# MICRO IMAGING

New applications are now appearing in image processing as a number of low cost, real time storage video framestores are appearing on the market. This is due to falling RAM prices and the availability of an increasing number of fast analogue-to-digital converters for use at video speeds, writes D. Ogilvy.

The minimum resolution that is acceptable for the capture and analysis of images is 256 × 256 × 4 pixels, or preferably 6 or 8 bits. It is now possible to purchase such a framestore, with real time storage, for under £500. More demanding applications will require a 512 × 512 pixel store, or better. These may be bought for £1200 to £2000. 768 × 575 pixel stores are also available from £1500 upwards. These offer a 50% faster sampling rate and will store the full active periods of the line and field which means there are no borders to the stored image when viewed. All the latter framestores are available with 6 or 8 bit resolution (64 or 256 grey levels).

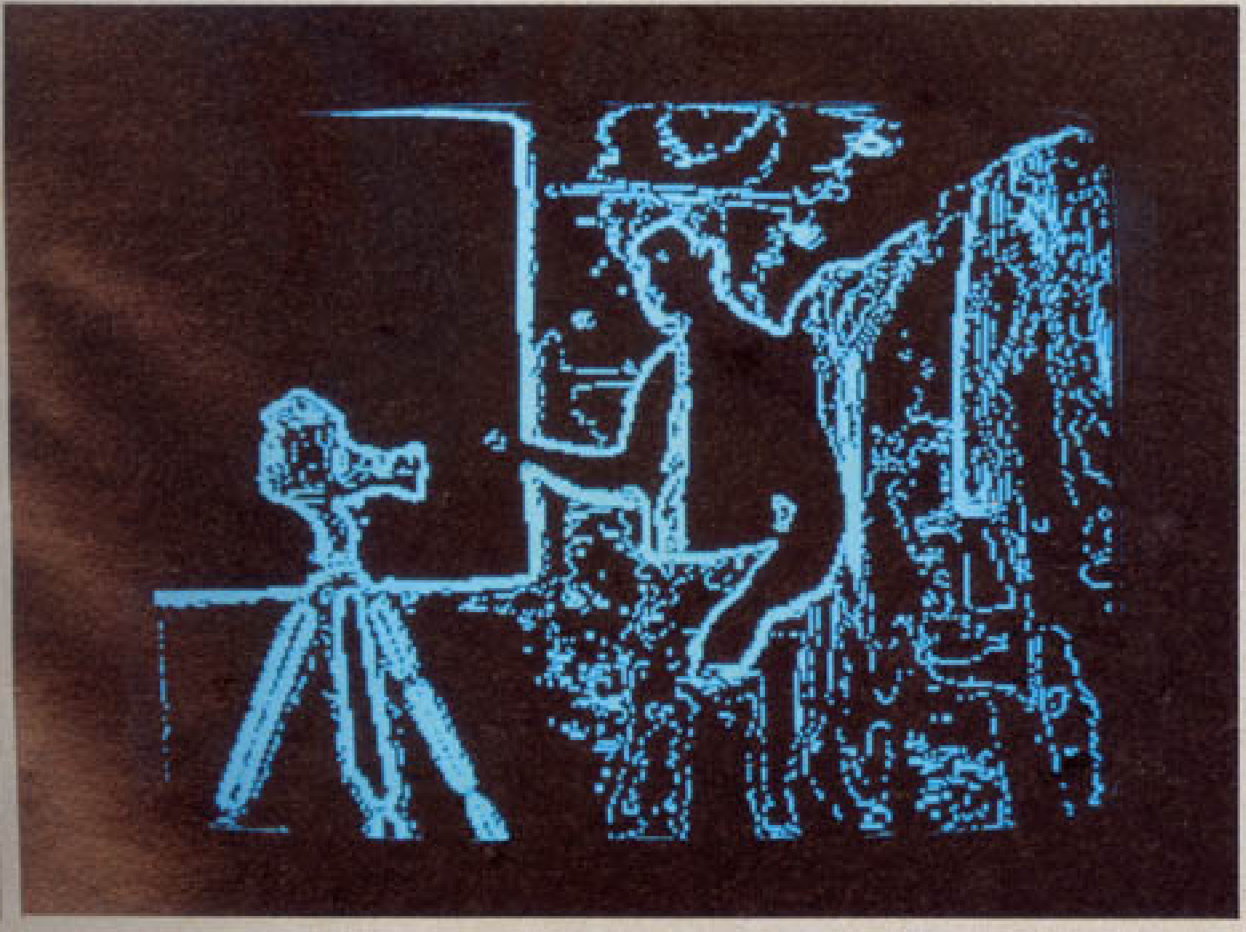
Framestores usually offer some form of computer interface for the development of image processing algorithms or to enable access to the image for storage on a more permanent medium. The single card versions are designed to be memory mapped into a particular computer bus such as VME or DEC Q-bus. Other stand-alone framestores may be designed to interface with a particular microcomputer or microprocessor family; again some offer general purpose interfaces such as serial, parallel or direct memory access.

