Media Channel (easily confused with the VL bus) is a feature built into cards that is independent of bus architecture and can therefore be found on ISA, PCI or VL cards. Vesa Media Channel allows one to link (daisy chain) up to 15 cards together, thus allowing any limitation in bus speeds to be bypassed or enabling the cards to run in parallel with the bus effectively maximising bandwidth.

Aims

To evaluate a number of still image capture cards in order to provide recommendations and guidelines on purchase to the academic community.

Method

A number of cards (11 in total) were evaluated. For each card, details including appearance, connectors, installation of hardware and software, capture times and other observations are given. The default settings given for each card for brightness, contrast and colour were used. The cards and any associated software were assessed using the same set of images in each case. The quality of the captured images was compared against a group reference.

The cards can be divided into two categories:

1. where the normal PC VGA output is diverted from the monitor onto the card, the card then overlays (in hardware) the incoming video signal onto the VGA signal and the combined output is shown on the monitor. Some systems (for example, the TARGA card) may additionally use a separate monitor, other systems may obtain the VGA signal from the feature connector which is found on a number of VGA cards.

2. where software is used to ‘overlay’ the incoming video signal onto the VGA card’s normal output (as in Video for Windows). No re-wiring (other than the connection of inputs) is normally needed.

Equipment set-up

A standard set-up of hardware and software was used throughout the evaluation. Figure 3.1 illustrates the hardware set-up used.

Hardware
Viglen PCI 486 DX2 66Mhz, 32 Mb RAM, Diamond Stealth PCI graphics display card with 4 Mb video RAM, multisync monitor (Idek Ilyama 8217). In addition, to enable a thorough test of the installation procedure for each card, the computer also contained two further cards: a SoundBlaster Pro card and Ethernet card in addition to the on-board SCSI-2.

A Sony DX 3-chip camera giving both composite and RGB outputs and carousel unit for holding the test transparencies. The video signal (composite or RGB as appropriate) was fed into the capture cards and also fed to a second monitor to enable the images to be focused. A Waveform monitor was used to maintain a standard video level for each image for all the cards tested.

Software
Images were captured using the image capture software provided with the card. In the one case where a TWAIN interface was provided, images were captured using Micrografx Photomagic.

Images:

The following images were selected and used to evaluate the cards:

Image number	Type of Image	Colour/greyscale /b&w	Video Level %
1	Microscopy - transmission electron micrograph	grey scale	90
2	Microscopy - light micrograph	grey scale	100
3	Line Drawing	b&w	90
4	Scenic - canal scene	colour	100
5	Scenic - buildings	colour	100
6	Light microscopy, section - histology	colour	100
7	Anatomical	colour	100
8	Macro, mosquito and skin tones	colour	80
9	Colour/grey-scale test cards	colour	100

Table 3.1 giving details of the images used.

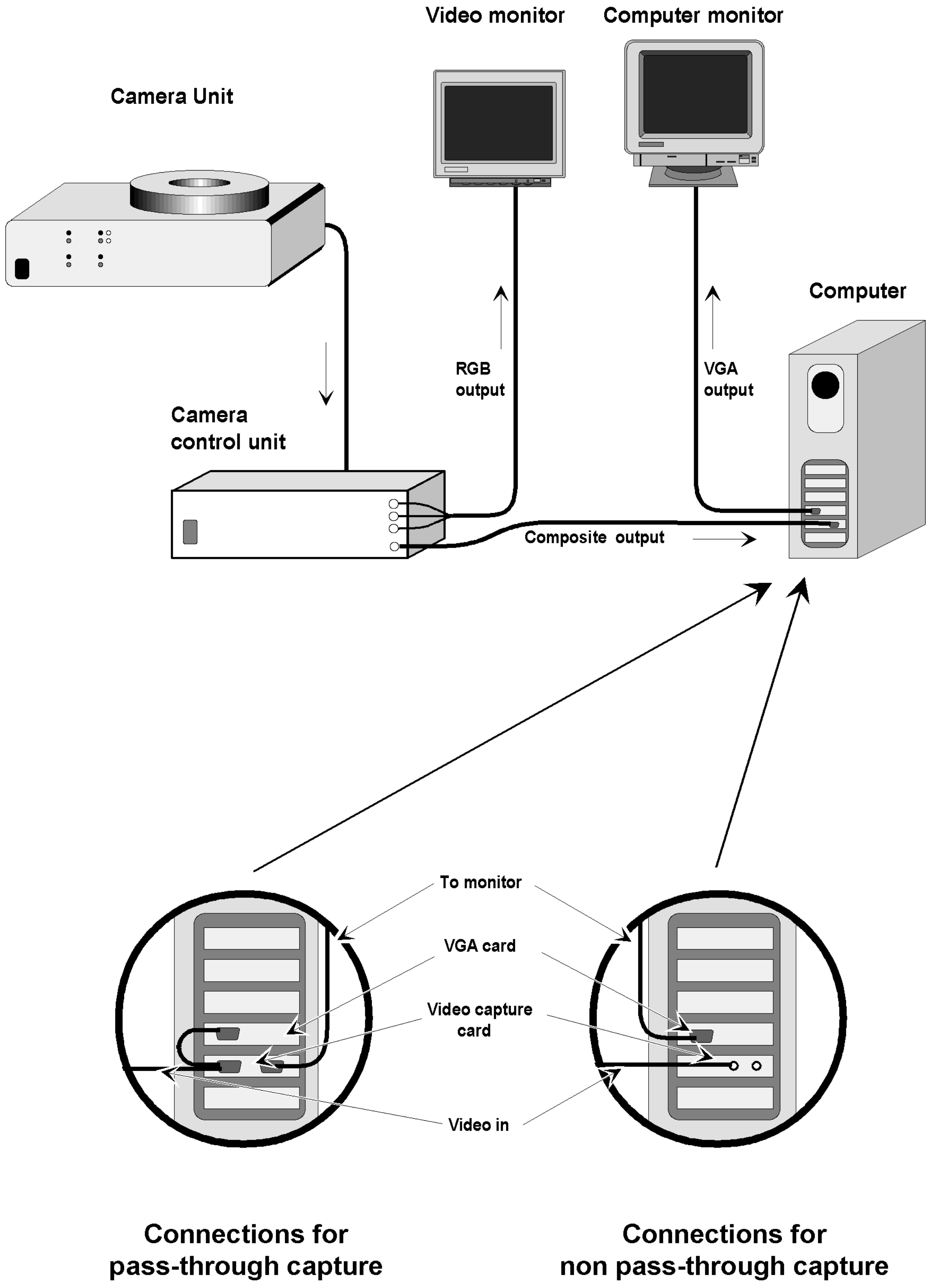
Video monitor
Computer monitor
Camera Unit
Computer
RGB
output
VGA
output
Camera
control unit
Composite output
To monitor
VGA card
Video capture
card
Video in
Connections for
pass-through capture
Connections for
non pass-through capture

Figure 3.1

The images were chosen as representatives of the types of image (and associated problems) that would be captured in reality.

