TELEVISION SYSTEM

The present invention generally concerns the field of television systems.

A number of commercially available television sets and video cassette recorders have picture-in-picture (also called "pix-in-pix" or simply P-I-P) and multi-picture (also called "multi-pix") provisions.

In one form of the multiple-picture feature, essentially multiple "still" pictures derived from the same video source (e.g. channel) "taken" at successively different times are simultaneously displayed in a rectangular array and thereafter periodically and sequentially up-dated. This provides a type of static stroboscopic display which, may be used to study the progression of an action such as swinging a golf swing.

In one aspect the invention provides, a television system with an "instant-replay" feature, comprising means for compressing successive input fields of a television signal to produce successive compressed fields having fewer lines and pixels than respective ones of said input fields; means for storing successive ones of said compressed fields in a predetermined number of respective memory sectors; and means for retrieving and expanding said compressed fields stored in said respective memory sectors in a repetitive sequence to produce a sequence of television fields.

In another aspect the invention provides in a picture-in-picture television system including a memory for storing compressed versions of respective input fields of a television signal in respective memory sectors, the compressed fields stored in said respective memory sectors corresponding to respective picture sectors of a multiple picture display produced during a

"multiple-picture" mode of operation, apparatus comprising: means for reading and expanding the contents of said respective memory sectors in a repetitive sequence during an "instant replay" mode of operation to produce a sequence of expanded television fields corresponding to respective pictures larger in size than said respective picture sectors.

With regard to the present invention, it has been recognized by the present inventors that is it desirable to sequentially magnify (or "zoom") individual ones of the plurality of the small inset pictures of a multi-picture array to a larger, e.g. full screen, size in order to "re-animate" the action in which may be termed an "instant replay" mode.

Specifically, the disclosed embodiment concerns the structure for magnifying at least one picture insert, particularly the context of a multi-picture memory arrangement. More specifically, this structure comprises, in cascade, subsampling unit which produces one sample for a given number, N, of input video samples, a memory for storing the subsamples, and an interpolator for producing interpolated samples from the stored subsamples. The memory is operated so that the subsamples are written-in a

one rate and read-out at a different rate to affect a picture size change.

To produce the "instant replay" operation referred to above, the memory is loaded in a plurality of memory sectors with respective subsampled fields of a video signal. In sequence, each sector of the memory is read out at a rate slower than the write-in rate and the stored subsamples are interpolated to produce interpolated samples. The read-out subsamples and the interpolated subsamples are combined to produce resultant output video samples which are coupled to a display device. The displayed picture comprises a sequence of enlarged images, each image corresponding to a smaller image associated with a respective section of the memory.

The invention will be described with reference to the accompanying drawing in which:

FIGURE 1 is a block diagram of a picture-in-picture processor including a preferred embodiment of the present invention;

FIGURES 2a and 2b represent displayed images useful in understanding various operating modes of the processor shown in FIGURE 1; and

FIGURES 3a and 3b represent memory arrangements useful in understanding various operating modes of the processor shown in FIGURE 1.

The picture-in-picture processor shown in FIGURE 1 may be incorporated, e.g., in a television system which includes a display device such as a television set or monitor or in a television system which does not include a display device such as a video cassette recorder/player (VCR). In the former case, the output signal of the picture-in-picture system is coupled to the driver for display unit, e.g., a kinescope. In the latter case, the output signal of the system is intended to be coupled to a television system which includes a display device such as a television set, either as a baseband

video signal or as a modulated RF carrier, through an output signal connector.

The various operations are performed in component form and one processor like the one shown in FIGURE 1 is utilized for each component. The components may be luminance (Y) and two color difference signals (e.g., R-Y and B-Y or I and Q) or three color difference signals. The following description is made with respect to the luminance (Y) component, but applies similarly to the color difference signals; noting however, that lower sampling and clock frequencies are utilized and that less memory capability is required.

The picture-in-picture processor shown in FIGURE 1 includes a first video signal source 10, e.g., comprising the tuner/demodulator section of television system in which it is incorporated, and a second video signal source 12, e.g., comprising a baseband video input signal connector.

