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**Kondo et al.**

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(54) **MOTION VECTOR CODING METHOD AND MOTION VECTOR DECODING METHOD**

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(73) Assignee: **Dolby International AB**, Amsterdam (NL)

(21) Appl. No.: **14/803,739**

(22) Filed: **Jul. 20, 2015**

**Related U.S. Patent Documents**

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Filed: **Oct. 30, 2007**

U.S. Applications:

(63) Continuation of application No. 10/468,203, filed as application No. PCT/JP03/00055 on Jan. 8, 2003, now Pat. No. 7,362,807.

(30) **Foreign Application Priority Data**

| | | |
|---|---|---|
| Jan. 9, 2002 | (JP) | 2002-001983 |
| Jul. 12, 2002 | (JP) | 2002-204714 |
| Nov. 28, 2002 | (JP) | 2002-346062 |

(51) **Int. Cl.**
***H04N 7/18*** (2006.01)
***H04N 19/52*** (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H04N 19/52*** (2014.11); ***H04N 19/105*** (2014.11); ***H04N 19/137*** (2014.11);
(Continued)

(58) **Field of Classification Search**
CPC ..... H04N 19/51; H04N 19/52; H04N 19/56; H04N 19/58; H04N 19/513; H04N 19/573; H04N 19/577; H04N 19/583
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,905,535 A 5/1999 Kerdranvat
5,991,447 A * 11/1999 Eifrig et al. ..... 382/236
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1132983 10/1996
EP 0651574 5/1995
(Continued)

OTHER PUBLICATIONS

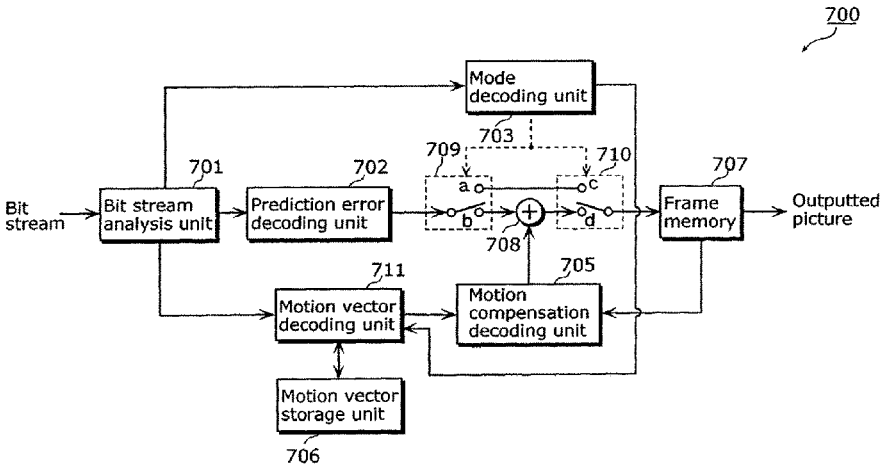
Gary J. Sullivan and Thomas Wiegand, "Rate-Distortion Optimization for Video Compression", Nov. 1998, IEEE Signal Processing Magazine, pp. 74-90.*
(Continued)

*Primary Examiner* — Adam L Basehoar

(57) **ABSTRACT**

A motion vector coding unit **117** executes processing including a neighboring block specification step (**S100**) of specifying a neighboring block which is located in the neighborhood of a current block; a judgment step (Steps **S102**, **S104**) of judging whether or not the neighboring block has been coded using a motion vector of another block; a prediction step (**S106**, **S108**) of deriving a predictive motion vector of the current block using a motion vector calculated from the motion vector of the other block as a motion vector of the neighboring block; and a coding step (**S110**) of coding the motion vector of the current block using the predictive motion vector.

**7 Claims, 22 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| ***H04N 19/184*** | (2014.01) |
| ***H04N 19/50*** | (2014.01) |
| ***H04N 19/51*** | (2014.01) |
| ***H04N 19/513*** | (2014.01) |
| ***H04N 19/61*** | (2014.01) |
| ***H04N 19/593*** | (2014.01) |
| ***H04N 19/517*** | (2014.01) |
| ***H04N 19/577*** | (2014.01) |
| ***H04N 19/137*** | (2014.01) |
| ***H04N 19/139*** | (2014.01) |
| ***H04N 19/176*** | (2014.01) |
| ***H04N 19/537*** | (2014.01) |
| ***H04N 19/533*** | (2014.01) |
| ***H04N 19/105*** | (2014.01) |
| ***H04N 19/172*** | (2014.01) |
| ***H04N 19/56*** | (2014.01) |

(52) **U.S. Cl.**

CPC ..... ***H04N 19/139*** (2014.11); ***H04N 19/172*** (2014.11); ***H04N 19/176*** (2014.11); ***H04N 19/184*** (2014.11); ***H04N 19/50*** (2014.11); ***H04N 19/51*** (2014.11); ***H04N 19/513*** (2014.11); ***H04N 19/517*** (2014.11); ***H04N 19/521*** (2014.11); ***H04N 19/533*** (2014.11); ***H04N 19/537*** (2014.11); ***H04N 19/56*** (2014.11); ***H04N 19/577*** (2014.11); ***H04N 19/593*** (2014.11); ***H04N 19/61*** (2014.11)

