

The invention relates to a method and/or a device for freeze frame improvement according to the preamble of patent claim 1.

Television devices cause a disturbing flicker on playback because of the intermediate line method. It is known to prevent this disturbing effect by switching off the line jump.

From H Schönfelder, Bildkommunikation (Picture Communication), which appeared in 1983 published by Springer-Verlag, Berlin Heidelberg New York, television receivers are depicted on page 154 which have digital stores for storing pictures. These stores are slowly filled up via a channel of limited band width, a telephone channel, and serve to compile the slowly incoming signals into a complete picture.

Improving the freeze frame is neither indicated nor achieved. The invention consists in principle of digitalising extraneous signals and storing them intermediately in an electronic store. In this electronic store the field flicker or vertical and/or horizontal brightness and/or colour shifts between two fields, which are caused by movement, are eliminated by correction.

It is the object of the invention to provide a method which eliminates the field flicker and/or vertical and/or horizontal brightness and/or colour shifts between two fields, which are caused in the picture by movement, in a freeze frame representation, without the line jump being switched off.

This object is achieved by the measure provided in claim 1. Advantageous modifications of the invention are mentioned in dependent claims.

For better understanding of the invention some embodiments are described below in greater detail together with drawings.

- Fig. 1 shows a greatly simplified block circuit diagram of a video recorder during playback,
- Fig. 2 shows a greatly simplified block circuit diagram of a video recorder during recording,
- Fig. 3 shows a visual screen with a moved object,
- Fig. 4 shows a visual screen with diagonal edges,
- Fig. 5 shows a store with elements for horizontal correction
- Fig. 6 shows a store with elements for an improved horizontal correction
- Fig. 7 shows a store with elements for a vertical correction and
- Fig. 8 shows a greatly simplified block circuit diagram of a digital video recorder during playback.

Fig. 1 shows a magnetic head 1 which scans a magnetic tape not shown, on which video signals are recorded. The scanned video signals reach from the magnetic head 1 via an amplifier 2 to a high pass filter 3 and to a low pass filter 4. The luminance signal of the video signal is filtered out at the high pass

filter 3 and supplied to the demodulator 5. The luminance signal is demodulated by the demodulator 5 and from there reaches an ADU 7 (ADU = Analogue/Digital converter). The digitalised luminance signal is stored intermediately in an electronic store 8, called picture memory in the following. From the picture memory 8 the digitalised luminance signal reaches the DAU 9 (DAU = Digital/Analogue converter). The chrominance signal of the video signal is filtered out in the low pass filter 4 and supplied to the colour electronics 6. The chrominance signal reaches from the colour electronics 6 via an ADU 7 to the picture memory 8. The chrominance signal is converted back into an analogue signal in the DAU 9 and supplied to the mixer 10, in which the chrominance signal and the luminance signal are mixed. The FBAS signal is present at the output 11 of the mixer 10 (FBAS = colour picture synchronous scanning signal). The FBAS signal may be made visible on a viewing screen 12 as a television picture.

Fig. 2 shows an antenna 13 which receives the television signals. The television signals are supplied to a demodulator 14. The FBAS signal emanating from the demodulator 14 is broken down into its luminance and/or chrominance elements in a 4.43 MHz wave trap 15 and a 4.43 MHz band pass filter 16. From the wave trap 15 the luminance signal reaches an ADU 7 and from there a picture memory 8 where the signal is stored intermediately. From the picture memory 8 the digitalised luminance signal is converted back in the DAU 9 into an analogue signal and modulated in the modulator 17. The chrominance signal is digitalised in the ADU 7 and is

supplied to a picture memory 8. From the picture memory 8 the digitalised chrominance signal reaches a DAU 9 and is converted back into an analogue signal there. The chrominance signal is modulated in a converter 18 with a carrier placed therebeneath and is supplied from there to a mixer 19.

The modulated chrominance and the modulated luminance signal are mixed in the mixer 19 and fed to a video head 1. The branch with the blocks 7,8,9,15 and 17 forms the luminance branch, the branch with the blocks 7,8,9,16,18 forms the chrominance branch.