The baseband video signals produced by sources 10 and 12 are coupled to a first switching unit 14. First switching unit 14 as well as other portions of the picture-in-picture processor are controlled by a microprocessor (μP) control unit 16. Microprocessor control circuit 16 generates control signals for the picture-in-picture processor in accordance with a stored set of instructions, i.e., a computer program and in response to commands received from a user command entry unit 18, typically including a keyboard (not shown).

The picture-in-picture processor has several operating modes selectable in response to user entered commands. In part, these operating modes are established by the switching states of first switching unit 14, a second switching unit 20, a third switching unit 22, and a fourth switching unit 24.

First switching unit 14 has a first input IN1 and a second input IN2, to which the first and second video input signals are respectively coupled, two outputs OUT1 and OUT2, and, under the control of microprocessor

control circuit 16, is capable of providing the following connection configurations.

OUT 1	OUT 2
IN1	IN1
IN2	IN1
IN1	IN2
IN2	IN2

Output OUT2 of first switching unit 14 is coupled to the cascade arrangement of an analog-to-digital converter (ADC) 26, a subsampling unit 28 and a first input IN1 of second switching unit 20. Second switching unit 20, has a second input IN2, to which the output of ADC 26 is coupled, and an output OUT. Second switching unit 20 has a single pole, double throw operation and accordingly connects either of inputs IN1 and IN2 to output OUT as is indicated by the switching symbol within the block.

Output OUT of second switching unit 20 is coupled to the cascade arrangement of a memory 30, an interpolator unit 32 and a first input IN1 of third switching unit 22. Third switching unit 24 has a second input IN2, to which the output memory 30 is coupled, and, like second switching unit 20, has a single pole, double throw operation.

Output OUT of third switching unit 22 is coupled to the cascade arrangement of a digital to analog converter (DAC) 34 and a first input IN1 of fourth switching unit 24. Fourth switching unit 24 has a second input IN2, to which first output OUT1 of first switching unit 14 is coupled, and also has a single pole, double throw operation. The output signal of the picture-in-picture processor is developed at output OUT of fourth switching unit 24.

A clock generator 36 generates clocking and timing signals for various portions of the picture-in-picture processor.

A write/read control unit 38, under the control of microprocessor control unit 16, generates address signals and write and read clocking signals for memory 30. Write/read control unit 16 receives pairs of horizontal (H) and vertical (V) synchronization signals from both video sources for synchronizing the write and read operations of memory 30 in the various operating modes.

With the arrangement shown in FIGURE 1, several primary modes of operation are possible. These are:

1. normal = full screen display from either video source;
2. zoom = magnified display from either video source;
3. picture-in-picture = small picture from either video source inset within full-screen display from other video source;
4. multi-picture = display of plurality of small "still" images in rectangular array (the "still" images are periodically and sequentially updated); and
5. "instant replay" - sequential and repetitive enlargement (e.g., full screen) of small "still" images to form a re-animated form of a corresponding multi-picture array.

These modes of operation correspond to different configurations produced by controlling the various switching units and other components and will be explained in detail below. The following table briefly relates the operating modes with the configurations.

MODE	ACTIVE UNITS	SWITCH STATUS
1. NORMAL	selected video source directly connected to output	SW1 selects source (IN2 or IN2); SW4 selects IN2
2. ZOOM	ADC26; memory 30; interpolator 32; DAC34	SW1 selects source; SW2 selects IN2 to by-pass subsampler 28; SW3 selects IN1; SW4 selects IN1
3. PICTURE-IN-PICTURE	ADC26; subsampler 28; memory 30 (stores every subsampled field in one sector), DAC34	SW1 selects main and inset (IN1 or IN2); SW2 selects IN1; SW3 selects IN2 to by-pass interpolator 32; SW4 switches between IN1 and IN2
4. MULTI-PICTURE	ADC26; subsampler 28; memory 30 stores successive subsampled fields in respective sectors; DAC34	SW1 selects source; SW2 selects IN1; SW3 selects IN2 to by-pass interpolator 32; SW4 selects IN1
5. INSTANT REPLAY	ADC26; subsampler 28; memory 30 stores successive subsampled fields in successive sectors as in pix-in-pix; interpolator 32; DAC34	SW1 selects source; SW2 selects IN1 (subsampler 28 not by-passed) SW3 selects IN1 (interpolator 32 not by-passed); SW4 selects IN1

