Practical Computing

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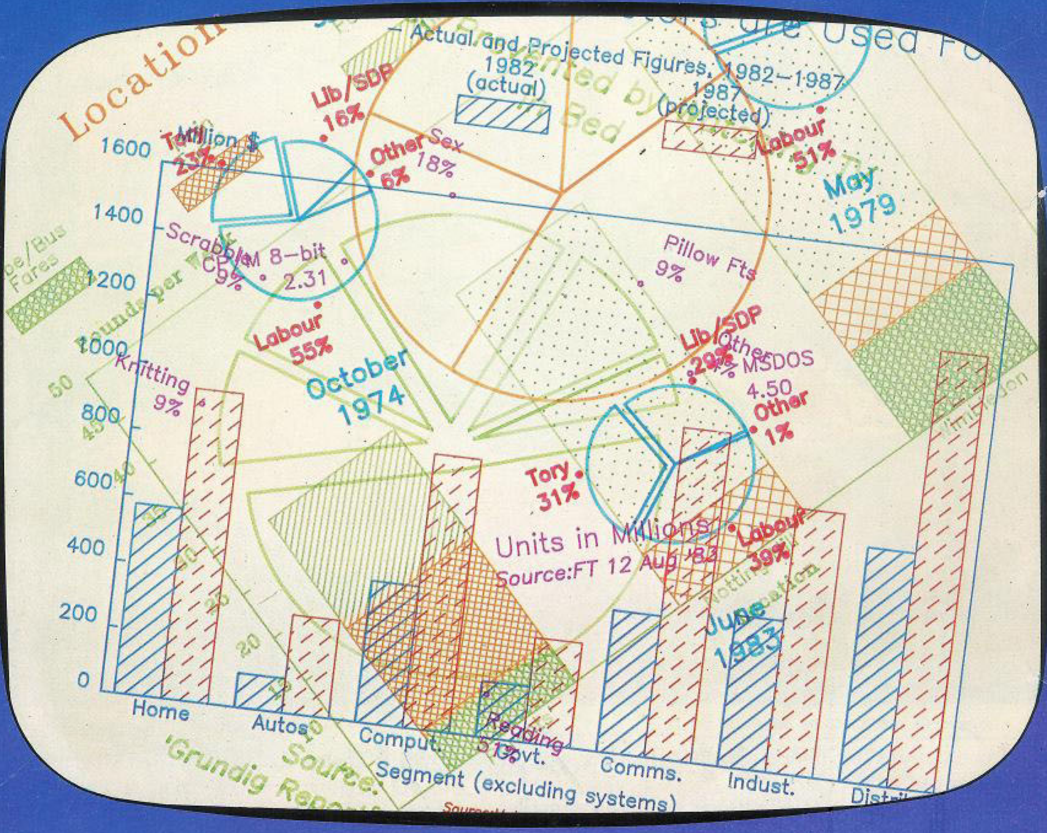

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Images of digits

Peter Kruger and Stephen Cronk of Digithurst Ltd explore the potential for high-resolution vision systems.

FOR SOME TIME the subject of image analysis has interested engineers and computer scientists. The ability to put a graphical representation of a real object into a computer and manipulate it has found countless applications from pattern recognition to CAD. Until recently most of the available vision hardware was based around either mainframes or specially designed processors; it did not have the general applications which would allow high-volume sales over which to spread development costs.

The microcomputer has a wide range of applications from office administration to process control and is proportionally lower in cost. Rather than using external hardware such as CPUs and RAM to capture the image the micro's own hardware is used as a frame store. The data becomes much more accessible to the user for the purpose of image processing.

Solid-state cameras provide the computer with digital data representing a map of pixels, which make up the image falling on the sensors of the camera's solid-state array.

Due to the low level of production solid-state cameras can be quite expensive. This is changing and solid-state sensors are being applied to a range of consumer products. Some solid-state cameras use optic RAM rather than a sensor. This enables an image to be fed straight into RAM, and the sensor itself to be read in the same way as a frame store. It provides a very rapid, low-cost method of obtaining a binary image.

The alternative to the solid-state camera is the Vidicon television camera which provides an analogue signal, which is then digitised. Unless expensive A to D converters are used this method is slower than the solid-state camera, but it does have the advantages of being both low cost and giving a grey-scale output. In general terms, where the object being analysed is slow moving and a grey-scale image is required a television camera system can be used. If a rapid access time is required and a binary image is sufficient, then a solid-state system should be used.