Parallel processing of the chrominance and luminance signals is shown here, but multiplex processing would also be conceivable. The storage spaces for the parallel picture memory 8 for the chrominance and/or for the luminance signal may be of equal size, but it is also conceivable (to have) a size ratio of 2:3 (two parts of chroma and three parts of luminance). A picture has about 720 columns and 576 lines, which gives a number of 414 720 picture dots. In practice each scanning dot is coded with 8 bits. Thus for a complete picture there are 3.4 Mbits of storage space. For problem-free running a picture storage space for two complete pictures, i.e. 68 Mbits, is made available.

If a complete picture contains objects moved in a horizontal direction, corresponding line portions of the second field are displaced as compared to those of the first field. With moving television pictures, which show a coherent action, irregularities, which arise due to the field method, are

integrated by the eye. With freeze frame representation however there is an unpleasant flickering of the picture.

Fig. 3 shows a viewing screen 12 with an object 20 which is moved in a horizontal direction 21. The object 20 is shown across eight lines 22 - 29. The lines 22, 24, 26 and 28 belong to a first field, lines 23, 25, 27 and 29 belong to a second field. Across regions 30 - 33 the object 20 is shown distorted. The picture flicker, which arises due to the movement in the regions 30 - 33, is perceived as disturbing by an observer. If line portions of the second field in the regions 30 - 33 of the brightness and/or colour are matched to the lines of the first field, then the picture flicker or movement flicker is eliminated.

Fig. 4 shows a viewing screen 12 with two diagonal dark stripes 34 and 36 and a light stripe 35. With a comparison between two lines it cannot be decided whether a diagonal edge or whether a moved object is present. Therefore three lines 37 lying one above the other are compared with picture dots 38 and/or correlated (therewith) in order to recognise diagonal edges and not to evaluate them as movement.

Fig. 5 shows a digital picture memory 8 which is used to improve the freeze frame. Digitalised signals of a complete picture and/or two fields are stored in the picture memory 8. An intermediate memory 42 stores digitalised colour and brightness signals of three line portions which lie one above the other. The

number of picture dots which are contained in a line portion corresponds roughly to the maximum possible distortion correction in moving objects, i.e. in practice about 15 scanning dots. The mean value of the digitalised colour an/or brightness signals of adjacent picture dots is formed in the mean value forming device 43. By forming a mean value noise may be recognised and suppressed. Noise means small differences in the brightness and/or colour; in contrast to this distortion or displacement mean the number of picture dots, at which there are large differences in the brightness and/or colour, as occur for example with a movement of a dark object in front of a light background. The mean value is formed according to the following equation:

$$M = \text{Suml} (Z_o(i) + Z_m(i) + Z_u(i)) / 3L.$$

Thus Suml represents the Greek S (summation symbol) and the addition of the summands in brackets to the running index i of 1 to L (L is in the order of magnitude of 15). $Z_o(i)$, $Z_m(i)$ and $Z_u(i)$ represent the brightness and/or colour at the picture dots i, also called pixels (picture elements), in an upper (o), in a medium (m) and in a lower (u) line, in which m identifies a first and/or second field and o and u a second and/or a first field. In the subtracter 44 the absolute values and the respective mean values are compared with each other and subtracted. The subtracter 44 operates according to the following equations:

$$D_o(i) = Z_o(i) - M, i=1, \dots, L$$

$$Dm(i) = Zm(i) - M, i=1, \dots, L$$

$$Du(i) = Zu(i) - M, i=1, \dots, L$$

Values of picture dots are correlated with each other in the correlator 45, a value is the difference between the mean value and the absolute value of a scanning dot. This may take place with the aid of a product or difference formation. The correlator 45 operates with a product formation according to:

$$Ko(j) = \text{Sum2 Pro1} (Do(i) * Dm(i+k))$$

with 1 less than or equal to $(i+k)$ and $(i+k)$ smaller than or equal to L , otherwise $Do(i) * Dm(i+k) = 0$. Thus j runs from $(-L+1)$ to $(+L-1)$. Pro1 represents the Greek P (P_i , product symbol) and the multiplication of the factors with the running index i from 1 to L . Sum2 represents the Greek S (summation symbol) and the addition of the products with the running index k from $(L-1)$ to $(1-L)$. The location j of the maximum correlation value gives the necessary displacement vo at the scanning dot P . The correlation is carried out in lines, beginning with the first scanning dot of a line, then follows the second, the third, etc., The threshold circuit 46 decides whether digital signals are changed for matching. It evaluates small correlation values which are smaller than the threshold $S1$ as noise. Between the blocks 44 - 47 in each case are arranged two transmission paths, since one correlation of a current line is carried out both with a line lying thereunder and thereabove. If only the values $Zo(i)$ and $Zm(i)$ from the intermediate memory 42 are regarded as

