Gerald's Column
by Gerald Fitton

This month I want to 'move' (!) on—to moving pictures.

A Digitised Screen

Let's start by considering the number of pixels there are in a single frame.

A TV screen in the UK is said to have 625 lines. You might think that this means that the number of lines which you need to fill a TV screen is 625. Not so! The number is considerably lower than this.

Someone whom I believe has told me that the number of lines containing picture information is 532. So I asked him, "Where have the other 93 lines gone?" The answer seems to be something to do with (a) the time it takes to get the flying spot from the bottom of the screen back to the top and (b) ensuring that the vertical movement has become linear with time and (c) the time it takes to be sure the line pulse generator is synchronised with the incoming data. The 625 line standard has been around for a long time and the synchronisation circuitry and the frame and line linearity has improved to the extent that all of these 93 lines are unnecessary. Now some are used for Teletext data.

Anyway, I shall assume that 532 lines is somewhere near the correct number of rows even if it's slightly wrong. However, estimating the number of pixels per line is not so easy. I had a look at the output from my digital camcorder and I found that each frame consisted of 696 by 532 pixels. If the screen has an aspect ratio of 4:3 screen then this is about right. Digital colour is 24 bits (3 bytes) per pixel. If we multiply these numbers together we get 696 * 532 * 3 = 1 110 816 bytes per frame, just a little more than 1.11MB per frame.

Moving Pictures

Our UK standard TV picture is often referred to as 50 frames per second. This is not quite true; it uses a cheat to reduce this 50 fps by a factor of two. The way it works is this. On the TV screen only half (266) of the 532 lines are rendered in one pass from top to bottom of the screen. Every alternate line is missed out. This 'half frame' of 266 lines is rendered in one fiftieth of a second. On the next pass the other 266 lines which were missed out are rendered and placed exactly between the first lot of lines. Consequently the number of 'full' frames per second is 25 rather than 50. It takes a twenty-fifth of a second to complete a full frame consisting of 1.11MB of (digital) data.

Multiply this out and you'll see that the data rate is a massive 28MB per second! Wow!

Contrast this with the data rate we first discussed, about 3 Bytes per second when typing at a keyboard. Even the data rates for playing musical CDs, around 175KB per second, seems insignificant when compared with 28MB per second.

These days we do have computers which can load, process, transfer from machine to machine and store data at a rate of 28MB per second (with capacity to spare) but that was not always the case. A 'fix' was necessary; that 'fix' is still used and is still useful.

JPEG

I have been told (and I have no reason to disbelieve my source) that Journalists wanted to send pictures 'by wire' from one location to another perhaps so that newspapers could be written in one place and printed elsewhere. It was necessary to devise a common standard for compressing digitised photographs. TIFF is one such standard but JPEG was, initially at least, the most favoured format because JPEG files are smaller.

I am sure that the PEG (in JPEG) stands for Picture Expert Group but opinion seems to be divided on whether the J stands for Joint or for Journalists. Does anyone know?

Like SparkFS, the TIFF format does not lose any information. JPEG does lose information but the files are usually smaller. The smaller the JPEG file the more information is lost.
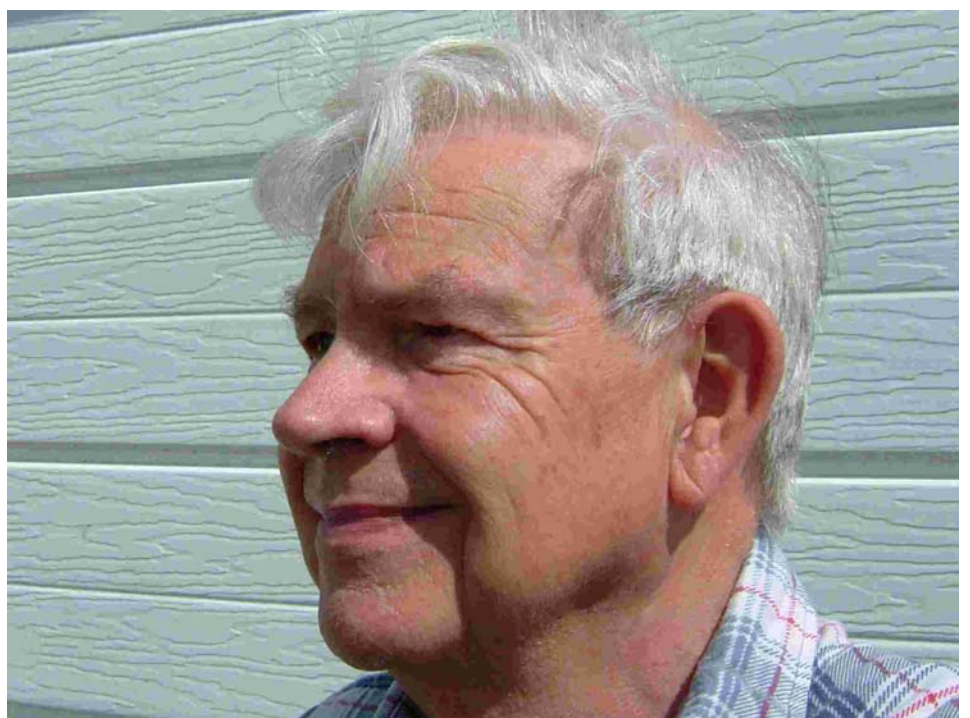
Look carefully at the two versions of the picture of me shown here. Both pictures are 3 MB sprites. However, the picture on the left is derived from a lightly compressed JPEG file of 405KB; the picture on the right is derived from a JPEG which has been considerably compressed to 59KB. It might not show on the printed page (particularly in monochrome) but I can see the difference in the colour rendering and in some of the texture. I did try a reduction to about 25Kb but the colour rendering was so bad that I couldn't bring myself to include it in Archive! However, in monochrome I found that a 10KB JPEG version of the picture was fairly acceptable.