Images 1-3 are greyscale. These were used to check not only the ability to handle continuous grey tones but also for purposes of seeing overall colour casts. Image #3 is quite detailed with a lot of edges, high in contrast, and is useful for illustrating the problems encountered when handling images with high frequency content.

The remaining images are colour. Image #4 was used for the initial comparison of cards, as a number of elements within the picture illustrated the differences between the cards well: the sharp edges of the houses; the roof tile (pattern); the telephone wire and lamppost against the sky; deep shadows; etc. Being of fairly high contrast, image #5 was used when assessing the amount of detail present in deep shadow. Image #9 provided a more objective measure of colour casts and black/white levels (contrast range); the CMYK levels being used for measuring (supposedly) black and white areas of the scales.

For each card the images were captured at the highest combination of resolution and number of colours offered.

Results:

The results are divided into two sections: 1) Details of individual cards and 2) Comparison of cards in relation to quality of image capture.

1) Individual cards

Aviator

Manufacturer
FAST

Appearance
½ length low profile ISA card, 16 bit slot only
1 jumper (5 position) for IRQ selection (default 15)

Connectors
Externally : 3 x RCA composite video inputs (all three may be connected simultaneously, software selectable)
Internally : none

Installation
Hardware
Select a suitable IRQ and set the jumper accordingly. Insert card as usual. Connect input(s) to video source(s).

Software
After the initial set-up program copies the necessary files to the hard disc a message is displayed telling you to go to the drivers section of the Windows Control Panel. There you should find that the Aviator drivers have been installed, selecting 'FAST Electronic Aviator driver' and then 'Setup' leads to a dialog box with IRQ and I/O address settings. Choosing 'selftest' runs the card/driver through various performance checks (e.g. memory read/write, video and onboard registers). The Movieline application is installed in a group.

Note that Video for Windows 1.1 (runtime at least) must be installed before running the Aviator installation.

Capture times

640x480x24	8s
640x480x8c	9s
640x480x8g	7s

These times include the time taken to save the file to disc, as this happens immediately after image capture and without further intervention on the part of the user.

Observations
A few minor problems :

- when clicking on the 'about...' menu item no information is displayed, but the Movie Line window is deselected and cannot be re-enabled until 'Return', 'Escape', 'Space' or 'Alt' are pressed (the about dialog box is probably hidden behind the Movie Line window)
- If an attempt is made to capture a still image without naming the file first the same happens as above (possibly the same applies to movie files but this was not tried)
- be sure to keep changing file names (and be careful about which names you use) as no warning is given about overwriting existing files (remember: files are saved without further intervention immediately after capture)
- although the last colour depth is remembered between captures the file format isn't – it has to be set specifically each time
- on-screen images appeared to be very dark with a reddish cast
- even if the file format is set to greyscale the displayed image is still colour (24 bit?)

- even using a fast computer/graphics card the menus and text entry seemed sluggish (similar to, but slightly worse than Captivator – which also used Video for Windows)
- in the viewing window there appeared to be dropped lines (seen as the bottom of characters missing)

Captivator

Manufacturer
Videologic

Appearance
½ length ISA card (16 bit slots only). Jumpers (1 of 4) for I/O addressing. IRQ's set in software.

Connectors
Externally : 1 RCA, 1 S-video (both can be connected simultaneously but auto-sensing needs to be turned off).

Installation
Hardware
Software should come first (to identify free I/O addresses)...

Software
The set-up software attempts to detect I/O conflicts as well as installing VideoSnap for still capture – VidCap and VidEdit will have been installed when Video for Windows (VfW) was installed and you are referred to the applications manual for moving video capture setup. This does unfortunately mean that you have to have VfW already installed – otherwise Captivator's setup will not complete – even if you only want to capture still images.

The optional scanning for available I/O addresses may cause the system to lock up (a warning to this effect is displayed). If scanning is chosen and successful you will be shown addresses which it thinks are free and gives further instructions on installation........

Back to the hardware
This then becomes a matter of setting the address jumper, fitting the card and connecting a video input.

And back to the software again
Now the card has been installed physically, the software can detect IRQ conflicts. In our case it detected a (known) conflict with a network card. Following on-screen suggestions it then scanned I/O addresses again (finding and identifying itself this time) and eliminated other IRQ's, leaving its recommendation (from the remainder) on screen – this was accepted with no ensuing problems.

Capture times

640x480x24	3s
640x480x8	1½s

Observations
Max. image grab size is 640x480. Colour depths 24, 16, 8 palettised. No palettes supplied - to get a grey scale palette you must not grab an image or select 'palette from frame or sequence' options. We saved a grey scale palette early on.

Dithering is used to show images on displays not providing the colour range of the palette selected. File formats (still images) are BMP and DIB.

Kingfisher (Macintosh)

Note: The Kingfisher card was purchased at the same time as the Apple Macintosh and was installed by the suppliers

Manufacturer
Graphics Unlimited

Appearance
Full length Nubus card

Connectors
Two multifunction 9 pin D-sub sockets: 1 input, 1 output (not labelled)
These sockets are very versatile and tables are included in the manual showing the connections for the various functions

Installation
Hardware
Pre-installed (but removal/replacement when checking appearance was very straightforward).

Software
Pre-installed – in common with most Mac software, the installation seems to be easy enough.

Capture times

Resolution/depth	capture	save
768x576x24	4s	40s
768x576x8c	4s	16s
768x576x8g	4s	15s

Observations
Middle settings for contrast and saturation (64 out of 128) were used, along with ¼ brightness (32/128).

At 256 colours the on-screen image appeared slightly granular - possibly due to the type of palette optimisation/reduction.

Images were grabbed from both composite and RGB sources.

