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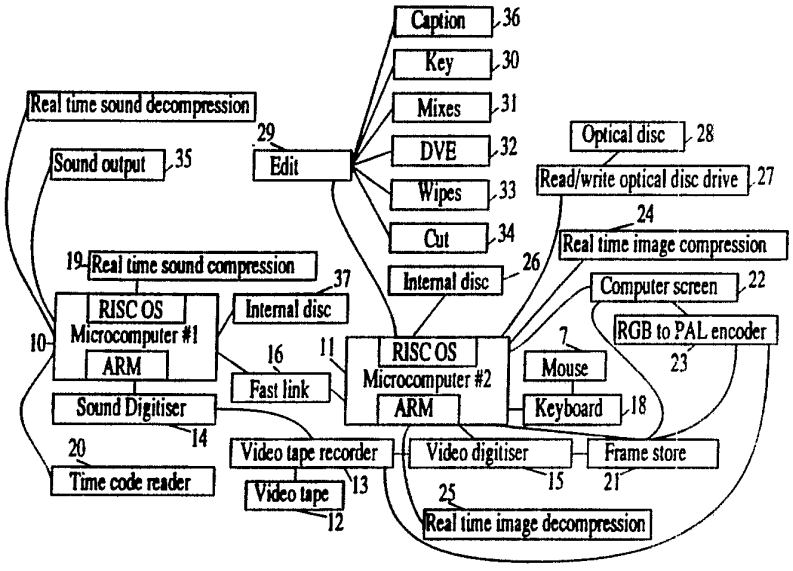

(57) Abstract

A video processing system employs a microcomputer (11) which functions to effecting real-time on-screen functions on original video images for storage on an optical disc (28). The system employs an adaptive program which efficiently extracts visual image data from a digitizer (15) and compresses this data for the real-time processing to create dynamically the best available sub-set of pixels of the original image.

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IMPROVEMENTS IN OR RELATING TO VIDEO PROCESSING SYSTEMS

TECHNICAL FIELD

The present invention relates to a video processing system and a method of processing signals for use, for example, in real time editing of video images and signals.

BACKGROUND TO THE INVENTION

Hitherto the editing of video images has involved the use of expensive and sophisticated studio equipment and it has not been possible to effect off-line editing of video images even with sub-broadcast quality with low cost microcomputers.

A general object of the invention is to provide a video system fulfilling this need and employing one or more such microcomputers as well as methods of controlling and processing digital signals therein.

DISCLOSURE OF THE INVENTION

In one aspect the invention provides a video processing system comprising a video source, such as a video tape reproduction machine, a microcomputer, a large capacity storage medium, such as an optical disc, for storing video digital data representing coloured visual and sound images, at least one conversion means, such as a digitiser, for converting signals from the source into digital signals, and means for extracting selected digital signals derived from the conversion means and for

compressing and converting the selected signals into an adapted format in real time up to and including broadcast tv frame rates for processing within the computer for storage on the storage medium.

In a practical realization of the system two microcomputers are used one serving to process audio signals and one to process video signals as aforesaid.

The means for extracting, compressing and converting the signals can operate on a frame by frame basis with information taken to represent each frame. This means can be embodied as an algorithm represented by software or hardware or a mixture of both. As appears hereinafter the means can be visualized, at least in conceptual terms, as: means for storing data and stored data representing a skeleton screen, an interpolate screen a skeleton list and a detail list. The skeleton screen is initially a low resolution subset of an original image representing one video colour field or frame and is derived by selecting one pixel in a group of say sixteen pixels to represent that entire group. The algorithm includes a function which detects when there is some change in corresponding pixels in successive image frames. Whenever some area of the image is identified in which changes are occurring then additional data is identified using the skeleton list and is then transferred and stored. The skeleton list represents at

least some of the pixels judged to have changed significantly. The detail list represents all the pixels of the original image which have been extracted. The interpolate screen data is created from the original image to simulate the best possible compressed low resolution version of the original image. This data can be modified to create many real time editing effects such as cuts, mixes, DVEs captions and keys when the system is used for editing.