Now modes 2, 3, 4 and 5 will be described in detail. The mode 1 (normal) is believed to be sufficiently clear from the above table. It is only noted

that since the normal mode only involves the selection of a video source and does not involve any digital operations, the conversions to and from digital form are not necessary.

Zoom Mode

The purpose of the zoom mode of operation is to magnify or "blow up" the entire image produced from the selected video signal. Of course, because the display device has a fixed display area (i.e., scanning area), those portions of the magnified image falling outside the display area (due to the magnification) will not be visible. Thus, only a portion of the image is effectively magnified. In other words, the viewer perceives a "zooming-in" on a portion of the original image.

ADC 25 is used in all the modes except the normal mode.

ADC 26 converts the selected analog video signal coupled to it by first switching unit 14 to digital video samples occurring at the sampling rate determined by clock generator 36. E.g, the sampling frequency or rate for the luminance component can be a multiple of the color subcarrier, such as $3f_{sc}$, or a multiple of the horizontal scanning frequency. The digital video samples produced by ADC 26 are coupled to subsampler unit 28 and to second input IN2 of second switching unit 20.

Subsampler unit 28 is utilized in the picture-in-picture, multi-picture and instant replay modes of operation. However in the zoom mode of operation, second switching unit 20 is caused to connect second input IN2 to output OUT, thereby by-passing subsampler unit 28 and directly coupling the output of ADC 26 to the input of memory 30.

Memory 30 is utilized in all but the normal mode of operation. Memory 30 is capable of storing samples for an entire field of complete (not subsampled) video information, e.g., for luminance, 512 samples (or pixels) per line and 256 lines.

In the zoom mode of operation, as noted above, subsampler unit 28 is by-passed by second switching unit 20, and therefore memory 30 stores an entire field of complete (not subsampled) video information. The 512 samples of each line and 256 lines of each field are sequential written into memory 30 sample-by-sample, e.g., left to right, and line-by-line, e.g., top to bottom, at the sampling rate ($3f_{sc}$) of ADC 26 and sequentially read out in the same order, but at a slower rate under the relative slower reading rate causes the samples and lines to be separated further apart in time and therefore to appear correspondingly separated further apart in space in a displayed image. The reading rate is controllable by microprocessor control unit 16 to control the amount of magnification.

In the zoom mode, output of memory 30 is coupled to interpolator unit 22. Interpolator unit 32 is not used in the picture-in-picture and multi-picture modes, it being by-passed by third switching unit 22 in those modes.

Interpolator unit 32 in concert with WRITE/READ memory control unit 38 provides missing interstitial samples and lines.

Interpolator unit 32 sequentially provides the "real" and "interpolated" samples in interleaved form to third switching unity 22 and thereby to DAC 34. The analog signal produced by DAC 34 is coupled through fourth switch 24 to the output of the picture-in-picture processor. DAC 34, like ADC 26 (and memory 30), is used in all but the normal mode, since the picture-in-picture processor operates in digital form in all but the normal mode.

Other possible zoom features are discussed in a copending European application based on US application No. 340,931 entitled "APPARATUS AND A METHOD FOR AUTOMATICALLY CENTERING A VIDEO ZOOM AND PAN DISPLAY", filed on April 20, 1989 in the names of B.A. Canfield, D.J. Duffield and D.L. McNeely.

Picture-in-Picture Mode

The purpose of the picture-in-picture mode is to insert a small or inset picture corresponding to one of the two input video signals within the full screen picture corresponding to other input video signal (see FIGURE 2a). Either video signal can be chosen to produce the inset picture and the two can be "swapped" under user control.