Media Pro HiRes

Manufacturer
Rombo

Appearance
2/3 length ISA card, 16 bit slot only
2 sets jumpers : 1 set for I/O address, 1 for IRQ enable

Connectors
External :
Stereo audio out (3.5 mm jack socket)
RCA mono audio in - not labelled
RCA composite video out - not labelled
S-video in
VGA out socket (15w HD D sub)

Internal :
MediaPro to VGA feature connector
VGA internal plug (from VGA card output)
VID2 (function unknown, possibly for secondary card [e.g. TV Tuner], not mentioned in manual)

Installation
Hardware
The most awkward card to fit of those evaluated. Jumper setting was fairly straightforward, but mechanically fitting the card and its associated connectors did present a few difficulties:

- the output from the VGA card is taken via a lead (approx. 10") which goes from outside the PC to inside. This lead has to be fitted through the backplate hole (in the PC) and then connected to the card (the lead now being held in position on the card's backplate with a grommet)
- there are two versions of the feature connector cable supplied: one plain lead and one incorporating fast buffering (on a daughterboard) for higher resolution/refresh graphics cards. For standard ISA SVGA cards this adapter might cause problems by effectively increasing the cards' thickness (>10mm). The PC used for these evaluations has a 4MB Diamond Stealth Pro PCI card fitted and its feature connector is on the opposite side to ISA card connectors and is the other way up as well – this means that the daughterboard, which would normally overhang an ISA card, sticks up above the PCI card by about 35mm. Fortunately this did not cause a problem with adjacent cards or case clearance on our (mini-tower) machine but is certainly something to watch out for. Just to make things a little more interesting – pin 1 on the Diamond card (the graphics display card) is not marked nor is it shown on the diagrams in the manual.

Software
This card comes with a range of software :

- Video for Windows (for full motion video capture)
- VGA Buster – allows VGA output to RGB PAL monitors/TVs from supported VGA chipsets (via optional VGA-RGB → SCART lead)
- Windows image capture and manipulation, with a variety of special effects
- TWAIN driver for TWAIN aware applications

Once the hardware installation has been performed the software will need to be set up. This means setting the I/O address to the same setting as that on the jumpers and setting the buffer address (for the on-board 1MB RAM). This defaults to 13 but if your PC has 16MB or more fitted (we have 32MB) this may cause problems – there is a special memory driver incorporated (v2 and later) but this is not guaranteed to work on all systems.

At this point the evaluation came to halt as no image from our video source could be seen – a number of checks were carried out but to no avail. We then contacted the company and explained the problem and the attempts made to solve the problem. Unfortunately, although they were helpful, there were no suggestions they could make beyond what we had already tried.

Movie Machine Pro

Manufacturer
FAST

Appearance
Full length ISA card, 16 bit slot only
2 jumpers (only need changing if installing more than one Movie Machine Pro in a system)

Connectors
External :

- Aerial socket for on-board TV tuner
- 3.5mm stereo jack for audio output
- 2 x RCA composite video inputs }
- 1 x RCA composite video output } all on one lead to 15p HD D-sub connector
- 1 x VGA input }
- 1 x VGA output

Internal :

- VGA feature connector (for overlay work), both cable types supplied (edge connector and pin header)
- expansion connector

Installation
Hardware
If this is the only MMPro card in the system (most likely) then just check the jumpers are in position and insert the card as normal. In this instance there was a problem with the card hitting the CPU heatsink. Another full length card had to be removed and the MMPro inserted into the vacated slot (although the Viglen has 4 ISA slots, only one can accept a full length card).

Before proceeding to monitor/VGA card/MMPro connection the Windows display had to be set to 800x600 @ 75Hz (normally 1024x768 @ 90Hz). See summary for explanation.

Software
This card could take quite a bit of setting up if optimising for moving video capture (memory mapping, UMB and port I/O options need to be traded off). On our system – with a known 64K UMB problem and 32MB RAM – port I/O was selected (speed not being a high priority for still image capture). Even so we ran into a problem with the system 'hanging'. On contacting FAST they thought it was a driver problem and sent an updated version of the software.

New software installed – the autoscan (of IRQ's) did not find the network adapter card (at IRQ 10), but the first attempt at port I/O based setup worked fine.

Capture times
Image freezing was instantaneous, so the file saving time becomes a critical factor and this depends on the performance of the system as well as the program. Example times for set-up used:

734x493x24	6s
734x493x8c	14s
734x493x8g	3s

Observations
The software appears very versatile, allowing on-screen adjustment of colour, sharpness, noise filter, hue and bandpass (all of which affect the saved as well as the displayed image).

There seems to be no easy way of setting up the display for correct pixel aspect ratio. The size of the saved image appears to depend on the size of the displayed image with no override at the saving stage – choosing 'Full', 'Half' or 'Quarter' options under the 'Size' menu gives preset image sizes but the aspect ratio is not correct when brought into an image editing package.

Because the initial captured images were not very good, some trial images were taken with the various filter settings. This was to establish whether there was a direct relationship with the effect as displayed on-screen and the saved image and also to see if the filters would improve the quality of the captured images. The effect of the pre-filter and sharpness (set at 1 out of a range of 0-3) seemed very similar and both gave a slightly better image. Using both together and/or increasing levels of sharpness offered little discernible improvement (slightly sharper but with more fringing/ringing). Therefore the rest of the images were grabbed with just the pre-filter in.

The software does not remember the last used file type or directory, which means they have to be set for each save. This is tedious.

One disconcerting problem was that part of the video image would overlay part of the Movie TVs (the still image capture module) dialog boxes.

If we were using this card on a long-term basis one feature that could prove useful would be the hue control.   This allows video input colour casts to be removed (or at least minimised) for both the displayed and saved images.

Screen Machine

Caveat:
This version of the card (and software) is the original (now called Screen Machine Lite, we believe) and there are likely to have been some updates to the system – although FAST seemed to imply that there were no major changes. Please take this into account when reading the following observations. There is a second version of this card - Screen Machine II.

Manufacturer
FAST

Appearance
Full length ISA card. 16 bit slot only.
4 jumpers (I/O address and wait state).
Various headers for option boards (SECAM, audio I/O, colour keying, RGB, TV tuner).

Connectors
Externally
VGA output, VGA and video input (both 15 pin HD D-sub, inputs via adapter cable)

Internally
Daughter board options as above.

Installation
Hardware
Select a suitable (free) I/O address. This was another card that clashed with the heatsink and, therefore, had to go in one specific slot. Connect the adapter cable between the VGA output and Screen Machine input, connect monitor to Screen Machine output (no drop in screen intensity).

Software
First attempt at installation wrote 0 length expanded files – corrupted some DLL's in the Windows directory (probably not checking for existence/date and overwriting with corrupt and/or of date versions of the same file).

Therefore a manual installation was performed. A few more problems were encountered before getting the card working properly:

- make sure you have your video source connected to input 1 during SM_SETUP (the setup program), as there is no (apparent) way to choose the video source from this module – so there is no image on which to do the setup (unless you run SM Camera first, but you wouldn't normally do that until you've run setup!)
- problems with the display card/driver. Forced to drop back to the standard VGA driver (640x480, 16 colour). Even then the setup.inf file had to be edited to get the image near to the correct position in its window – this is after setup, which then had to be run again to fine tune the position, size, proportion.
- after the above the video image position (relative to its viewing window) would vary according to the viewing window’s position on the screen.
- image quality on the monitor was slightly degraded compared to the output direct from the VGA card, more so at 800x600 – however images could not be grabbed at this resolution anyway (although it should handle it – and may with other VGA cards).