The invention also provides a method of extracting, compressing and converting digital information in an adapted format for processing in real time within a memory of a microcomputer for video editing purposes and for storage on a storage medium which may be removable and rewritable; said method comprising creating information representing a skeleton screen as a subset of digital signals representing an original colour image of pixels present in an analogue to digital conversion means, comparing information representing each pixel with the corresponding pixel in a preceding frame of the original image to detect a significant change, creating information representing a skeleton list of the addresses and description of any pixels which are judged to have changed significantly, creating information representing an interpolate screen from the original image as the best available low resolution version of the original image, transferring additional detail information pertaining to

the pixels judged to have changed significantly and, if possible, neighbouring pixels thereof in one or more subsequent time periods and repeating this sequence to ensure the data for storage is the best available compressed sub-set of the pixels of the original image.

In a practical realization of this technique the interpolate screen is a 40 * 32 or more preferably a 80 * 48 pixel array. Each pixel may have 12 bit colour definition information.

In transferring information from the converter means or digitiser the method further adopts a filtering technique as set out hereinafter.

Preferably the method also involves additionally loading and storing the detail of every nth pixel (e.g. every 111th pixel for a 40 * 32 pixel array) from the subset of each of at least some of the fields or frames regardless of change.

The invention may be understood more readily, and various other aspects and features of the invention may become apparent, from consideration of the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described by way of examples only, with reference to the accompanying drawings wherein:

Figure 1 is a block schematic diagram of a video

processing system constructed in accordance with the invention;

Figure 2 is a further block diagram depicting another system in accordance with the invention; and

Figure 3 is a block schematic diagram depicting a method of extracting data from the digitiser in accordance with the invention and as used in the systems shown in Figures 1 and 2.

BEST MODES OF CARRYING OUT THE INVENTION

In Figure 1, the various blocks represent hardware or software or more usually a mixture of these and the lines connecting the blocks are a simplified representation of the main signal information flow paths. As shown, the video processing system employs two proprietary microcomputers 10, 11 preferably PCs utilizing 'Reduced Instruction Set Computer' (RISC) operating architecture such as 'Archimedes' designed and marketing by Acorn Computers Limited (UK). Video tape 12 to be processed, e.g. edited, by the system is inserted into a video tape recorder 13 in the play back mode and the recorder 13 provides analogue signals to separate audio and visual image analogue to digital converters or digitisers 14, 15. The digitiser 14, feeds the microcomputer 10 and the digitiser 15 feeds the microcomputer 11 via a frame store 21.

There is a fast data transfer link 16 between the microcomputers 10, 11. The microcomputer 11 provides the

main control functions with the aid of a mouse 7 and a keyboard 18 and images from the frame store 21 are displayed on a screen 22. After encoding to the PAL format in an encoder 23 video information can be recorded back onto the video tape 12 via the recorder 13 if desired.

The microcomputer 11 has an internal storage disc 26 and performs real time visual image compression at 24 and conversely real time visual decompression at 25. A read/write optical disc drive 27 is used to transfer data representing edited visual and audio information from the microcomputer 11 to an optical disc 28 e.g. a disc capable of storing 600MB representing about 1 to 2 hours of video playing time. The microcomputer 11 is adapted to perform various editing functions as indicated by the box 29 and the boxes 30-34 and 36. The options as generally described may be part (designated 1) of an overall system depicted in Figure 2 where other functions are designated with boxes 2 to 6 and the overall system utilizes the "Risc operating system".

The system as described in connection with Figure 1 needs to extract data efficiently from the frame store 21 and without special adapted data extraction and compression and conversion techniques of some sort, for example as will now be described it would not be possible with a low cost PC to download and process sufficient

data from every frame of a full video image sequence. A typical frame has a resolution of x (640 pixels) and y (512 pixels) with 16 bits per pixel so a store needs a capacity of 320K for each field of the frame. With the PAL format there are 25 frames per second giving an equivalent total data transfer rate of about 16 Mbytes per second. With a low cost PC there is simply not enough external data bus bandwidth to enable video image sequences to be downloaded and stored let alone processed as well. Normally reading one pixel from the digitiser 15 is very slow-typically 1500n secs as compared with a typical access time to the main memory of 333n secs and to a cache memory of 33n secs.

