

Gerald's Column

by Gerald Fitton

My theme for this series of articles is about the future of computers. I asked you "What will you use your next computer for?" and I warned you that it was unlikely that it would be 'more of the same but faster'! Thank you for the many emails letters. Although Video Editing has been mentioned by several people, nobody has mentioned my subject for this month's article.

Pictures

Last month I concentrated on still pictures. Consequently I have been asked to describe in more detail the pictures produced by such devices as digital cameras (and scanners) and then to discuss the ways in which software which can be used to process these images.

The processing which most of you want to do is fairly modest. Amongst the most important is to be able to rotate your pictures through ninety degrees (anticlockwise). The second most important facility you want is called 'cropping', selecting just part of your picture. A few of you took up my main theme of file sizes and asked for guidance (and software) which will reduce the size of the huge files which pictures produce. Two of my correspondents, perhaps inspired by the picture of my video processor, remarked that they needed software which could be used to adjust the 'colour temperature' of their pictures—software which can be used to adjust the hue and saturation of a picture without going through it pixel by pixel.

I was tempted—but I decided to leave these subjects for another day. Instead I shall introduce into this series another application which you just might want your next computer to handle.

Basic Sound

The basic BBC computer did not have a hard drive (I do remember a 1MHz bus to which a hard drive could be connected) nor even a floppy drive. Programs and data were stored on audio cassette tape as a stream. I am reminded of the sounds on those tapes when I hear the noises produced by a modem.

It was back in the early 1980s that I had much correspondence with someone whose name I regret I have forgotten. We exchanged cassette tapes and hand written letters. These audio tapes contained musical programs written in BBC BASIC.

Music

By now you will have guessed that my topic for this month's article is 'Music'.

RISC OS computers are in daily use for document production (in which category I include spreadsheets and the processing of pictures). Very few are used in a musical context. Right now you may not think that your next computer will be used in a musical context; I think that you're wrong.

Apart from a recent article by Philip Perry, it is a long time since I saw anything about music in Archive so I am not surprised that the vast majority of you will not associate computers, particularly your own personal computer, with music.

I hope to change your mind.

I recall that when some of the early Art programs were released onto the RISC OS market the general opinion was that !Paint would do everything that anyone except a skilled artist needed. I guess that by now the popularity of digital cameras has put paid to that idea?

I am sure that many of us will need to process digital pictures on our next computer. We will need to understand and process pictures which are in formats such as JPEG, TIFF and even bitmaps. If you are wedded to the Acorn Sprite format then you will regard these formats as 'foreign' and therefore of little interest. I assure you that you are seriously mistaken! You will want your next computer to handle JPEG and other picture formats and you will need to know the advantages and disadvantages of each.

I spoken previously about the value of History. It was wrong to consider that only skilled artists would be able to obtain any benefit from having a computer which could process pictures. It is equally invalid to consider that the benefits of using a computer to process music will be limited to skilled musicians. It is my opinion that all of us can and will benefit from using our next computer as a musical machine!

Keyboards

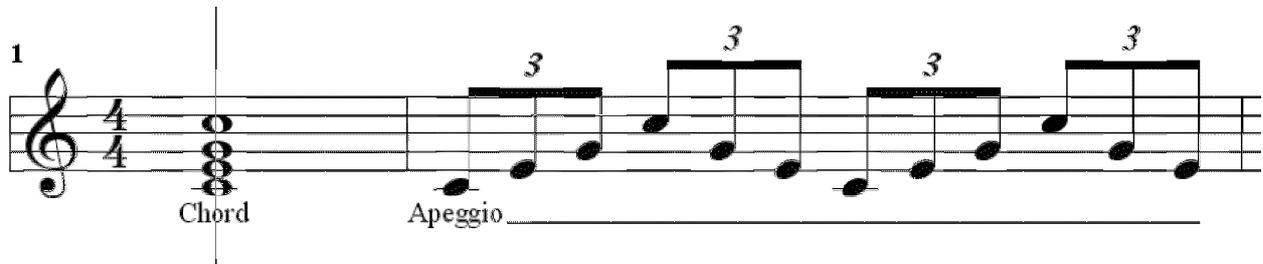
I am sure that the number of households owning a musical keyboard is on the increase. These days all but the cheapest musical keyboards have a MIDI interface. Many allow you to store in MIDI format whatever it is that you play at the keyboard. Most schools these days have a 'band' and it is becoming increasingly likely that your youngster will be invited to join and, therefore will either have or want a musical keyboard. You too can have fun with music!



The keyboard in the picture is a Yamaha DGX-200. The price of such keyboards has fallen substantially during the last couple of years and the features they contain are far more than most people will ever use. There is a wealth of extra benefit to be gained from a musical keyboard when it is connected to a personal computer which is capable of storing and processing musical files. Let me repeat; you can have fun with a musical keyboard.