Capture times
Virtually instantaneous for capture (Note: will capture from moving source images), so these times are for the saves.

640x512x24	5s
640x512x8c	7s
640x512x8g	3s

Observations

The capture software provides three main modules : TV; camera; dark room

TV	provides a scaleable window; captured still images can be saved in a number of formats.
Camera	gives a fixed window and saves the captured images to a 'film strip', which can then be saved. *Note* : this is in Screen Machine's own FLM format.
Darkroom	used to 'develop' films, i.e. process the images in FLM format to other formats, colour depths, image size, rotation, resampling etc.

Both TV and Camera allow source setup (now they tell you!) which includes video input and type, composite colour on/off (for greyscale images), time base correction, prefilter, sharpness, noise, bandpass and hue filters (all 0-4 range). They also have control over the image brightness, contrast, saturation and RGB values, and size. But, although they both read the same settings file, only the TV module appears to be able to save these settings.

The manual briefly discusses the effect of the controls on image quality if they are not immediately obvious (e.g. explains that 'row correction off' will give higher resolutions from still image images). The 'Basics' chapter of the manual also briefly covers such issues as lossy compression, printing, colour models, palette optimisation, etc.

TARGA

Manufacturer
Truvision

Appearance
Full length ISA card. 8 or 16 bit slot. This card is unusual in that it extends 30mm above the top of the backplate (instead of the more normal 0-10mm)
Jumpers and switches :

1 unidentified jumper
2 banks of 5 DIP switches (I/O base and mode; IRQ)
1 other switch (H/V sync or video out)

The card has a lot of analogue tuning components that are not sealed - beware of fiddlers!

Connectors
Internal - VGA feature connector (=< 640x480)
External - video in and out – not labelled

Installation
Hardware

- Slightly troublesome – card guides had to be removed and mounting bracket needed bending
- I/O connectors not labelled
- some jumpers had to be set *before* installation (I/O etc)

Software
The software supplied by the manufacturer was not recommended by the suppliers and extra software, TipsPlus, is usually sold with the card.

- would like 1MB EMS (expanded memory) – does not provide this information in the software manual.
- needs an address range excluding (e.g. $D000 for VGA systems), gives start *but not* range.
- moved I/O address to $240 to avoid conflict with Soundblaster card.
- Well worth backing up autoexec.bat and config.sys (of course you do this before every installation already!) as installation routine may (optionally) make quite a few changes to these files (although it does create its own backups).
- problem setting up EMS for TipsPlus – the Viglen's on board SCSI BIOS resides at $E000-$E3FF and so there is not an uninterrupted 64K page frame available and, naturally, the SCSI BIOS is not relocatable. Fortunately TipsPlus seems to support LIMS (for EMS) 4 so some jiggery-pokery with addresses for 4 x 16K page frames was possible. Even so this did not permit the TipsPlus software to function fully, thus keyboard input appeared on the computer monitor rather than the secondary video monitor that was in this case for image capture (Fig. 3.1)
- Large range of capture modes (32) available therefore a full assessment was not possible. Chose 768x512 pixels by 16 bit colour (composite and RGB)

Capture times
< 1s

Observations
With the setup used in this evaluation (probably more complex than normal) the only mode that would work consistently was 768x512 pixels by 16 bit colour. This was not helped by the need to switch inputs on the TARGA card itself.

Video Blaster RT300

Manufacturer
Creative Labs

Appearance
2/3 length ISA card.
2 sets of jumpers : 1 set (of 8) for I/O address, 1 set (of 4) for IRQ

Connectors
Externally
4 x video in (3 RCA, 1 S-video) labelled – tiny, but labelled!

Installation
Hardware
Set I/O address and IRQ to available ones – although IRQ jumpers are not labelled as shown in the manual and, confusingly, have the same numbers as the IRQ (9, 10, 11, 12) but are in the reverse order, e.g. IRQ9=JP12 and IRQ12=JP9. Install card, connect to video source.

Software
Fairly straightforward *except* you must have a video capture application that supports Video for Windows/Intel Indeo (a version of Adobe Premiere 1.0 supplied, so install this as well unless you have a similar application already set up).

Capture times
640x480x8c	5s (not including save)

Observations
Because Premiere is primarily a motion video capture program its defaults are set accordingly. Capture options (a menu selection) will have to be changed for higher resolution still image capture, for example (default settings in square brackets[ ]) :

Capture type	single frame [normal]
video format	Intel Indeo video raw [Intel Indeo video 3.2], then resolution configured to 640x480 [160x120]
compression	Full frames (uncompressed) [no compression]

When setting the capture file you can only point to a drive, not directories (although you can pre-allocate space – showing motion video origins again).

Although understandable for video sequences the maximum palette of 256 colours (no greyscale) for still images is very limiting (in theory video for windows is a 24 bit CODEC and does not need to be reduced to 8 bit for 256 colour displays - see section 2 for further information). The Intel Indeo video formats (both raw and 3.2) are supposedly 24 bit colour capable. After several discussions with Creative Labs it appears that the problem might be with the drivers or Premiere (which means it may be 'fixable' if someone gets around to modifying/updating them).

The only still format supported is .BMP – but at least a standard 'Save As' dialog box is presented, allowing choice of drive/directories.

(Black Widow) Video Snapshot

Manufacturer
Devcom

Appearance
Dark grey box, about the size of a mouse (3½ x 2¾ x 1") with a lead that connects to the computer's parallel port (has printer pass-through - can have printer connected at same time).

Connectors
1 video (RCA), 1 S-video and the above mentioned parallel lead.

Installation
Hardware
Insert 3 x AAA (UM4) cells, connect to parallel port*, connect to video input.

* The first attempts at video capture were not successful. After trying all the setup permutations within the driver and still failing to get the image to synchronised, the problem seemed to be related to the synchronisation, as the on-screen 'image' would alter (consistently) when slides were changed. Hardware then seemed to be a possible source of the problem: the Viglen has a parallel port which can be set up as standard, ECP, EPP or both ECP and EPP. It was tried with each of the settings but with no success. However technical support at Devcom suggested that it was likely that the parallel port was quite simply too fast for the Snapshot to synchronise with and therefore could not transfer the data back to the PC (the distributors had come across this problem on a couple of other PC's). In this instance the solution was to fit an ordinary MIO card with its parallel port set up as LPT2 (and with serial, FDD and HD options disabled) and capture from that port (a driver option when other ports are detected) – this worked fine. This is certainly something to be aware of if you have a fast computer with a fast parallel port. Latest news (1/3/95) is that Devcom are aware of the problem (their devices are designed in Scotland) and a new version of Video Snapshot, due for release around the middle of 1995, should cure this problem and provide other features/enhancements.