In accordance with the invention, an algorithm is proposed which may be termed a 'grabbing' algorithm which enables the main computer 11 to choose only the important data in the digitiser 15 for downloading. Typical video images do not undergo much change frame to frame i.e. in 1/25 second and it is quite efficient to compare the current frame with a previous frame and to detect changes. The data transfer must take place in real time and must thereafter involve compression and the algorithm has at the most 1/50 second to extract the key information which is needed. Only a proportion of pixels are actually downloaded from the digitiser 15.

The compressed frame resolution which can be achieved with the invention is 160 by 128 pixels and up

to 12 bits of information per coloured pixel.

Figure 3 is a pictorial representation of the features of the control operation involving the algorithm which can be thought of as means for storing data and stored data representing a skeleton screen, an interpolate screen, a skeleton list and detail list. These 'screens' do not necessarily exist in reality but data or information representing these functions would exist from time to time in workspace arrays of the memory of the computer 11. There is also a notional main screen which represents an image frame with 160 * 128 pixels taken from the digitiser 15 which is the best available approximation to the original image after all the processing. The skeleton screen can be derived by selecting each top left pixel from a group composed of a block of 4 * 4 adjacent pixels from the original image to form a 40 * 32 subset. The skeleton screen at this stage is thus simply a low resolution approximation of the current image frame. However, by comparing each pixel in the skeleton screen with a corresponding pixel in the preceding frame of the original image to detect where significant changes have occurred the system can be controlled to transfer data from areas of the image where more detail is required. In other words the skeleton screen is dynamically assessed in real time to detect areas where changes are occurring and where further data

is judged to be needed. This further data is also downloaded from the store 21 of the digitiser 15 in a subsequent cycle. The additional data transferred in this manner is not yet part of the data representing the skeleton screen; instead a skeleton list is created to represent the pixels judged to have changed significantly and the equivalent data is downloaded if and when time permits. There is also a detail list (not shown) which is a full list of all the pixels loaded from the store 21 of the digitiser 15 in one phase of operation and thus each group of 16 pixels in the detail list has an equivalent of a single pixel in the skeleton screen. The interpolate screen is again a 40 * 32 pixel subset of the 160 * 128 image on the notional main screen but the interpolate screen is derived under the control of the algorithm always to represent the best available 40 * 32 compressed version of the image.

The grabbing algorithm and the equivalent control operations function as follows with reference to Figure 3 where time flows downwards and each row corresponds to a step in the algorithm.

1. Set a spare 2MHZ timer on the IOC support chip in the computer 11 to Hex FFFF and initiate the timer to count down.

2. Load each skeleton pixel from the frame store 21 of the digitiser 15 in turn. Since there is inevitably noise in the signals there is preferably a filtering

technique as follows:

If the new pixel is P_n and the old pixel is P_o then the pixel added to the list is U (P_n, P_o),

where U (x,y) =

x if any RGB component of P_n < the corresponding component of P_o,

or x if any RGB component of P_n > = the corresponding component of P_o + too_bright,

or x if 'intensity' of P_n < 'intensity' of P_o,

or x if 'intensity' of P_n > = 'intensity' of P_o + grey_too_bright,

or y otherwise,

too_bright depends on the noise level, and is currently set to 3.

grey_too_bright is currently 1 1/2.

'intensity' = 1/4 (red value + 2* green value + blue value).

3. Compare each newly constructed filtered skeleton pixel with the preceding skeleton pixel. If these differ then:

i) Set the done flag in the new pixel.

ii) Update the list of skeleton pixels with the new pixel, its address and the detail flag set; and

iii) Update the interpolate skeleton screen with the new pixel, its address and the done flag set.

Repeat this sequence until all the skeleton pixels

which have changed significantly are on the skeleton list and put a terminate symbol at the end of the skeleton list. Download as much of the further data (detail) on the significant pixels as time permits (e.g. timer is bigger than Hex 6400).

4. If there is time available then work through the list of changed pixels until time or the changed pixels run out adding their neighbours to the skeleton list as well and their detail to the detail list. Any edge pixels do not have the neighbouring detail loaded off in view of the likely noise at the edges of the screen.