An Arpeggio Generator

Back in the long ago of the 1980s I sent to my correspondent (who, I think, lived in Marlow) a BASIC subroutine I had written which converts chords to arpeggios. I shall explain what my subroutine did using the example shown in the picture below. If the input to the BASIC subroutine is the chord of C major as shown in the first bar of the music then the output from the subroutine is an arpeggio of triplets such as those shown in the second bar of the music.



For those of you who are unfamiliar with musical notation I must explain that the chord in the picture consists of four notes played simultaneously. The corresponding arpeggio consists of the twelve notes in the second bar played one after the other. The effect is a rippling sound; the notes run up and down the scale. It is an effect which is often used as counterpoint.

BBC Sound

The BBC computer produces sound from a data file of numbers. Each musical pitch has a number associated with it. The subroutine which I wrote took as its input the numbers corresponding to the four notes of the chord and the output was the sequenced twelve notes of the arpeggio. The data from the subroutine is inserted into the musical data file so that when the data file is run (using another BASIC program) then the arpeggio is played rather than the chord from which it is derived.

MIDI Files

MIDI format files use exactly the same concept as that used on the BBC computer, namely the allocation of a number to specify pitch of a note. MIDI files conform to a 'standard'. Given a note number (they run from 1 to 128) the same musical pitch is generated on all instruments conforming to this standard. Note number 1 is the lowest pitched note and number 128 is the highest pitched note available (from a standard MIDI file).

For those of you who have an application such as RealMIDI which plays MIDI format files I have sent a small one to Paul for inclusion on the Archive monthly disc. If you run it you will hear first the four note chord and then the twelve note arpeggio. This file is called Arp04/mid; it is only 283 bytes and, in real time, takes about two seconds to run.

I shall return to MIDI format files later but for now I would like you to notice that this very simple example has a data rate of less than 150 bytes per second. Whilst this is much faster than typing at a keyboard is it much slower than the data rate which you need to handle pictures taken with a digital camera or which can be generated by a scanner. You do not need a fast computer to handle MIDI files.

Returning to my theme, your next computer, if you or your progeny are interested in playing music on a musical keyboard then you should ensure that your next computer is able to communicate with musical keyboards in MIDI language.

Music on CD

If you look at the files on an audio CD then you will find that the three letter extension is .cda which I think stands for Compact Disc Audio. Without exception, all the Audio CDs which I have looked at use what is called 16 bit stereo sound samples at 44 100 samples per second.

With no loss of information whatsoever these cda format files can be converted to .wav (wave) files and stored on a hard drive. All CD writing software which can burn Audio CDs will convert these wav (wave) format files to cda format during the writing process. Generally full fidelity audio files are stored on CD in cda format and on hard drives as wav format. Let me emphasise that so far as the information content is concerned there is no loss whatsoever in this conversion process and you can change from one format to the other and back again as many times as you like without any loss of information or fidelity.

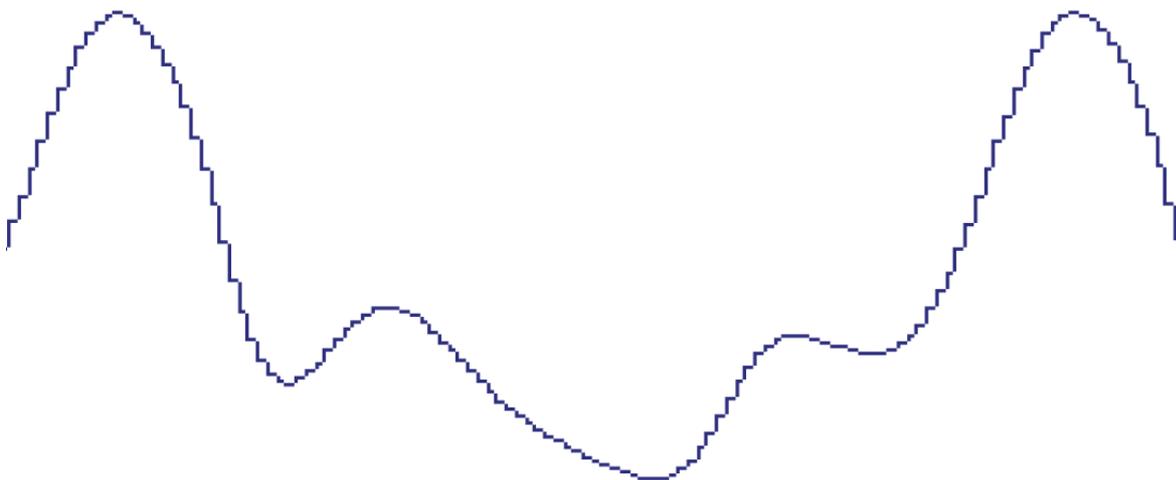
I know that in a recording studio the files are not 16 bit but 32 bit (or even higher) and that the sampling rate can be as high as 96 000 samples per second. Let's not confuse ourselves with the master copies used by the recording studio; let's concentrate on the CD Audio with which we are familiar. We can always multiply by two or four later if we have to do the sums again for a recording studio situation.