Software
Installation of the driver software is probably about as simple as it can be (although see later for prerequisites)

- change to the floppy drive that has the installation disc in it and type INSTALL <your windows drive/directory>
- installation done.

The installation process simply copies a TWAIN driver to the Windows\TWAIN directory (or will create it if it does not exist). This obviously means that you need to be using an application that supports TWAIN devices. As usual things are not quite so straightforward : there's TWAIN and then there's TWAIN. Using Photostyler the Video Snapshot is not even seen; with Photoshop 2.5 the device can be selected but trying to grab an image returns a *scanner* error. Fortunately we also have Micrografx Photomagic and this had no problems seeing the device or grabbing an image. Devcom offer/bundle *i*Photo Plus (an image editing package) that supports Snapshot.

Capture times
Depends on the data transfer rate of the parallel port.

Observations
This could be a solution for image capture using lap-top/notebook computers.

Videovue

Manufacturer

Appearance
Full length ISA card, works in an 8 or 16 bit slot
1 jumper for I/O address (not mentioned as jumper in manual index, therefore you have to guess what to look it up under).

Connectors
Externally – VGA in; VGA out; S video
Internally – Min-key - proprietary connector similar to Vesa Media Channel (to connect to Micro key card - another card from the manufacturers)

Installation
Hardware
Slightly troublesome. Card guides had to be removed. Mounting bracket (backplate) needed careful positioning (i.e. judicious bending).

VGA input and output connectors are a bit too close together; some plugs and sockets (particularly with moulded housings) may be difficult to seat fully.

Video connector (4 pin mini-DIN) had RCA (phono' plug) at the other end, no S-video or BNC supplied. For the set-up used in this evaluation, an adapter was needed.

Software
Installation was very straightforward – no problems. During initial setup (first time the software is run) the video window, that is the window displaying the source video, was displaced from the VideoVue control window and covered part of the controls needed to adjust relative window positions. In our case we were fortunate that there was just enough of the control window exposed to permit making adjustments.

Capture times

Resolution/pixel depth	approx time (s)
1024x768x24	9
1024x768x8	9
1024x768x8grey	6
800x600x24	7.5
800x600x8	8
800x600x8grey	5.5
640x480x24	6
640x480x8	6
640x480x8grey	4.5

Observations
Capture
On-screen (live video window) image quality did not appear to be very good, although using some of the adjustments improved it a little. There did not seem to be any way of leaving the 'adjust' button bar on screen during image capture.

With 'Adjust|Input|Sharpness' controls anything greater than 0 appeared to cause 'ringing' around objects (more horizontally than vertically). The noise filter seemed to make little difference (@1024x786) – at least with the video sources used for this evaluation.

VidiPC 24

Manufacturer
Rombo

Appearance
½ length ISA card (16 bit slot only)
3 jumpers : 2 user settable for I/O address, 1 factory setup only
3 potentiometers : 2 user adjustable (black and white levels), 1 for factory use (not sealed!)

Connectors
Externally : 1 RCA video in, 1 S-video in, 1x 9 pin D sub socket for specialist RGB connection (some information given in manual)
Internally : none

Installation
Hardware
Straightforward : select free I/O address and set jumpers accordingly, fit card.

Software
One of the only systems to come with DOS-based image capture software. This was not tried but appears to be useful enough if you need this sort of facility. The Windows software was easy to install – only needing the I/O address set if it is not the default setting.

Capture times

640x544x24	3s
640x544x8g	1s

Observations
This is the only card that has user adjustable (hardware) controls for black and white levels. Whether these should be provided is probably debatable but it seemed only reasonable to set the board up properly so as to give a fair evaluation. Image quality after setting these levels was much better than that prior to fine tuning.

In addition to options for capture resolution (320x272, 640x272 and 640x544) and colour/mono selection, the software has 'panel' controls for brightness (0-100%), contrast (0-100%), colour [saturation] (0-100%) and RGB intensity (±7 each) thus allowing a reasonable degree of image manipulation before capture.

The Windows version of this package allows images to be saved as BMP (24 bit and 8 bit greyscale) format only.

The VidiPC 24 package has a number of unusual features :

- a sample image to demonstrate what the system is capable of
- hints and tips on how to obtain good quality digitised images
- short discussion on video image capture and the limitations of video sources.

	Aviator	Captivator	Kingfisher	Media Pro HiRes	Movie Machine Pro	Screen Machine	Targa	Video Blaster RT300	Video Snapshot	VideoVue	VidiPC 24
Manufacturer /distributor	FAST Electronic	Videologic	Graphics Unlimited	Rombo	FAST Electronic	FAST Electronic	Truvision	Creative Labs	Devcon	Video Associates	Rombo
Card length	½	½	N/A (≡full)	$^2/_3$	Full	Full	Full	$^2/_3$	N/A	Full	½
8 /16 bit slot	16	16	Nubus	16	16	16	16	16	Parallel port	8/16	16
Pass through	✘	✘	✘	✓	✓	✓	sep. monitor	✘	✘	✓	✘
Composite	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
S-video	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PAL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RGB	✘	✘	✓	✘	✘	✘	✓	✘	✘	✘	✘
SECAM	✘	✘	✓	✘	✘	✘ (option)	✘	✘	✘	✘	✘
NTSC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
24 bit colour	✓	✓	✓	☒	✓	✓	†♦	✘	✓	✓	✓
16 bit colour	✘	✘	✘	☒	✘	✘	✓	✘	✘	✘	✘
8 bit colour	✓	✓	✓	☒	✓	✓	†	✓	✓	✓	✘
8 bit grey	✓	✓	✓	☒	✓	✓	†	✘	✓	✓	✓
Approx. cost	£200	£179	£900	£250	£495	£795 (SM2)	£2000	£265	£200	£595	£100

☒ unsuccessful installation
♦ 16 bit save
† not as set up

Table 3.2 listing the options for each card evaluate

2) Comparison of Cards

Figure 3.2 illustrates a portion of image #4 for each card. Please note that this portion is a constant *pixel* area (and therefore dependent on capture resolution) not different 'magnifications'. All the images captured for each card are available from the World Wide Web (http://www.ets.bris.ac.uk/). The set of images used in this evaluation will also be scanned and captured onto Photo-CD for further in-house comparisons. These will also subsequently be available from the URL given.

A preliminary examination of the captured images suggested that the Targa card (in RGB mode) gave the best overall image quality and was therefore used as a reference for the other cards (and the Targa in composite mode).

