Informatics

Informatics Department Demonstration Handout

Image Processing Algorithms Library

Introduction

The Image Processing Algorithms Library has been developed jointly by the Rutherford Appleton Laboratory and the Numerical Algorithms Group Ltd. (NAG Ltd.), Oxford with support from the Alvey programme.

Since even simple English words can hide a technical meaning it is worth explaining what is meant by an "image" in this context. An image is a picture which has been broken up into smaller pieces called pixels (picture elements). The intensity within each pixel is represented by one number. For this to give a good representation of the original picture the pixels must be small or, to put it another way, the picture must be broken into a lot of pixels. Typically these pixels are rectangular and in this demonstration most of the large images have 512 lines of pixels with 512 pixels in each line. The computer may be processing an image to make it easier for a person to understand or the processing may simply be the first stage before the computer goes on to try to extract information about what the image contains. The library deals with the first stages of image processing not the later reasoning to decide what is in a picture.

Work for the first release of the library has concentrated on images shown as shades of grey rather than colour. Alternative but complementary versions of the library have been developed in two computing languages; Fortran and C.

This demonstration uses code from both versions and illustrates some typical image processing functions, concentrating on four types of operation:

- Contrast adjustment
- Boundary detection
- Simple grey-value manipulation
- Data reduction

Contrast Adjustment

An original image as taken by a video camera and stored on a computer may be lacking in contrast and not ideally suited for viewing. In order to improve contrast for the human viewer an operation called "Histogram Equalization" is performed. This makes better use of the range of intensities allowed within the image so that the eye has an easier job to do. This is somewhat similar to adjusting the contrast control on a television set. The distribution of intensities before and after the operation is shown. This illustrates one important aspect of image processing, namely presenting the image in ways that make it easier for the person viewing it to extract information. A look at the new intensity distributions shows that the information between the peaks is now being squeezed into a smaller range. This illustrates that this operation is for the benefit of the observer rather than the computer which may have further processing to do and can make better use of the original information.

Boundary Detection

A common but far from trivial problem is to identify boundaries between different parts of a picture. (This is an example where the combination of the eye and the brain does a remarkably good job.) The first stage of one approach to this problem is shown using parts of the larger images.

First the size and direction of intensity changes near each pixel are calculated. The boundaries have relatively high values of intensity change. This operation is called a "Sobel" filter but we also show the results of two other ways of calculating the size of the intensity changes. One is a "Laplace" filter which shows up boundaries as a very sharp swing between bright and dark. Another uses a simple operation which replaces each pixel value with the difference between the brightest and dimmest pixel in a group which includes the pixel in question. The demonstrations continue with the results of the "Sobel" filter since it gives the direction in addition to the size of the change. The next step shows the result of selecting the brighter parts of the image. Instead of displaying the size of the intensity change (which we used to make the selection so we already know that it is a large number) we use colour to display the direction. We would therefore expect that along a boundary running in one direction the colour would stay the same.

Simple Grey-value Manipulation

This demonstrates how some simple operations can still lead to useful results. The brightness of each pixel is adjusted in different ways depending on its own brightness and that of other pixels which are nearby. First we show the effect of replacing each pixel by the dimmest pixel, then by the brightest and finally by the difference between these two. This last operation enhances boundaries. It is possible to adjust the number of neighbouring pixels used in these operations from just one to twenty. In the examples shown just the central pixel and its four nearest neighbour are used. The technical name for this type of operation is "grey-value morphology".

Data Reduction

A major problem in storing and transmitting images is the large amount of data involved. There are techniques which can be used to reduce this amount and an example of one of these techniques is included in the demonstration.

The picture shown in this example originally contains 256x256 pixels or units of information. An operation called a "cosine transformation" is performed and the information is reduced to 64x64 units before the operation is reversed to recover the original picture. This is a very drastic reduction and this shows in some small spurious features which are introduced into the image. However the reduction in size of the image data by a factor of one sixteenth could be very useful if the image needs to be transmitted over a network.

Conclusion

In a short demonstration we can only show a few operations to try to give some feel for what is meant by image processing. It is worth pointing out that images contain a lot of data and as most of the main images displayed were 512x512 pixels, each of which is represented by 8 bits in a computer, the number of bits needed to record one image of this size is typically 512x512x8 or roughly two million. Our eyes and brain do a quite remarkable job in making some sense out of the real world!

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