Data Rate

Another sum for you. Each sample has a Left channel and a Right channel. Each sample consists of 16 Left bits and 16 Right bits. The total is 32 bits per sample or, if you prefer (and I do) that is 4 bytes per sample. At a sampling rate of 44 100 samples per second this means that the real time data rate is $4 * 44\ 100 = 176\ 400$ bytes per second, about 176KB/sec.

I'm sure that you will appreciate that this is not only a higher data rate than that needed for keyboard use and a thousand times faster than the rate needed to use MIDI files but also that it is considerably faster than the data rate you would reasonably specify for handling still pictures taken with a digital camera. 176KB/sec is the 'fastest' job we've seen up to now!

If you want to play wav or cda files on your next computer then it must be able to process data files at 176KB/sec.



Sampling

Have a look at the picture above. It shows just over one cycle of a musical waveform sampled 44 100 times per second. It is the note A. Indeed it is the A which has an audio frequency of exactly 440Hz. The time taken for one cycle is exactly 1/440 sec. During that time 100 samples are taken; in the picture you can see them. If you count the steps between the peaks of the waveform then you will find that there are 100 (plus a very small fraction of a step which is far too small to be seen).

The 16 bits

The use of 16 bits means that the amplitude of the wave can be measured to one part in 2^{16} . A straightforward calculation gives $2^{16} = 65\,536$, a measure of the precision with which the amplitude (of every sample) can be measured. When this sampled waveform is fed into a loudspeaker the jagged bits are smoothed out and we hear the mellow tone of the 'standard', MIDI number 73, flute playing the 440Hz note called A.

You will not be able to see these 65 536 levels in the picture. What happens is this; 44 100 times every second the amplitude of the waveform is measured and then this amplitude is converted into a 16 bit number which is stored in cda or wav file format.

Dynamic Range

The sampled waveform of my picture does not use all these 2^{16} levels. The loudest sound which can be produced would use all these levels; try to go beyond this and the waveform becomes flat topped and the consequential overload distorts the sound. Quiet sounds use fewer bits; the amplitude of the waveform is reduced. The range of volumes between the quietest and loudest sounds is called the dynamic range.

Professional recording studios create their master recordings at higher sampling rates and with many more bits per sample. Only when all the tracks have been mixed is the edited recording converted to the CD standard of 16 bits sampled 44 100 times per second.

CD or MIDI Format

Please do not get confused between MIDI encoding and the formats used for CDs (cda) and for storage of sampled music on a hard drive (wav).

MIDI files are much smaller and rely for their operation on a common standard, the MIDI standard, for their interpretation. The pitch of every note is given a number. The most basic MIDI standard (there are extensions to the standard) includes 128 different instruments starting with a concert grand piano at #1 (the American # is used in this context to mean the same as the English word 'number') and this MIDI range includes all the usual strings, woodwind, brass, percussion of a concert orchestra as well as rock music sounds such as an 'overdriven guitar' and a range of 'synth' instruments.

Files stored in cda or wav format are huge by comparison with the corresponding MIDI files. For my 440Hz (sampled) example I chose to generate it using MIDI instrument #73, a 'standard' flute which has what I would describe as a mellow sound. The waveform is not a pure sine wave because there are even harmonics present. I do have software which can be used to 'doctor' waveforms (for example to remove annoying clicks or scratches from tracks transferred from vinyl to my hard drive) but I have not used it in this example. The waveform in the picture is sampled straight from the MIDI generator complete with even harmonics.

Next Month

To some extent I must be guided by you! However, my intention is to discuss, with worked examples where possible, the ways in which a computer can be used to process files which are musical in their nature. In order not to risk breaching any copyright I have composed a little tune which I am going to use for my worked example.

I know it is not a masterpiece but it has the dubious merit that it can be used to demonstrate the four basic elements of a musical composition which are: melody, rhythm, harmony and counterpoint—and it is easy to play. I shall use it to compare the file sizes and the data rates (and the quality of the reproduction) associated with a range of file formats including a format which is growing in popularity, MP3.

The MIDI version MyTune/mid is on the Archive monthly disc. It plays for 2min 34sec; as a MIDI file its size is 7.05KB; as a wav file it is 26MB; in MP3 format it is 2.35MB.

The Future

Before I close this month's article I must emphasise my key point.

I am sure that your next computer will not be used only for the applications with which you are currently familiar. You will learn how to do new things and, for many of you, it will be such things as transferring your vinyl recordings to CD or MP3. It might be that you or your progeny will use your next computer to process MIDI files which will be played on a musical keyboard in the school band! These new things (which may be musical things) will require a computer which has a different specification from the one you have now.

Computers make playing music much easier than it was in the days of piano lessons.

In my personal view, anyone can learn to play a musical keyboard!

If you (or your children) do that then I assure you that it is 'good fun'!

Communication

Please contact me by email (preferred) or by letter if you have any questions or comments.

Please email me at <Archive@abacusline.demon.co.uk> and not <gerald@abacusline...>.