matching criteria and/or displacement criteria then in a picture an apparent movement would be detected without moving objects at inclined edges (Fig. 4). This is avoided by correlating $Z_u(i)$ with $Z_m(i)$ too:

$$K_u(j) = \text{Sum3 Pro2 } (D_u(i) * (D_m(i+k))$$

with i less than or equal to $(i+k)$ and $(i+k)$ less than or equal to L , otherwise $D_u(i) * D_m(i+k) = 0$. j runs from $(-L+1)$ to $(+L-1)$. Pro2 represents the Greek P (Π , product symbol) and the multiplication of the factors with the running index i from 1 to L . Sum3 represents the Greek S (summation symbol) and the addition of the products with the running index k from $(L-1)$ to $(1-L)$. From this, corresponding to v_o , comes also v_u . At an inclined edge $v_o = -v_u$. Signals which are a measure of the operations carried out in each case, are transmitted on the transmission paths between the individual blocks 8, 42 - 48. The brightness, colour values and/or the number of the picture dots which are matched depends on the mean value forming device 47 which takes into account both the distortion v_u of a line lying thereunder and the distortion v_o from a line lying thereabove to a current line. It is advantageous to proceed according to the following equation: $V(\text{total}) = (v_o + v_u) / 2$. $V(\text{total})$ is zero at the inclined edge. The correlator 45 and the threshold circuit 46 have the same function for calculating v_u and v_o and are only present once. The brightness and/or colour value of the scanning dot displaced by $-V(\text{total})$ is stored from the same line

into the line store 48 instead of the scanning dot P. If the brightness and/or colour values of a complete line is (are) contained in the linestore 48, these values are loaded at the appropriate place in the picture memory. If all lines of the second field have been treated in the manner described, the picture contained in the picture memory 8 is largely free of horizontal movement flicker. The current line is corrected in the line memory 48 and rewritten into the digital picture memory 8.

Fig. 6 shows a preferred embodiment of a freeze frame improvement. In addition to the function described in the preceding figure a filter 50 is added which takes more account of the picture dots from the centre of the line portion than picture dots which lie at the edge of the line (portion) section. The filter 50 operates advantageously according to the equation : $f(j) = (1 + \cos \pi j / (L+1)) / 2$ with the running index j from $(-L+1)$ to $(+L-1)$ and L as the number of scanning dots. In practice it has proved that after correlation adjacent, approximately equally large correlation values may occur. This occurrence arises if with an analogue/digital conversion peaks of an amplitude curve, which lie between two adjacent picture dots and/or scanning dots (scanning dots and picture dots are identical in this case), are not detected (scanning theorem: $T = 1/2 f_g$). An interpolation circuit 51 remedies this, which calculates the intermediate values between scanning dots and thus interpolates these peaks and recognises (them). This corresponds to over scanning. A maximum of four extreme values and their

locations are stored away in the location circuit 52. Two extreme values arise from the comparison of a line lying thereabove to a current line and two extreme values arise from a line lying thereunder to a current line. The location corresponds to the distortion or the displacement, and the location is marked by a displacement vector. All four extreme values are supplied to the threshold circuit 46, the extreme values below a threshold S_1 are not taken into account, extreme values between two thresholds S_1 and S_2 are evaluated and/or multiplied by a factor between 0 and 1 and extreme values above the threshold S_2 are multiplied by the factor 1. The factor between 0 and 1 is calculate from a linear function between S_1 and S_2 . S_1 is of the order of magnitude of 250 to 500, $S_2 = 2 * S_1$. The noise in the signals, which is a measure of the composition of picture dots of the pictures, may be provided in a mean correlation value. S_1 lies slightly below, S_2 slightly above the mean correlation value.