In the picture-in-picture mode of operation, subsampler unit 28 is not by-passed by second switching unit 20.

Subsampler unit 28 reduces the number of video samples received by it during each horizontal scan line by a factor N and also reduces the number of scan lines per field by a factor N. Thus, one output sample is produced for every N input samples and one scan line is produced for every N scan lines. The factor N is controlled by microprocessor control unit 16 to determine the size (length and height) of the small picture inset in the picture-in-picture mode (and also determines the size and therefore number of picture insets in the multi-picture mode.)

Subsampler unit 28 may, e.g., comprise a sample averaging arrangement for averaging N samples followed by a line averaging arrangement for averaging N lines.

The subsampled fields of video information corresponding to the small or inset picture are written into a predetermined area of memory 30 controlled by microprocessor control unit 16. Since a subsampled field contains fewer samples and lines (determined by N) than a complete field, only a portion of memory 30 is occupied by the samples of the subsampled field and the rest of memory 30 may be considered as being empty.

E.G., with reference to FIGURE 3a, in the present embodiment, writing of the subsampled field begins at the "top-left" memory location (indicated by the dot), corresponding to line 1, sample 1 of the complete field and ends at some memory location (indicated by the X) dependent on N, thus "filling-in" only the top-left

sector. The circle represents the memory location at which reading begins. By changing the address of the memory location at which reading begins horizontal and vertical time delays are introduced before the inset field information is read out. These delays corresponds to horizontal and vertical spatial shifts of the inset picture in the displayed image.

In the picture-in-picture mode, the write-in rate is slower than the read-out rate (related to the subsampling factor N), the size reduction for the inset picture being produced as a result of subsampling.

As earlier noted, in the picture-in-picture mode, third switching unit 22 is controlled by microprocessor control unit 16 to connect second input IN2 to output OUT, thereby by-passing interpolator unit 32 and directly coupling the output of memory 30 to DAC 34. Thus, interpolator unit 32 is not available for controlling the size of the inset picture in the present embodiment, that function being accomplished by controlling the sub-sampling factor N of subsampler 28.

The analog output signal of DAC 34 and the unconverted analog signal produced at first output OUT1 of first switching unit 14 are coupled to first input IN1 and second input IN2, respectively, of fourth switching unit 24. Fourth switching unit 24, under the control of microprocessor control unit 16, replaces the main video signal with the inset video signal (produced at the output of DAC 34) in the appropriate time interval corresponding to the desired location of the inset picture within the main picture. In this regard, the operation of fourth switching unit 24 is synchronized with the read operation of memory 30.

Other features concerning the positioning and sizing of the inset picture are described in a copending PCT application based on US application No. 341,123 entitled "INSET PICTURE CENTERING IN A PIX-IN-PIX SYSTEM", filed on April 20, 1989 in the names of B.A. Canfield and D.J. Duffield.

Multi-picture Mode

The purpose of the multi-picture mode is to display a rectangular array of small pictures insets. The small pictures may correspond to different fields of the same video signal or different fields of different video signals, such as may be provided at different channels.

As in the picture-in-picture mode of operation, the subsamples provided by subsampler 28 are written-into and read-out of memory 30 at different rates, the write-in rate being slower than the read-out rate. However, unlike in the picture-in-picture mode of operation, the subsamples from successive fields are not written into the same area of memory, but rather, into different respective areas or sectors, such as shown in FIGURE 3b, under the control of microprocessor control unit 16. In addition to controlling the storage location of the different fields within memory 30, microprocessor control unit 16 also determines the rate at which subsampled fields are written into respective memory sectors. The number of small pictures in the rectangular array is related to the size of the pictures and therefore subsampling factor N.

If the field sampling rate is relatively slow, the small pictures will appear as still images. In the case different fields of the same video signal are sampled at a slow rate, the small pictures will appear as stroboscopic "snap-shots" of an event taken at different times (see FIGURE 2a) and as such, may be useful to study the various states of the event in detail.