5. If there is still time available, load off the detail associated with every 111th skeleton pixel. This mopping up operation will eventually tidy up any pixels left out by the earlier phases since 111 is coprime with 40 * 32. A record is kept of the last block of pixels downloaded in this manner and the next time the routine occurs the mopping up operation will start where it left off previously. By choosing the 111th pixel the pixels appear to be loaded randomly rather than with any particular order on the screen thus reducing artifacts.

6. The detail list is terminated once the skeleton pixels have been downloaded in this manner. The end of the detail list pointer and the end of the skeleton list pointer are then stored and any miscellaneous tasks such as recording the elapsed time and counting the skeleton pixels can be performed at this stage.

7. Finally, the skeleton screen is updated from the skeleton list while the next field is being grabbed by the digitiser 15.

The data represented by the pixels of the skeleton list and detail list is compressed with a compression algorithm to provide the main screen which may involve the following steps.

1. Store one pixel of colour information for each pixel of the of the skeleton list while all detail list pixels are represented as intensities only.

2. Compress all the stored grabbed pixel information in a loss free manner by the known Huffman technique (all pixels since there is not sufficient time to compare a current pixel with a previous frame) except that any skeleton which is judged to be worth maintaining by the grabbing algorithm is not compressed. In the implementation of such compression the pixels between the skeleton pixels are estimated by interpolation of the skeleton pixels and the differences between the intensities of these interpolated estimates and the actual details pixels is Huffman compressed.

In an alternative grabbing algorithm a finer resolution of 80 * 48 pixels is achieved and there are six detailed pixels per skeleton pixel instead of 16. In this modified technique:

1) a pixel is added to the skeleton list of Figure 3

if

a) its intensity has varied by >i grey scale compared with the previous frame or

b) its red component has varied by >r compared with the previous frame or

c) if a) or b) is or has been applied to a neighbouring pixel in the previous frame where i and r are integers use to control quality and compression rates and are sufficiently large to preclude random noise effects. In on implementation i and r are 1.

The test b) has been found to provide more accurate red components leading to better quality reproduction of skin and lipsync.

The assessment of what are neighbouring pixels for test c) can be left to the compression phase in order to free more time during the grabbing phase.

2) If the pixels in a skeleton block of 2 * 3 pixels consisting of one skeleton pixel(S) and five detail pixels (D1-D5) have the following relative positions:

D1 D2

S D3

D4 D5

then when the skeleton list is made all the "S" pixels must have been grabbed and the remaining pixels are grabbed in an order to assure information is spread throughout the blocks particularly if time runs out before all the detail pixels have been grabbed. The

following order is one example: D2 D5 D4 D1 D3 (i.e. all the D2's are grabbed first then the D5's etc). This is repeated until all the required detail has been grabbed or time runs out.

To achieve extra speed in decompression there is no interpolation between the blocks.

During the subsequent compression phase the neighbours of the pixels grabbed under step 1) above are calculated and the following steps are carried out:

1) Convert all the new detailed lists after step 2) of the grabbing phase into intensities.

2) Store colour information for each grabbed block representing a skeleton.

3) Store intensity information only for the grabbed pixels D1-D5.

4) Effect Huffmann compression on the difference in intensity of each pixel and the intensity of the skeleton in its block so that 4 bits intensity information is compressed on average to between 2 and 3 bits.

5) Store the number of detail pixels grabbed in each block for each frame.

For every key sparsity, typically 25 frames, the entire current best estimate of the frame is compressed to allow easy access to the video sequence using a similar format except that every skeleton block contains a counter for the number of pixels in the block which have been

grabbed.

CLAIMS

1. A video processing system comprising a video source (12, 13), at least one microcomputer (11), a large capacity storage medium (28) for storing video digital data representing coloured visual and sound images at least one conversion means (15, 21) for converting signals from the source into digital signals and means for extracting selected digital signals derived from the conversion means and for compressing and converting the selected signals in an adapted format in real time up to and including broadcast tv frame rates for processing within the microcomputer for storage on the storage medium.