Aviator
All the images were quite dark with an overall sepia cast. The right hand side of the slides were cropped and there was a slight (associated?) horizontal stretch. The ringing on edges (slide #3) was quite bad. In slide #5 the shadow detail was suppressed to a fair degree.

Captivator
As with Aviator the images had an overall sepia tint and were quite dark. Ringing was quite bad, with more colour in the fringes than the Aviator. Shadow detail (slide #5) was fairly suppressed.

Kingfisher
For this card (as with the Targa) images were captured via RGB and composite inputs.

Composite: a dark, slightly sepia tinted appearance characterised these images. Edges showed a little ringing. Detail in the shadow of slide #5 was slightly less than the Targa.

RGB: captured images appeared slightly dark with a light sepia tint. No apparent ringing on edges. Shadow detail was comparable to the image taken from the composite input.

Media Pro HiRes
Unfortunately nothing to comment on here as the card could not be installed successfully.

Movie Machine Pro
This card captured images that appeared soft (i.e. slightly diffuse) with a slight sepia cast. The images were slightly stretched horizontally so that the right hand side was cropped. Edges exhibited quite bad ringing. Detail in the shadow of slide #5 showed a fair degree of suppression.

Screen Machine
Slightly compressed horizontally, the images were also missing a small part of the right hand side. The soft appearance of these images was not helped by their overall greyness. There was slight ringing on edges. Shadow detail did not appear too bad, probably due in part to the lowish contrast.

Targa
From its composite input the images had a very slight pinkish tint, appeared a little bit brighter and the colours possibly slightly more saturated. Edges showed only a very small degree of ringing. Slide #5's shadow seemed to show more detail – maybe due to slight overall brightness.

Taking an overall look at the Targa's RGB (our reference) in comparison to the other cards in the evaluation :

> the images tended to appear 'clean' and 'bright' with good contrast, shadow detail was also good and there was no apparent ringing on edges; colour balance seemed the most neutral of all the cards (possibly slightly on the 'cool' side).

The 16 bit capture (both RGB and composite) did show some limitations, slightly more obviously on the greyscale images where some of the middle tones were missing.

Video Blaster RT300
A slight yellowish cast did not help the soft appearance of these images. The latter may have been due to the strange mosaic effect – this could be seen on most cards images (especially on zooming in) but to nowhere near the same degree – and/or the 8 bit capture depth. There was some ringing on edges but this was diffuse – possibly due to above effects. Shadow detail was not too bad but, unlike images grabbed at higher bit depths, 8 bit capture does leave much flexibility for adjusting brightness, contrast, colour balance etc.

Video Snapshot
The overall appearance of images captured with this device (not a card) were that they were a little contrasty, with a slight pink tinge. Edges gave rise to slight ringing, with a (faint) contrasting 'ghost' around some of them. Shadows were quite dark and the detail was not there. Possibly this was why the images appeared contrasty – all tones below a certain value being read as black.

VideoVue
These images were slightly soft and 'blocky' with an overall slight pink tint, although the general perception of the colour balance was that it was more neutral than most of the cards. A slight amount of ringing was visible on edges. Shadows were dark with moderate detail.

VidiPC 24
Images captured with this card, in addition to being slightly dark and 'soft', had a slight orange tint and, unfortunately, this tint was in the form of a gradient across the image (making it very difficult to remove in most image processing applications). The images were compressed horizontally. Even after the card was set up the black was still not really black (although, to be fair, further tuning may have corrected this). Edges gave rise to smearing in addition to a moderate amount of ringing. Shadow detail was slightly down.

Figure 3.2 Colour plate. For each of the cards 320 x 240 pixel clips were taken from the same region of slide #4. As the images would have only been about 1 x 0.8" they were resampled to 640 x 480 pixels (with very little apparent degradation) in order to make the effects more easily visible. Note that the varying proportion of the original image that can be seen is due to difference in the number of pixels (by each card) used to capture the whole image.

Some points to look for: roof tile patterns; fringes on edges; shadow detail; colour balance (within printing limitations); loss of detail (e.g. lampost) against the sky.

Conclusions - Recommendations and Guidelines

Recommendations: but which is best?
Many factors will have a bearing on the answer to this question, some of these are:

- the image source(s) you are using – for instance the camera used provides RGB and composite video outputs but not S-video, so it is not possible to comment on how the cards which can handle this input would perform. RGB signals give better quality images but this option increases the cost of the cards.
- your current system may not have the space or clearance for a (or another) full length card (note the height of the Targa card). If you have no free slots, no spare computer or a laptop then your choice becomes not much of a choice at all – be aware that there are other parallel port (and some PCMCIA) image capture devices in addition to the Video Snapshot and since their installation is likely to be very simple you should find it easy to evaluate them before purchasing.
- is it to be single function or, for example, will it mainly be used for motion video capture and still image capture be very much a secondary function (e.g. VideoBlaster RT300)
- and, of course, cost. You might decide the quality of the images produced by the Targa card is what you want but it is not cheap and the extra funds may not be available.

From the devices available for this evaluation it was considered that Truvision's Targa card (£2000) gave the best overall image quality even at 16 bit colour. The quality is attributed to the RGB input available on the card. A range of image capture, handling and output software is available (specifically) for this card. In this instance TIPSPLUS was used but it is not very 'user-friendly', especially when compared to current software user interfaces. Among the less expensive devices the Black Widow Video Snapshot (£199) performed well, its major drawback being the loss of shadow detail (though if you are lucky enough to have a variable output on your video source you may be able to compensate for this). It also has the advantage of being instantly transferable between computers (although this portability may be seen as a disadvantage as the device may be easily 'lost'), as long as they have a suitable TWAIN aware application but do not only have high speed parallel ports. For those who need to capture images when visiting other locations this is probably the sort of device to use.

Guidelines and tips for Image Capture and other considerations

- Cards that use pass-through/hardware to overlay the incoming video image may have input bandwidth limitations, which may mean that you have to reduce the refresh rate and/or resolution of your display card. If you are then using the same computer for image editing as well as image capture you may find yourself swapping cables and changing software setups on a regular basis. Capture cards which use software overlay have an advantage in that driver updates are easily installed.

- RGB inputs gave much better results than composite – compare the images captured using the TARGA and Kingfisher cards from their RGB inputs to those obtained via their composite inputs, then compare both these sets to other cards (all composite).

  Although the Targa captured images at 16 bits (in our set up) they appear much 'cleaner' and sharper than the 24 bit images from the Kingfisher, although the effects restricted by the dynamic range of 16 bit capture could sometimes be seen when looking at areas of gradual tonal change (dithering; slight granular appearance). Note: the Targa saves its images as 24 bit even when captured at 16 bit.