These flexible image processing tools are now finding their way into an increasing number of applications and we will look at some of these below.

A framestore may be an essential element in a video system where a moving object needs to be captured. In all the framestores we have considered, real time capture still requires a minimum of 20ms to perform (one field period is the time for the camera to scan the image). This time is still long enough to cause motion blur in some circumstances. The solution to this is to synchronise the capture of a frame or field with the triggering of a flash gun or strobe light.

The flash would be triggered during the field blanking period of the camera, when its beam is cut off, and the resultant image on the camera target is then written into the framestore during the next field scan. The framestore can then hold the image until the flash has recycled or whatever processing required is performed. Using this method components on a conveyor belt may be captured by a framestore without resorting to stopping the belt. The minimum exposure is only determined by the flash length.

A technique known as target integration can improve the contrast of weak images, and requires a framestore to produce acceptable results. The method is similar to a long exposure in photography. The beam of the camera is arranged to be shut off for a number of complete fields. The image is gradually built up on the target of the camera, approximately doubling in intensity every $2^n$ fields. It is then written into the framestore at the end of the integration period. The cycle is then repeated.



A useful feature of a framestore that allows this capability is the ability to select one of the two fields captured to be displayed continuously, as large amplitude differences can occur between the two fields of a frame, leading to unpleasant flickering on the monitor image. The technique is of use in low light applications such as astronomy, medicine or microscopy where detector sensitivity, filtering or a simple lack of photons have reduced the image intensity reaching the video camera. The framestore may also be used to perform an integration function, where instead of rewriting the image each time, a number of consecutive frames are accumulated by it. A fast arithmetic logic unit is used to perform this function and may be available as an option or built into the framestore. The only limit to the integration time is the noise generated by the camera, and this can be reduced by cooling in the case of CCDs.

A framestore may be adapted as a timebase corrector for some purposes. The output from a video source may be non-standard and the framestore can be used to translate between it and a standard video output for viewing on a television monitor. Equally a framestore may be used to convert the fast camera input to a slow output for transmission along telephone lines for example.

Movement detectors are one application of framestores in security. The fast arithmetic processor will continuously monitor differences between the incoming live video and a set of reference stored images. Thresholding will be performed on the result and a count kept of the number of pixels that exceeds this. This thresholding prevents tripping of the alarm by small changes in lighting level or the passing of spurious objects. The pixel count will then be used to sound the alarm (which may take the form of autodialling a telephone number) if it exceeds an operator-set alarm threshold. The image may usually be masked to define an area of importance such as a door or window.

The output from the movement detector is used to start a video tape recorder which keeps a record of the intruder. However, the tape requires time to attain speed before recording commences by which time the intruder may have disappeared from the field of view. In such instances the framestore may be instructed to replace its reference image with an image of the intruder.

A framestore may be used as the basis of an alternative to an optical comparator. Optical comparators are used extensively in forensic science, whether the subjects be tool marks (crowbars against locks or forged stamps), fingerprints, footprints or shoe prints, dentistry, handwriting, cheques or any one of a number of objects that daily reach the forensic science laboratory. Typically an optical comparator consists of two manoueverable stages, each of which has its own lighting, and a system of mirrors and lenses which allow the images from the two stages to be overlayed or viewed separately.