2. A system according to claim 1, wherein the means for extracting, compressing and converting the selected digital signals comprises means for creating information representing a skeleton screen as a subset of digital signals representing an original colour image of pixels present in the conversion means, means for comparing information representing each pixel with the corresponding pixel in a preceding frame of the original image to detect a significant change, means for creating information representing a skeleton list of the addresses and description of any pixels which are judged to have changed significantly, means for creating information representing an interpolate screen from the original image as the best available low resolution version of the

original image and means for transferring additional detail information pertaining to the pixels judged to have changed significantly and neighbouring pixels thereof in one or more subsequent time periods and means for causing the creation comparing and transferring means to repeat their operation to ensure the data for storage is the best available compressed sub-set of the pixels of the original image.

3. A system according to claims 1, wherein the means for extracting compressing and converting the selected digital signals comprises means for creating stored data representing a skeleton screen as a low resolution subset of an original image representing one video colour field or frame by selecting one pixel in a group to represent the entire group, means for detecting a change in corresponding pixels in successive image fields or frames, means for creating stored data as a skeleton list whenever a significant change has been detected to represent at least some of the pixels which have been changed, means for creating stored data representing a detail list of all the pixels of the original image which have been extracted and means for creating stored data representing an interpolate screen from the other stored data to produce a low resolution compressed version of the original image.

4. A system according to claim 2 or 3, wherein the

interpolate screen data or information represents a 40 * 32 or 80 * 48 pixel array.

5. A system according to claim 2 or 3, wherein the means for extracting compressing and converting the selected digital signals further comprises means for storing one pixel of colour information for each block of the skeleton screen and for storing other pixels in the block as intensities only and means for compressing the stored data representing pixels by the Huffmann technique.

6. A system according to any one of claims 2 to 5, wherein the means for creating the skeleton list information or stored data only adds pixel details if

a) the intensity of the pixel has varied by >i (grey scale) compared with the previous frame or

b) the red component of the pixel has varied by >r compared with the previous frame or

c) if a) or b) has been applied to a neighbouring pixel in the previous frame where i and r are integers used to control quality and compression rates and are sufficiently large to preclude random noise effects.

7. A system according to any one of claims 2 to 6, wherein the means for storing data or creating information pertaining to pixels effects such operation in a skeleton block of 2 * 3 pixels consisting of one skeleton pixel(S) and frame detail pixels (D1-D5) with the following relative positions:

D1 D2

S D3

D4 D5

and serves to ensure that the "S" pixels are all stored or created in the skeleton list and the data or information on the remaining detail pixels are taken in an appropriate order in repetitive cycles to ensure information is spread out between blocks.

8. A system according to claim 6 when appended to claim 5, wherein the compression means calculates the neighbours of the pixels for the assessment c) and converts all detail list information into intensities and the compression means further comprises means for storing colour information for each block of pixels representing a skeleton and intensity information only for the pixels D1-D5 extracted from the conversion means and means for effecting the Huffmann technique on the difference in intensity for each pixel and the skeleton of its block.

9. A system according to any one of claims 1 to 4, wherein there is further provided means for subjecting the digital signals from the conversion means to a filtering technique as follows:

If the new pixel is P_n and the old pixel is P_o then the pixel added to the list is U (P_n, P_o),

where U (x,y) =

x if any RGB component of P_n < the corresponding

component of P_o,

or x if any RGB component of P_n > = the corresponding component of P_o + too_bright,

or x if 'intensity' of P_n < 'intensity ' of P_o,

or x if 'intensity' of P_n > = 'intensity' of P_o + grey_too_bright,

or y otherwise,

too_bright depends on the noise level, and is currently set to 3.

grey_too_bright is currently 1 1/2.

'intensity' = 1/4 (red value + 2*green value + blue value).

10. A method of extracting, compressing and converting digital information in an adapted format for processing in real time within a memory of a microcomputer for video editing purposes and for storage on a storage medium; said method comprising creating information representing a skeleton screen as a subset of digital signals representing an original colour image of pixels present in an analogue to digital conversion means, comparing information representing each pixel with the corresponding pixel in a preceding frame of the original image to detect a significant change, creating information representing a skeleton list of the addresses and description of any pixels which are judged to have changed significantly, creating information representing an interpolate screen from the original image as the best

available low resolution version of the original image, transferring additional detail information pertaining to the pixels judged to have changed significantly and neighbouring pixels thereof in one or more subsequent time periods and repeating this sequence to ensure the data for storage is the best available compressed sub-set of the pixels of the original image.