(58) **Field of Classification Search**

USPC ..... 375/240.12, 240.15, 240.16, 240.17

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 6,097,842 | A | 8/2000 | Suzuki et al. | |
| 6,272,179 | B1 | 8/2001 | Kadono | |
| 6,646,578 | B1 * | 11/2003 | Au | H03M 7/42 341/67 |
| 6,654,420 | B1 | 11/2003 | Snook | |
| 6,842,483 | B1 * | 1/2005 | Au et al. | 375/240.16 |
| 7,020,200 | B2 | 3/2006 | Winger | |
| 8,005,145 | B2 * | 8/2011 | Lainema | H04N 19/52 375/240.16 |
| 2002/0176505 | A1 | 11/2002 | Kim et al. | |
| 2003/2006589 | | 11/2003 | Jeon | |
| 2004/0013309 | A1 * | 1/2004 | Choi | H04N 19/52 382/238 |
| 2004/0101059 | A1 * | 5/2004 | Joch | H04N 19/159 375/240.29 |
| 2005/0123058 | A1 * | 6/2005 | Greenbaum | H04N 21/23439 375/240.28 |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| EP | 0765087 | 3/1997 |
| EP | 1 335 609 | 8/2003 |
| JP | 11-317961 | 11/1999 |
| JP | 2000-099864 | 4/2000 |
| JP | 2000-299864 | 10/2000 |
| JP | 2001-045498 | 2/2001 |
| JP | 2001-224036 | 8/2001 |
| KR | 20020077630 | 10/2002 |
| WO | 94/22269 | 9/1994 |
| WO | 00/33581 | 6/2000 |
| WO | 01/33864 | 5/2001 |
| WO | 01/50770 | 7/2001 |

OTHER PUBLICATIONS

H.26L Test Model Long Term No. 6 (TML-6) Draft "0", ITU-T Telecommunication Standardization Sector of ITU, Geneva, CH, Jan. 9, 2001, pp. 1-35, XP001089815.

"Text of ISO/IEC 14496-10 CD Advanced Video Coding", 60. MPEG Meeting; Jun. 5, 2002-Oct . 5, 2002; Fairfax, (Motion Picture Expert Group or ISO/IEC JTC1/SC29/WG11), No. N4810, May 14, 2002, XP30012280, ISSN: 0000-0366, pp. BSN1-BSN142.

"*Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG*", pp. 1-78, Pattaya, Thailand, Dec. 3-7, 2001.

Information Technology—Coding of Audio-Visual Objects—Part 2: Visual, (ISO/IEC 14496.2), pp. 146-148, Dec. 1, 1999.

European Search Report issued in European Application No. 07 70 0472, dated Feb. 28, 2006.

International Search Report issued in PCT/JP03/00055.

Japanese Office Action issued on Jul. 24, 2007 in corresponding Japanese patent application No. 2002-346062.

European Office Action issued Apr. 3, 3012 in European Application 10 187 172.1 which is a foreign counterpart of the present application.

Office Action dated Dec. 23, 2011 in U.S. Appl. No. 11/979,012.

Office Action dated Dec. 29, 2011 in U.S. Appl. No. 11/979,010.

Office Action issued Jun. 27, 2012 in corresponding U.S. Appl. No. 11/979,013.

European Office Action issued Sep. 26, 2012 in EP Application No. 10169923.9.

European Office Action issued Sep. 26, 2012 in EP Application No. 10169924.7.

European Office Action issued Sep. 26, 2012 in EP Application No. 10187151.5.

European Office Action issued Sep. 26, 2012 in EP Application No. 10187172.1.

Kadono et al., "Memory Reduction for Temporal Technique of Direct Mode", Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG 5$^{th}$ Meeting: Geneva, CH, Oct. 9-17, 2002, pp. 1-12.

Wiegand, Thomas, "Editor's Proposed Modifications to Joint Committee Draft (CD) of Joint Video Specification (ITU-T Rec. H.264|ISO/IEC 14496-10 AVC)", Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG 4$^{th}$ Meeting: Klagenfurt, Austria, Jul. 22-26, 2002, pp. i-136.

Tourapis et al., "Timestamp Independent Motion Vector Prediction for P and B frames with Division Elimination", Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG (ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 Q.6) 4$^{th}$ Meeting: Klagenfurt, Austria, Jul. 22-26, 2002, pp. 1-18.

European Result of Consultation issued Sep. 21, 2012 in European Application No. 10169925.4.

European Office Action issued Apr. 20, 2009 in the corresponding European patent application No. 03 700 472.8.

Alexis Michael Tourapis, Jizheng Xu, Feng Wu, and Shipeng Li, "Motion Vector Prediction in Bidirectionally Predictive (B) frames with regards to Direct Mode", Joint Video Team (JVT) of ISO/IEC MPEG & ITU-T VCEG (ISO/IEC JTC1/SC29/WG11 and ITU-T SG16 Q.6), May 2002, pp. 1-7.