- No matter how good (or bad) the quality of the captured image, it can be very easily degraded by poor handling/processing (much like photographs themselves). With this in mind here are a few guidelines that have been found useful in image capture :

  - capture at the highest colour depth
  - capture at the highest resolution; for video sources the number of pixels vertically should preferably be equal to the number of scan lines – any more or less will, almost inevitably, imply some form of averaging/interpolation.
  - clean system – stray dust tends to obey Murphy's law and be on the most important (and hardest to re-touch) part of the image.
  - for subsequent image processing : have the appropriate hardware and software tools and set them up properly. Editing 24 bit images on a 256 colour display is not a good idea. Setting up image editing software to match the gamma of <u>your</u> monitor and <u>your</u> room lighting can drastically affect the appearance of the displayed image – and don't forget to set up the monitor too.
  - for images which are (or destined to be) greyscale, either :

    \- capture as greyscale, although this may restrict the corrections available if the source image is colour rather than monochrome.

    \- or capture as 24 bit colour then convert to greyscale; avoid using 256 colour (even as an intermediary format). If captured as 8 bit colour and then converted to greyscale continuous (greyscale) tones are not as smooth, as some of the grey tones have been lost when the 256 colour palette was created. Ringing, seen as colour fringes at 24 bit, will (almost) disappear on conversion to greyscale as the colour, which stands out against the predominately grey background, is converted to grey.

- high frequency lines/edges (e.g. fence posts, railings) which are perpendicular to the video scan lines tend to cause 'ringing', especially on composite inputs. If the slide has such lines and they are predominantly vertical, a better image may be obtained by rotating the slide through 90° – and then rotating the image back again in your capture application before saving.

- Now that you have the images protect them :
  - write protect and/or make a working copy of the original file(s) – it is very easy (especially towards the end of a long editing session) to overwrite the original by forgetting to change the file name or format.
  - save work often; some image editors have a limited undo capability (often just the last operation) and you may have to start over if you make an unrecoverable error.

- The following sequence of operations has been useful when reducing the size and/or colour depth of images (as is likely for most CBL material). Note: this leaves out less common operations such as sharpening/blurring, background removal etc.
  - crop borders, but do not resample; this reduces filespace/RAM requirements which will speed up subsequent operations
  - adjust contrast/brightness
  - adjust colour balance/saturation
  - repeat the above, in small steps, as needed. Too great a jump in settings at each stage may mean that detail is irretrievably lost, e.g. a large increase in image brightness will lose highlight detail and subsequent colour adjustments are likely to be working only on white in those highlights.
  - now that the image is as 'right' as you can get it this is the time for resizing.
  - palette reduction; if this was done earlier (even before resizing) other operations are likely to change the colour 'population' of the image, which would compromise the palette.
  - SAVE and BACK UP

Section 4: Image Manipulation Tools

Introduction

The Multimedia Resources Unit of the Educational Technology Service, University of Bristol, facilitates the electronic capture and manipulation of images and video and encourages the correct use of such resources in computer-based learning materials. In doing so, the unit has realised the necessity to develop a number of software tools for image capture and manipulation.

Two of these tools, i) image processor and ii) palette manipulator, have undergone initial testing in a number of departments at the University of Bristol, the Centre for Personal Information Management, University of the West of England and the Department of Computer Science, University of Glasgow. We now require further feedback on their use and are making an evaluation copy of the two programs available as a beta test release.

I) Image Processor

The image processor was initially developed to assist in the batch processing of images that are currently being digitised from our videodisc based image archive. After digitisation these images are being converted to a resolution of 320 by 240 pixels by 256 colours and saved as GIF files ready for distribution via the World Wide Web. The image processor was developed to carry out a potentially tedious process automatically and unattended.

Remember to carry out any other manipulation needed to the images before reducing size or number of colours.

The program will convert images from one file format, size and colour resolution (colour depth) to another automatically. It is capable of converting all the images in one directory, unlike more conventional image processing software. Other features include the ability to strip unwanted black borders/frames from images (these may occur during over scanning), a review option, and colour balancing.

2) Palette Manipulator

As discussed in section 2, if you want to place more than one 256 colour image at the same time on a screen that is only capable of displaying 256 colours due to the limit of the graphic display card, these images need to have a common palette. The main function of palette manipulator is to optimise palettes from more than one (up to eight) 256 or less colour/greyscale images and produce a common palette.

Availability

Copies are only available electronically via the World Wide Web:

http://www.ets.bris.ac.uk/

This is a fully featured release but it will only function until the time stated on the World Wide Web.

The minimum machine specification required is:

A personal computer with an 80386 or higher processor
Microsoft Windows 3.1 or later
A hard disc with approximately 1Mb free of disc space for the programs and extra space for any image files
At least 6Mb random-access memory (RAM) - preferably 8Mb
A graphics adapter card capable of displaying at least 256 colours
Optional: a Photo-CD compatible CD-ROM drive for reading Photo-CD images

The Multimedia Resources Unit acknowledges the Joint Information Systems Committee for providing funding for the initial development of these tools as part of a grant under the New Technologies Initiative.

References

Alesandrini, K. L. (1987). Computer graphics in learning and instruction. In: The psychology of illustration vol. 2. Eds Houghton, H. A. and Willows, D. M. Springer-Verlag, pp 159-188.

Alesandrini, K. L. (1984). Instructional graphics in commercial courseware. Proceedings of the 25th ADCIS Conference, pp 188-195.

Bernard, R. M. (1990). Using extended captions to improve learning from instructional text. British Journal of Educational Technology, **21** (3): 215-225.

Brown, S. (1994a). Digital imaging in clinical photography, Part 1. Journal of Audiovisual Media in Medicine, **17**: 53-65

Brown, S. (1994b). Digital imaging in clinical photography, Part 2. Journal of Audiovisual Media in Medicine, **17**: 105-110.

Buzan, T. (1993). The Mind Map Book. BBC Books, London

Clark, A. (1992). The principles of screen design for computer-based learning materials. Learning Methods Project Report, Department of Employment, Sheffield.

Duchastel, P.C. and Waller, R. (1979). Pictorial illustrations in instructional texts. Educational Technology, **19**: 20-25.

Dwyer, F.M. (1970). Explanatory studies in the effectiveness of visual illustrations. Audio Communication Review, **18**: 235-249.

Dwyer, F.M. and Joseph, J.H. (1984). The effects of prior knowledge, presentation mode and visual realism on student achievement. Journal of Experimental Education, **52**: 101-121.