11. A method according to claim 10, wherein the detail of every nth pixel from the subset of at least some of the fields or frames is stored irrespective of change.

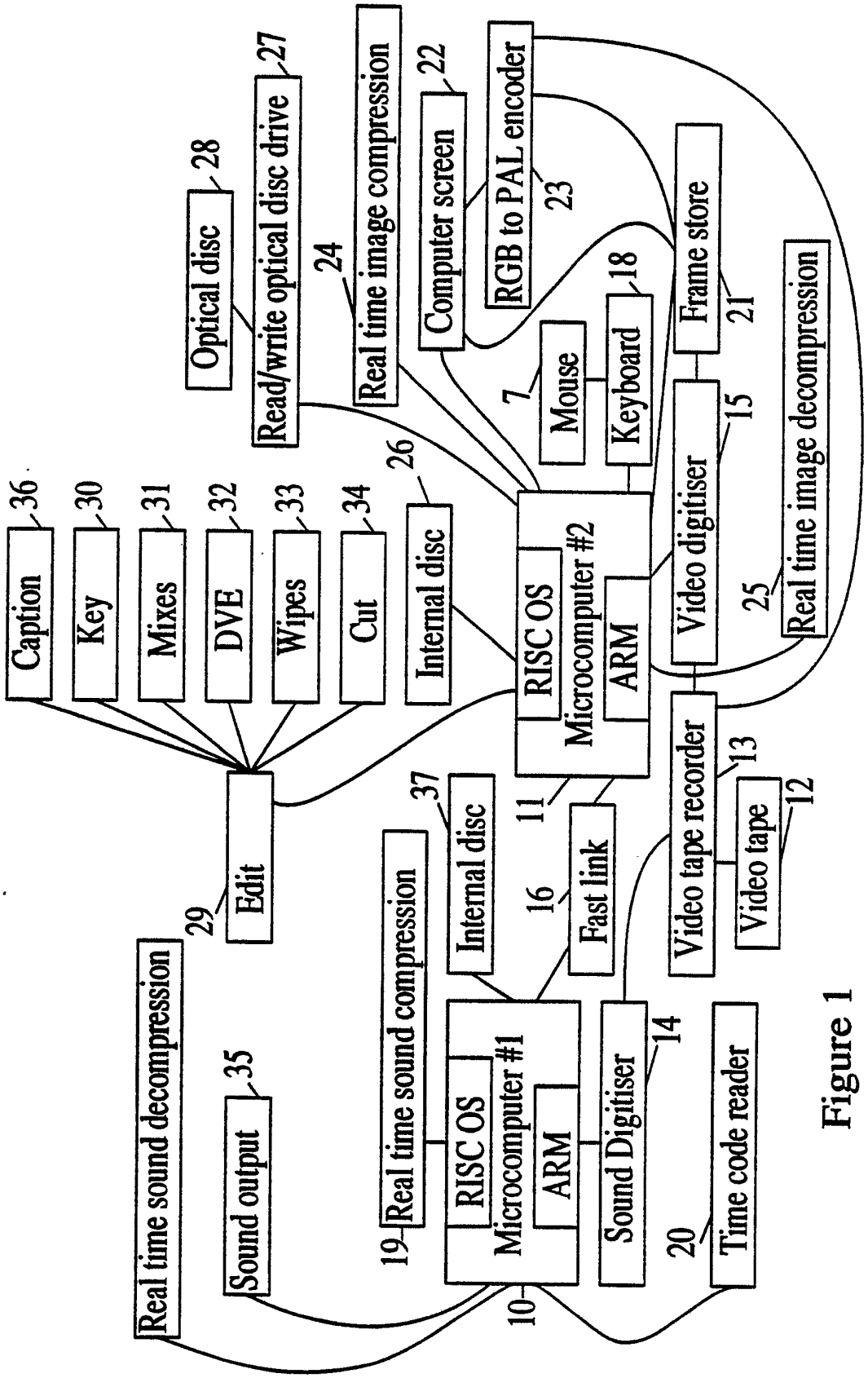
Optical disc
28
Read/write optical disc drive
27
Real time image compression
24
Computer screen
22
RGB to PAL encoder
23
Frame store
21
Mouse
7
Keyboard
18
Video digitiser
15
Real time image decompression
25
Caption
36
Key
30
Mixes
31
DVE
32
Wipes
33
Cut
34
Internal disc
26
RISC OS
Microcomputer #2
ARM
11
Edit
29
Internal disc
37
Real time sound compression
19
Fast link
16
Video tape recorder
13
Video tape
12
Real time sound decompression
Sound output
35
RISC OS
Microcomputer #1
ARM
10
Sound Digitiser
14
Time code reader
20