In the plausibility circuit 53, if two extreme values are present, a new location and/or a displacement vector is calculated which provides a location between the two extreme values. The position of the location between two extreme values corresponds to the difference in the extreme values. The smaller the difference, the less the signals are matched. In addition in the plausibility circuit 53, if correlation values of two adjacent picture dots are approximately the same size (two extreme values lie adjacent each other) and a peak from the

interpolation circuit 51 in the centre of the two picture dots is recognised, one or more signals are associated with the two picture dots which are marked by the location vector, these signals expressing an equal brightness and/or colour. This circumstance is shown by the signal path between the interpolation circuit 52 and the plausibility circuit 53. The displacement of the vectors between the line lying above to the current line and the line lying below to the current line is determined. If a mean value lies between two natural numbers, this corresponds to a scanning dot between two adjacent picture dots, then in each case one or more signals is associated with the two picture dots, said signals expressing equal brightness and/or colour. In the second plausibility circuit 54 v_o is then compared to v_u and checked for plausibility. If v_o is greater than zero and v_u is smaller than zero or vice versa, then v (total) is set to zero. If the amount of $(v_o - v_u)$ is less than 2, then v (total) remains unchanged, if this amount is greater than 11 then v (total) is set to zero, otherwise v (total) is multiplied by a factor interpolated linearly between zero and one.

Fig. 7 shows a digital picture memory 8, in which in an advantageous manner a freeze frame correction can be carried out in relation to a vertical displacement. For this a column portion is intermediately stored in the intermediate memory 42. In the column portion are arranged picture dots lying above each other, which all relate to different lines. The brightness and/or colour values S_1 and S_2 of the picture dots are arranged

in digital signal form (bytes) alternately in each case in a first (S1) and a second (S2) field. Then the mean value is calculated in the mean value forming device according to the following equation:

$$MS = \text{Sum4} (S1(i) + S2(i)) / 2LS$$

MS represents mean value of column, LS column length of a field and i is the running index from 1 to LS. Sum4 represents the summation symbol and the addition of the summands to the running index i from 1 to LS. In the subtracter the difference is formed according to:

$$DS1(i) = S1(i) - MS, i=1, \dots, LS$$

$$DS2(i) = S2(i) - MS, i=1, \dots, LS$$

in which LS is preferably of the order of magnitude of 10. DS1 and DS2 are correlated in the correlator 45 according to:

$$KS(j) = \text{Sum5 Pro3} (DS1(i) * DS2(i+k))$$

with i smaller than or equal to (i+k) and (i+k) smaller than or equal to LS, otherwise $DS1(i) * DS2(i+k) = 0$. j runs from (-LS+1) to (LS-1). Pro3 represents the Greek P and the multiplication of the factors with the running index i from 1 to LS. Sum5 represents the summation symbol and the addition of the products to the running index k from (LS-1) to (1-LS). The location j of the maximum correlation value provides the

necessary displacement $-Vs$ at the picture dot P. The correlation takes place in columns, beginning with the first picture dot from the upper and/or lower edge of a television picture, and is carried out for all other picture dots, the second, the third etc. up to the lower and/or the upper edge of the television picture via the path length LS. Signals reach the interpolation circuit 51 via the mean value forming device 43 and the subtracter 44. The interpolation circuit 51 is in front of the correlator 45. signals are passed to the filter 50 from the correlator 45. The largest and the second largest correlation values are retained in the location circuit 52. It is decided in the threshold circuit 46, whether digital signals are changed in the column memory 49. Intermediate values are eliminated in the plausibility circuit 53. The current column is corrected in the column memory 49 from the plausibility circuit 53.

In advantageous manner the digital picture memory 8 may be used with freeze frame improvement (Fig. 3-5) in a digital video recorder.

Fig. 8 shows the very simplified block circuit diagram of a digital video recorder. The magnetic head 1 scans a magnetic tape not shown and leads scanned signals to a demodulator 55. Instead of the demodulator 55 a decoder may also be arranged, a demultiplexer or a unit comprising all three units mentioned. digital signals are passed from the demodulator 55 to an inverse quantiser 56 and to a control device 57. The control device 57 controls the inverse quantiser 56 and the inverse transformer 58.

Digital data are passed to the inverse transformer 58 from the inverse quantiser 56. Digital signals are supplied to the picture memory 8 from the inverse transformer 58. Freeze frames may be improved in the picture memory 8 according to the invention (Figs. 5 - 7). A converter 59 converts the digital data coming from the picture memory 8 into a video signal and/or into a FBAS or NTSC signal and passes it to a viewing screen 12.