To carry out analysis the image data can either be sorted in external RAM, in the camera or frame store, or in the microcomputer itself. Advantages and disadvantages are present in both systems. The cost of external memory and the extra processing required is high, but may be necessary if the image analysis required is complex and takes up a large amount of RAM. If the microcomputer is large enough to hold the image and the software required, then the data becomes much more accessible to the user and the cost of additional hardware falls.

Once the image has been captured and stored it may be desirable to display it. The image may be shown as a binary or a grey scale. If a binary display is required the data must be scanned and each pixel compared to a preset threshold before deciding to display them or not. To simulate grey scale a group of screen pixels are used to represent each camera pixel. The thresholding technique is used for each pixel within the group and an image is displayed not dissimilar to newsprint. A contrast value can be used to set the threshold values for the pseudo grey-scale

Figure 1.

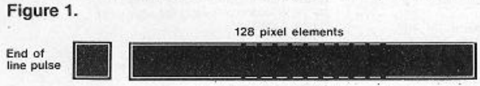
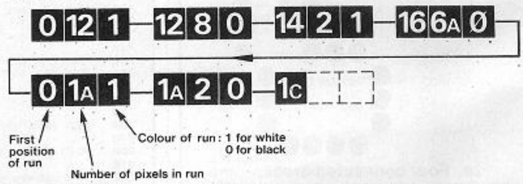


Figure 2.



The data structures hold data in unprocessed or processed forms. Figure 1 shows unprocessed data, which is held in RAM. Figure 2 shows processed data which is unprocessed data that has been encoded.

A grey-scale image.

A binary image.

display. Both routines can be written using the computer's point-plot routine making the software transportable between different micros.

Data may take one of two forms when it is read into the computer. It may either be binary image data and be bit mapped or it may be grey-scale data and be byte mapped, each byte having a value representing the brightness of the respective camera pixel. At this point it will be necessary to clean up the image. High-resolution pictures gained with a video camera which has random interlace must have the effect of the interlace removed, which is achieved using recursive processing.

This is a relatively simple yet effective way of reducing noise or any form of sporadic interference on a digitised television picture. A number of frames are captured, each being averaged with the previous using the algorithm:

NEW PIXEL = (OLD PIXEL + INCOMING PIXEL)/2

The random nature of the interference means that over a number of frames the unwanted noise will tend to cancel out. Increasing the number of frames captured and averaged in this way improves the final result but also increases the time taken to reach that result. It is usually found that acceptable results are achieved after the first three or four frames; after that the small improvement in picture quality is minimal compared to the extra time needed.

A slightly more advanced version of the technique which leads to more flexible filtering allows the user to define the proportion of the incoming image that is mixed with the previous image, using the algorithm:

NEW PIXEL = K * OLD PIXEL + (1 – K) * INCOMING PIXEL

where K is a user-specified constant weighting the new image.

Recursive processing techniques can also be used to intensify a low-level video signal such as one that is shot out of doors at night. Each captured frame is summed with the previous frame so that over a period of about 10 frames, depending on the light level, a clear image can be seen. The process requires the image to be stored in 16-bit words as it is quite likely that the values obtained may be greater than 255.

To remove any electrical noise appearing as individual pixels, or marks and small objects which appear as single pixels and therefore cannot be verified at the current resolution, the image data is cleaned. The cleaning consists of examining pixels in groups of three and eliminating any pixels whose neighbours differ radically in intensity.

Image compaction techniques can be used to reduce the size of the image-data file to speed up data access during future processing. One method of data compaction is run-length encoding which reduces the memory required to hold an image by up to 16 times. Each pixel is examined and compared with the current threshold value. The next pixel in the current raster is also compared to the threshold value, and a run of pixels of the same thresholded value is built up. Each run is stored in a three-byte record, the first byte giving the start point of the run, the second byte the number of pixels in the run, and the third the colour of the run.

The amount of grey-scale and processed data which can be held at any one time will depend on the memory size of the computer being used. For example, a 256K Sirius will hold a 256 by 256 grey-scale image occupying 64K as well as at least one processed image at any one time. This allows the image to be processed at various thresholds without disturbing the original data.

Object/pattern recognition can be undertaken either by using values of area and perimeter or by examining the grey-scale data in greater depth. By using edge-detection methods it is possible to build up a series of co-ordinates which can be passed to a CAD software package.

With the introduction of more powerful microcomputers and with greater speed and memory mapping capabilities there is a greater potential for higher-resolution vision systems. To anyone who has spent hours inputting graphics into their programs the applications of low-cost vision systems is obvious. Images can be used as backgrounds for games programs or computer-aided learning software with images being read in and reduced to line drawings in a matter of seconds.

Solid-state cameras provide the computer with digital data.

Grey-scale image with edge detection on one section.

Inverted image with edge detection on one section.