Figure 1

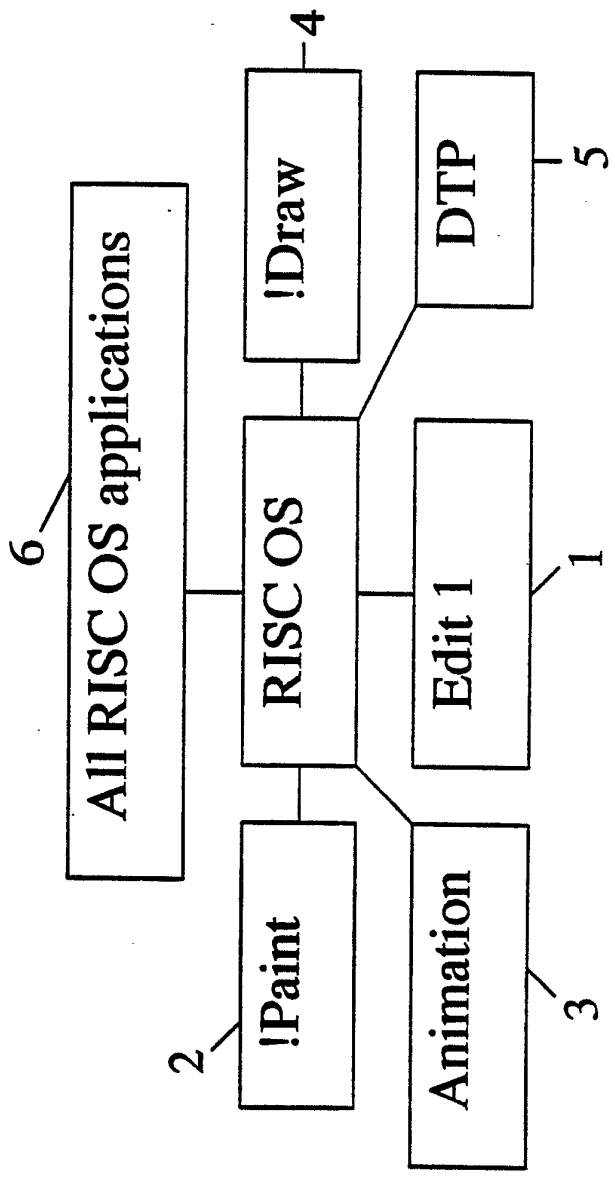
All RISC OS applications
6
RISC OS
!Draw
4
DTP
5
Edit 1
1
!Paint
2
Animation
3