The JPEG compression algorithm is a very good one provided that you don't mind losing some of the information in the picture. Many coloured pictures can be reduced in size by a factor of ten before there is any noticeable degradation. Even a factor of a hundred (using fewer colours) will still produce small pictures which are suitable for use on a web site. If you look at an estate agent's web site for pictures of houses you'll see what I mean.

MPEG

The 'Group' which introduced this excellent JPEG standard for single pictures were the obvious team to devise some means of compressing Moving Pictures. The 'Experts' were commissioned and came up with the acronym MPEG. Not only did they come up with the acronym MPEG but also a very efficient algorithm which takes advantage of the fact that there are usually not a lot of changes between consecutive frames.

My recollection of the history of MPEG is that their first algorithm was called MPEG 1 and compressed moving pictures to a data rate which could be used over the Internet, a few kilobytes per second. A later version, MPEG 2, employed much less compression.

DVD

Without exception the format used on a Versatile Digital Disc (DVD) is MPEG 2.

Like the JPEG format, the MPEG 2 format is not just one standard amount of compression. It can be varied from very slight to considerable! Let's do some sums!

The standard single layer writable or rewritable DVD will hold 4.7GB of data. If you have a DVD writer then, almost certainly, the DVD which you can write is a single layed DVD having a capacity of 4.7GB. Dual layer (and other clever formats) are becoming available but, for my purposes let's stick with this 4.7GB format for now.

A digital stream representing an uncompressed moving picture requires a data rate of 28MB per second. There are 3600 seconds in one hour so that, in uncompressed format, an hour's worth of data is about 100GB. The 0.7GB for an hour's worth of digital sound (and a few other bits and pieces) are negligible compared with this 100GB of picture data.

From this rather approximate sum you will see that the degree of MPEG 2 compression required to fit one hour's worth of moving picture (with sound) onto a 4.7GB DVD is close to 20. The relevant sum is 20 * 4.7 = 94GB. Whilst a JPEG begins to look a bit 'funny' if the compression is greater than 10, moving pictures will stand more compression. The reason is because changes from one frame to the following frame are relatively small. Only the changes need to be reported and represented in the MPEG 2 coded representation.

I have a Philips stand alone DVD recorder, model number DVDR 70. I use it with rewritable DVDs to record TV programmes which I might miss (perhaps because I am playing with my grandchildren!) or which want to keep. I use it instead of my S-VHS video recorder because the quality is much better. This recorder will record with six different compression ratios. The largest amount of compression is such that a 4.7GB DVD holds 6 hours of programmes.

Acceptable Quality is a subjective matter. For programmes I am going to throw away after I have seen them I find that the recording Mode, M6, does not seriously affect the enjoyment of most programmes I watch. For those programmes which have good scenery or shots which I may wish to freeze and look at in more detail, the M6 mode does have its limitations. Certainly the M1 (one hour) format is too good for most programmes recorded from the TV because the TV picture is not good enough in the first place. However, clips recorded using my own digital camcorder do justify the use of M1 rather than M2.

Of course I can play back my home made DVDs on a computer as well as through the TV. (I have to bring computers into this article somewhere or Paul will complain!)

When I play either commercial or home made (from my camcorder) DVDs on my computer the quality of the image is noticeably much better than playing back the same DVD to my TV (using the RGB rather than the S-Video or composite video link). I wonder if anyone else has noticed this?

AVI Format

A common format for moving pictures on a computer is the AVI format. I am not sure but I think that the AV stands Audio Visual and the I for Information?

All the digital camcorders I have used store the digital data on tape. I have seen more modern ones advertised which store the digital recording on a miniature version of a DVD!

When I connect my camcorder by, for example, a FireWire link to a computer I save the digital data to the computer as an AVI format file. I don't know the details of this format but it does seem to have a high degree of fidelity similar to the MPEG M1 (one hour for 4.7GB) mode of a (good) DVD. Certainly the moving pictures on the computer seem to me to have much more fidelity than I get when playing directly from the camcorder to the TV using the S-Video link. I don't have an RGB output from the camcorder.

My tests show that this AVI format (pictures plus sound) runs at about 1.4MB per second.

Summary

When it comes to moving pictures with sound, the data rate for uncompressed pictures is about 28MB per second. Whilst this data rate can be handled by modern computers it implies a file size of 100GB for a one hour recording. DVDs have about one twentieth of this capacity. Earlier computers couldn't handle this data rate and so a compression algorithm was devised to reduce the file size. The (nearly) universal standard for the compression of moving pictures is the MPEG 2 format (with MPEG 1 still in use for Internet streaming). The M1 mode of this MPEG 2 format runs for one hour. Other compression ratios are in common use such as the M6 (six hour) variant.

The MPEG format was devised by the Moving Picture Expert Group as a logical development from the JPEG format for single pictures. The MPEG 2 standard allows many different degrees of compression but these are typically between 20 and 120.

Generally the commercial DVDs which you buy in shops have been compressed by a factor of about 20 and the AVI files in common use on a computer have a similar degree of compression. The picture quality of M1 (one hour for 4.7GB) is noticeably better than a transmitted TV picture which, in turn, is considerably better than a VHS or SVHS analogue tape recording.

Playing back AVI or MPEG 2 M1 recordings on a computer give a better picture than does playing back an MPEG 2 M1 DVD on a TV set.

Communication

Please contact me by email (preferred) or by letter if you have any questions or comments. You can email me at <Archive@abacusline.demon.co.uk>.