Noise is suppressed by the mean value formation, subtraction and threshold value circuit 46. The threshold value circuit 46 decides whether digital signals are matched. After the correlation a second mean value formation 47 is provided. The second mean value formation 47 eliminates a distortion of a current line to a line lying thereabove and therebelow. An intermediate memory 42 is used for the three lines lying above each other. An intermediate memory 42 is used for a column. The processing of digital chrominance and luminance signals is parallel. A filter 50 is used after the correlator 45. The filter 50 takes account of picture dots from the centre of a line portion to a greater extent than picture dots placed at the edge of a line portion. An interpolation circuit 51 is provided in front of the correlator 50. The interpolation circuit 51 interpolates intermediate values between scanning dots of a luminance and/or chrominance signal. The interpolation circuit 51 recognises colour and/or brightness peaks. Because of the interpolation circuit 51 two signals are associated with two adjacent picture dots 38 which are about equally large. With a

correlation between a current and an adjoining line one or more extreme values can be ascertained. The difference in the extreme values is a measure of the distortion.

Patent Claims

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1. A method of improving the freeze frame in picture processing equipment, characterised in that brightness values and/or colour values of picture dots of adjacent line portions of two adjacent fields respectively are entered in electronic storage means (8, 42, 48), the second field of which in each case is to be movement compensated, and the brightness and/or colour values of the picture dots in one or two line portions (23, 25, 27, 29) of the second field are shifted to the appropriate position of the brightness and/or colour values of the scanning dots from the adjacent line portion (22, 24, 26, 28) of a first field, while with the aid of a correlation (45), which progresses dot by dot, between the brightness or colour values of the picture dots of the line portions, a measure of the movement in line direction between the two fields is ascertained and the brightness or colour values of the picture dots of the second field are arranged in the storage means (8, 42, 48) movement-compensated in accordance with this measure.

2. A method according to claim 1, characterised in that line portions which are ten to twenty picture dots wide in each case are correlated with each other.

3. A method according to claim 1 or 2, characterised in that before correlation (45) within the line portions a mean value formation (43) and a subtraction (44) from the brightness and/or colour values of the appropriate picture dots is carried out.

4. A method according to one or more of claims 1 to 3,



characterised in that the correlation (45) is effected by forming a product.

5. A method according to one or more of claims 1 to 4, characterised in that a line portion from the first field is correlated respectively with the line portion of the adjacent lines from the second field which lie above and below, and the movement compensation is only carried out if no diagonal structure is ascertained in the picture content based on a comparison of these two movement measures.

6. A method according to one or more of claims 1 to 5, characterised in that the movement compensation is only carried out if result values formed by correlation (45) exceed a fixed threshold (46).

7. A method according to one or more of claims 1 to 6, characterised in that the result values formed by correlation (45) are weighted towards the ends of the line portions as the amplitude falls.

8. A method according to one or more of claims 1 to 7, characterised in that before correlation (45) between the picture dots of the line portions, intermediate brightness and/or colour values are formed (51).

9. A method according to one or more of claims 1 to 8, characterised in that in addition, with the aid of a second correlation within column portions, picture dots of the field to be corrected are matched in their brightness and/or colour to the brightness and/or colour of appropriate picture dots of the other field by vertical shifting of picture contents, if there is an appropriate movement in the picture content.



10. A device for carrying out a method according to one or more of claims 1 to 9, provided with electronic storage means (8), in which are stored respectively the brightness and/or colour values of picture dots of two fields, having connected thereto in series: intermediate storage means (42) for scanning dot values of line portions, in which in each case a line portion from the first field and an adjacent line portion, which lies above and below it, from the second field are stored; first mean value former (43) for colour or brightness values of scanning dots of these line portions, a subtractor (44) connected after the intermediate store (42) and the first mean value former (43), which subtractor in each of the line portions subtracts the respective mean value for the line portion from the scanning dot values, a correlator (45) connected after the subtractor (44) for the line portions with the values formed in the subtractor (44), a threshold circuit (46) for the result values of the correlation which eliminates the shift of scanning dot values for result values below a threshold; a second mean value former (47) which effects the shift measures for the line portion which is above and below; and a line store (48), the content of which is loaded, after (successful) movement compensation for the scanning dot values of a whole line, into the appropriate point in the storage means (8).