Edwards, B. (1992). Drawing on the right side of the brain. Souvenir Press Ltd.. London

Erdelyi, M.H. and Stein, J.B. (1981). Recognition hypernmesia: the growth of recognition memory over time with repeated testings. Cognition, **9**: 21-33.

Freedman, J. and Haber, R. N. (1974). One reason why we rarely forget a face. Bulletin of the Psychonomic Society, **3**: 107-109.

Gage, N.L. and Berliner, D.C. (1988). Education Psychology, Houghton Mifflin Company, Boston. pp 279-310.

Gould, J. D., Alfaro, L., Barnes, V., Finn, R., Grischkowsky, N. and Minuto, A. (1987). Reading is slower from CRT displays than from paper: attempts to isolate a single variable explanation. Human factors, **29** (3): 269-299.

Holliday, W. G. (1976). Teaching verbal chains using flow diagrams and texts. A-V Communication Review, **24**: 63-78.

Holliday, W. G. and Thursby, P. M. (1977). Teaching visual concepts in the classroom. Proceedings from the Annual Convention of the Association for Educational and Communication Technology, Miami.

Hutchinson, B. (1991). Using illustrations to improve communication: back to basics. British Journal or Educational Technology, **22**.

Longstaffe, J; Marshall, J and Whittlestone, M. (1992). The Wellcome Trust Tropical Diseases Videodisc Project. Journal of Audiovisual Media in Medicine, **15**: 57-60.

Levie, W. H. and Lentz, R. (1982). Effects of text illustrations: a review of research. Educational Communication and Technology Journal, **30**: 195-232.

Levin, J. R. (1989). A transfer of appropriate processing perspective of pictures in prose. In: Knowledge acquisition from text and prose. Eds Mandl, H. and Levin, J. R. Elsevier Science Publishers, Amsterdam.

Miller, G. A. (1956). The magic number seven, plus or minus two. Psychological Review, **63**: 81-97.

Myatt, B and Carter, D. (1979). Picture preferences of children and young adults. Educational, Communication and Technology Journal, **27**: 43-45.

Paivio, A (1971). Imagery and Verbal Processes. Holt, Rinehard and Winston, Inc. New York.

Paivio, A. (1975). Imagery and Long-term Memory. In: Studies in Long Term Memory. Eds. Kennedy, A and Wilkes, A. John Wiley and Sons, London.

Paivio, A, Rogers, T.B. and Smythe, P.C. (1968). Why are pictures easier to recall than words? Psychonomic Science, **11**: 137-8.

Peeck, J. (1987). The role of illustrations in processing and remembering illustrated text. In: The Psychology of Illustration. Eds Willows, D. M. and Houghton, H. A. Vol 1: 115-151.

Rogers, D, Haynes, R. and Taylor, L. (1993). Evaluation of the Agfa Arcus Colour Scanner. Advisory Group on Computer Graphics. Technical Report Series, no. 21.

Rusell, A and Redhead, K. (1993). A guide to screen design for computer-based training. Computer-Based Education Section, Queensland University of Technology

Standing, L. (1973). Learning 10,000 pictures. Quarterly Journal of Experimental Psychology, **25**: 207-222.

Standing, L., Conezio, J. and Haber, R. N. (1970). Perception and memory for pictures: single trial learning of 2,500 visual stimuli. Psychonomic Science, **19**: 73-74.

Steele, M., Arnott, M, Williams, D., and Heath, S. (1994). Evaluation of Image Capture Pathways for Multimedia Application. A Support Initiative for Multimedia Applications (SIMA) Publication. Published as part of the Advisory Group On Computer Graphics (AGOCG).

Weidemann, B. (1989). When good pictures fail. In: Knowledge acquisition from text and pictures. Eds Mandl, H. and Levin. J. Elsevier Science Publishers, Amsterdam.

Whittlestone, K. D. (1993). Observations made during a workshop on Screen Design. Educational Technology Service, Bristol University.

Williams, P. J. (1992). The Bristol Biomedical Videodisc Project: A visual archive of some 20,000 medical, veterinary and dental stills. Published by the University of Bristol.

Williams, P. J. (1993). Videodisc and compact disc technologies. Journal of Audiovisual Media in Medicine, **16**: 85-87.

Williams. P. J. and Hammond, P. M. (1994). The creation of electronic visual archives for use in teaching and learning. In: Proceedings of the 12th UK Eurographics Conference, St Hugh's College, Oxford. pp. 87-91.

Further Reading

Adie, C. (1993). A survey of distributed multimedia. Research, standards and products. RARE Technical Report no. 5. RARE Secretariat, Amsterdam.

Kennedy, A and Wilkes, A. (1975). Studies in Long Term Memory. John Wiley & Sons, London

Morrison, M. (1993). The Magic of Image Processing. Sams Publishing, Indianapolis.

Robinson, P. (1993). The digitising of Primary Textual Sources. Office for Humanities Communications Publications, No. 4. Oxford University Computing Services.

Sosinsky, B. (1991). Beyond the Desktop. Tools and Technology for Computer Publishing. Bantam Books, New York, London.

Wodaski, R. (1994). Multimedia Madness! Sams Publishing, Indianapolis

Wodaski, R. (1993). PC Video Madness! Sams Publishing, Indianapolis.

Acknowledgements

The authors would like to thank the following people for their valuable contributions in the preparation of this material:

Dr Gilbert Howe, University of Bristol
Prof Fred Smith, University of Georgia, USA
Patricia Hammond, ETS, University of Bristol
Members of the ETS, University of Bristol

and also the following suppliers for providing cards for evaluation:

FAST
Marcom
Rombo

Evaluation form for Use and Capture of Images for Computer-based Learning II

We should be most grateful for your comments - anonymous if you wish. Please complete as many of the following items as you wish and return this form to:

Educational Technology Service, University of Bristol,
Royal Fort Annexe, Tyndall Avenue, Bristol, BS8 1UJ.

1. The best thing about the booklet was

2. Another good thing was

3. The worst thing about the booklet was

4. Another bad thing was

5. I would have liked more

6. I would have liked less

Please compare this booklet with others that you have used and rank each aspect in the bottom third, middle third or top third.

Please tick the appropriate box.

	Bottom Third	Middle Third	Top Third
Consistency with publicity			
Relevance to your needs			
Quality of Presentation			
Appropriateness of the content			
Appropriateness of the level			
Appropriateness of the style			
Usefulness of the materials			
Overall			

APPENDIX I

Suppliers:

FAST Electronic 0171 221 8024

Screen Machine
Aviator
Movie Machine
Movie Machine Pro

Mar-Com 0181 891 5061

Captivator

Rombo 01506 414631

Vidi PC 24
Media Pro HiRes

Devcom 01324 825005

Black Widow Video Snapshot