Figure 2

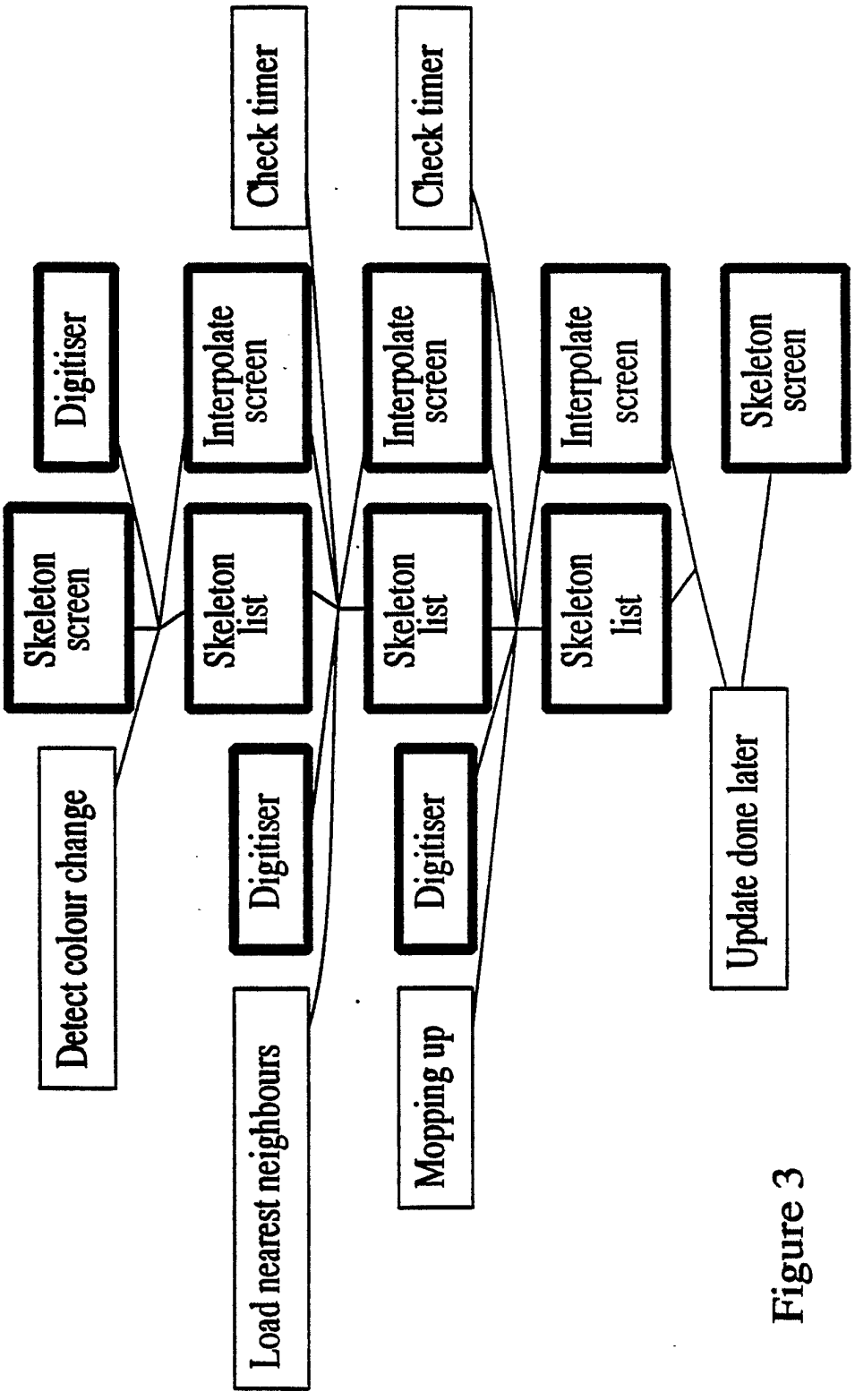
Digitiser
Skeleton screen
Detect colour change
Interpolate screen
Skeleton list
Digitiser
Load nearest neighbours
Check timer
Interpolate screen
Skeleton list
Digitiser
Mopping up
Check timer
Interpolate screen
Skeleton list
Update done later
Skeleton screen

Figure 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/01832

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G11B20/00; H04N9/804

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G11B ; H04N

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	EP,A,0 070 677 (DAI NIPPON PRINTING CO.) 26 January 1983 see page 10, line 24 - page 13, line 17 see page 36, line 23 - page 37, line 17; figures 1,10	1-3, 10-11
Y	US,A,4 785 349 (J.KEITH ET AL) 15 November 1988 see column 4, line 15 - column 13, line 9; figure 1	1-3, 10-11
A	US,A,4 468 708 (C.COLEMAN) 28 August 1984 see the whole document	1-3, 10-11

* Special categories of cited documents :[10]

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
04 FEBRUARY 1992	14 FEB 1992
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	KELPERIS K.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9101832 SA 52311

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 04/02/92
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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		JP-A- 58010741	21-01-83
		JP-B- 63022674	12-05-88
		JP-C- 1600256	31-01-91
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