Although a video camera based comparator cannot compete with an optical comparator in terms of resolution, it can offer a number of advantages over the latter. The contrast of the images tends to be higher with a video comparator which is not subject to same losses through the optical system. A higher contrast image can also give the impression of higher resolution, in that more detail can be perceived. Only one object stage is necessary, as one of the images may of course be stored: this can help with the setting up of the same lighting conditions for both objects. Use of a video system does not restrict the comparison to visible wavelengths; an ultra-violet or infra-red sensitive camera tube may be used with appropriate lighting. Also the comparisons tend to be more flexible, strobing between the images and overlay is offered as per the optical method, but differencing and ANDing (saming) of images may be performed with those areas that are different highlighted. The comparison may also be restricted to a selected part of the image.

One further addition to a framestore that can help to locate differences between images is the provision of pseudo-colour lookup tables. One or more of the grey levels of the image are mapped to a colour. If this grey level corresponds to a difference, visibility can be improved. Full pseudo-colour output is relatively rarely used, the colour/brightness relationship is not always obvious, but it can be effective where a colour temperature is measured such as satellite images and infra-red detector outputs. The comparison techniques outlined above can be applied to the fields of astronomy (star field comparison) or assembly line monitoring. In the latter case some thresholding of the output will be performed, similar to the movement detector, where an alarm may sound, the component be rejected or the conveyor belt stopped.

Some forensic science and most medical, astronomy and microscopy subjects are low contrast noisy subjects. Some form of noise reduction of the image can be extremely useful. Until now real-time noise reduction could only be performed in somewhat more expensive image processors, costing upward of £5000. It is now possible to obtain low-cost framestores with this facility incorporated, allowing the real time averaging of up to 64 frames of video, producing a 64 times increase in the signal/noise ratio. Although not applicable to moving objects (a recursive processing technique is necessary there) it offers a useful improvement in the contrast of an image. The contrast of weak images may be further improved by histogram equalisation. Usually performed in software on the stored image, it in effect looks at the frequency of occurence of each grey level in the image. Low contrast images will have the majority of pixels clustered within a few grey levels and this algorithm will stretch them across the full grey scale of the framestore.

This is an adaptive technique requiring no user intervention, but a more flexible approach can allow the user to view the histogram and manipulate it by hand, usually via a joystick. Manually, detail may be produced from a part of an image that was considered unimportant by the adaptive method. Rewriting of the image is unnecessary in either of these cases. An output lookup table (a fast memory) is used to map the old grey level value to a new one, the old value being available to be restored at any time.

The histogram and lookup tables may also be highlighted (usually turned white or to a colour) against the background of the image. The values and their range are user selectable. Examination of the histogram also allows binarising of the image to be performed. A threshold is calculated based on the distribution of the pixels and all the grey levels above it are set white, all below set black. This dramatically reduces the amount of data to be processed, thereby speeding up processing and simplifying hardware.

In some applications this one-bit image is not as limiting as it sounds. The examination of some forensic science material such as shoe prints or fingerprints, assembly line components, printed circuit boards and astronomy star fields are usually lit to produce as black and white an image as possible. The detail of the image is still retained, and what could be a fuzzy outline to the image hardened up to allow easier measurements on the object to be performed.

Finally we will look at the role of the framestore in the measurement of objects. Brightness measurements are necessary in medicine and astronomy for example. Individual pixel values may be read, having been selected by a movable X,Y cursor, or values may be averaged over an area. This may be useful for the measurement of diffuse light sources such as aurorae. Width of area measurement is of great use in assembly line component sizing and quality assurance, semiconductor line width measurement and other occasions when quantitative results are required from images. Real time width and area measurement is now possible even with the low cost framestores, together with alarm outputs for out of range components or objects.

We have looked at some of the facilities offered by a new range of affordable real-time framestores and the wealth of applications that are being opened up by them. They offer a real alternative to the dedicated hardware equipment that has been necessary for such things as the measurement of images, and are able to be tailored to the exact requirements of the user. Facilities such as real-time averaging and integration were unprecedented in this price range. Convolution and filtering of images, image encoding and transmission error correction (missing lines and pixels from Landsat or telephones) will soon open up a new range of applications. ■

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