When the fields are to be derived from different video sources such as different television channels, microprocessor control unit 16 has the additional function of coordinating the channel changes and is therefore coupled to the channel selection control input of the tuner of the appropriate video source, as is shown in FIGURE 1.

The stored subsampled fields are repetitively read-out of the respective sectors of memory 30 between

the respective field sampling intervals and coupled to DAC 34 through third switching unit22. As in the case of the picture-in-picture mode, interpolator unit 32 is by-passed. In the multi-picture mode, unlike in the picture-in-picture mode, fourth switching unit 24 continuously couples the output of the DAC 34 to the output of the picture-in-picture processor.

Instant Replay Mode

The capability of the picture-in-picture processor to couple subsampler unit 28, memory 30 and interpolator unit 32 in cascade allows for a so-called "instant replay" mode of operation previously referred to as well as an artistic "mosaic" mode of operation not previously referred to.

The "instant replay" mode of operation has in common with the multi-picture operation the manner in which different fields are stored in respective sectors of memory 30 (see FIGURE 3b). However, unlike in the multi-picture mode: (1) the read-out rate is the same as the write-in rate; and (2) interpolator unit 32 is not by-passed but is instead coupled between the output of memory 30 and the input of DAC 34 by means of third switching unit 22.

In addition, in the "instant reply" mode, the write operation is stopped after each sector has been loaded, and thereafter the sectors are sequentially and repetitively read out. The rate at which the sectors are addressed to be read out is user controllable to provide a range between slow motion reproduction and rapid motion reproduction. Further, the sequence can be changed, e.g., reversed under user control. The rate at which the sample and lines are read out of an addressed sector determines the expansion.

The result of this is that, as the subsampled fields are sequentially read out the respective sectors of memory 30 they are enlarged so that a sequence of enlarged, preferably near full screen size, "snap-shots" is repetitively displayed. This changes the previously

essentially still multi-picture display and provides an animated, continuous loop stroboscopic study vehicle of the event previously stored.

The same type of operation can be provided when the fields stored in the sectors of memory 30 correspond to different channels.

Mosaic Mode

The selectable configuration of subsampler unit 28, memory 30 and interpolator unit 32 also provides for a mosaic mode of operation whereby a full screen picture is produced in which image areas severals pixels high and long have the one color. In this mode, the configuration is the same as in the zoom mode except that subsampler unit 28 is not by-passed but instead, coupled between the output of ADC 26 and input of memory 30. As a result, subsampled fields of the input video signal will be expanded, with each sample and line of the subsampled field repeated (by interpolator unit 32).

CLAIMS:

1. A television system with an "instant-replay" feature, comprising:

means for compressing successive input fields of a television signal to produce successive compressed fields having fewer lines and pixels than respective ones of said input fields;

means for storing successive ones of said compressed fields in a predetermined number of respective memory sectors; and

means for retrieving and expanding said compressed fields stored in said respective memory sectors in a repetitive sequence to produce a sequence of television fields.

2. The system recited in claim 1 wherein:

said means for storing maintains the contents of all of said predetermined number of said respective memory sectors unchanged after all of said predetermined number of said respective memory sectors contain said successive ones of said compressed fields.

3. The system recited in claim 1, wherein:

said means for compressing includes means for deleting lines and pixels of said input fields; and

said means for expanding includes means for interpolating lines and pixels of said compressed fields.

4. The system recited in claim 1 wherein:

said means for storing has a capacity corresponding to one of said input fields.

5. In a picture-in-picture television system including a memory for storing compressed versions of respective input fields of a television signal in respective memory sectors, the compressed fields stored in said respective memory sectors corresponding to respective picture sectors of a multiple picture display

produced during a "multiple-picture" mode of operation, apparatus comprising:

means for reading and expanding the contents of said respective memory sectors in a repetitive sequence during an "instant replay" mode of operation to produce a sequence of expanded television fields corresponding to respective pictures larger in size than said respective picture sectors.

6. A television system substantially as hereinbefore described with reference to the accompanying drawings.

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