* cited by examiner

Fig. 1

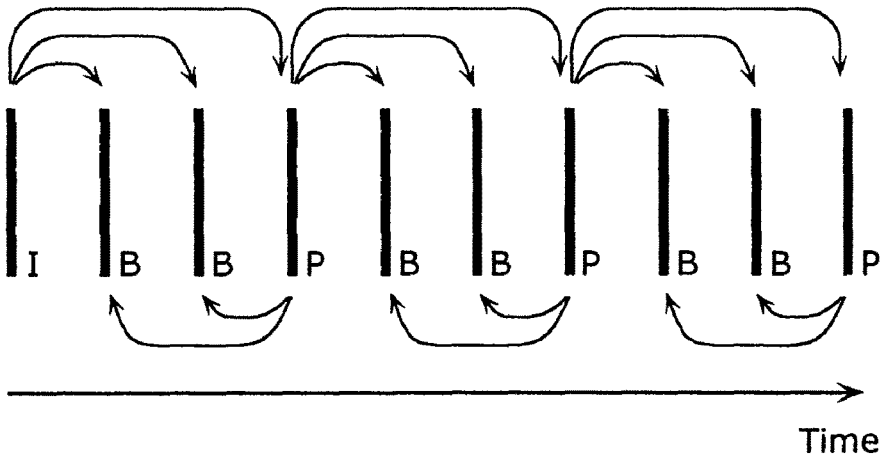
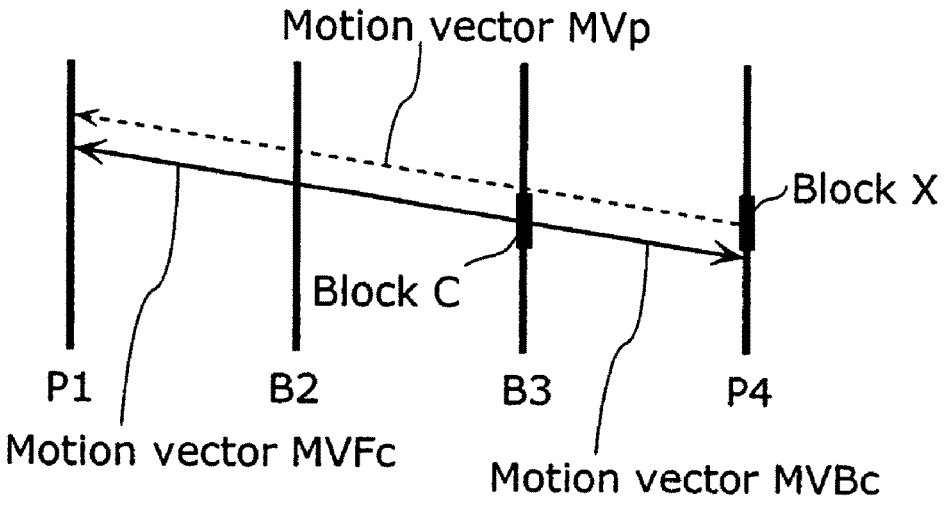


Fig. 2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Block X
Block C
P1
B2
B3
P4
Motion vector MVFc
Motion vector MVBc

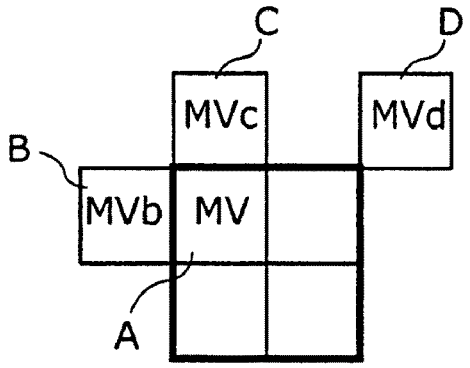



Fig. 3A

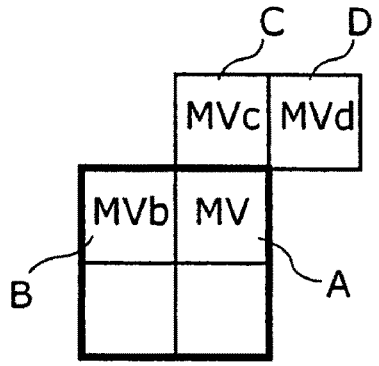



Fig. 3B

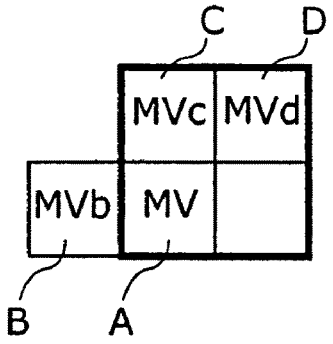



Fig. 3C

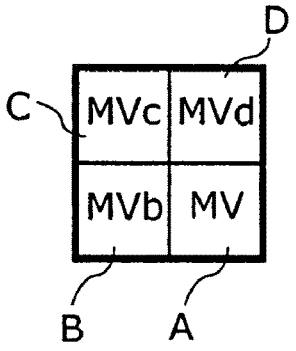



Fig. 3D

Fig. 4

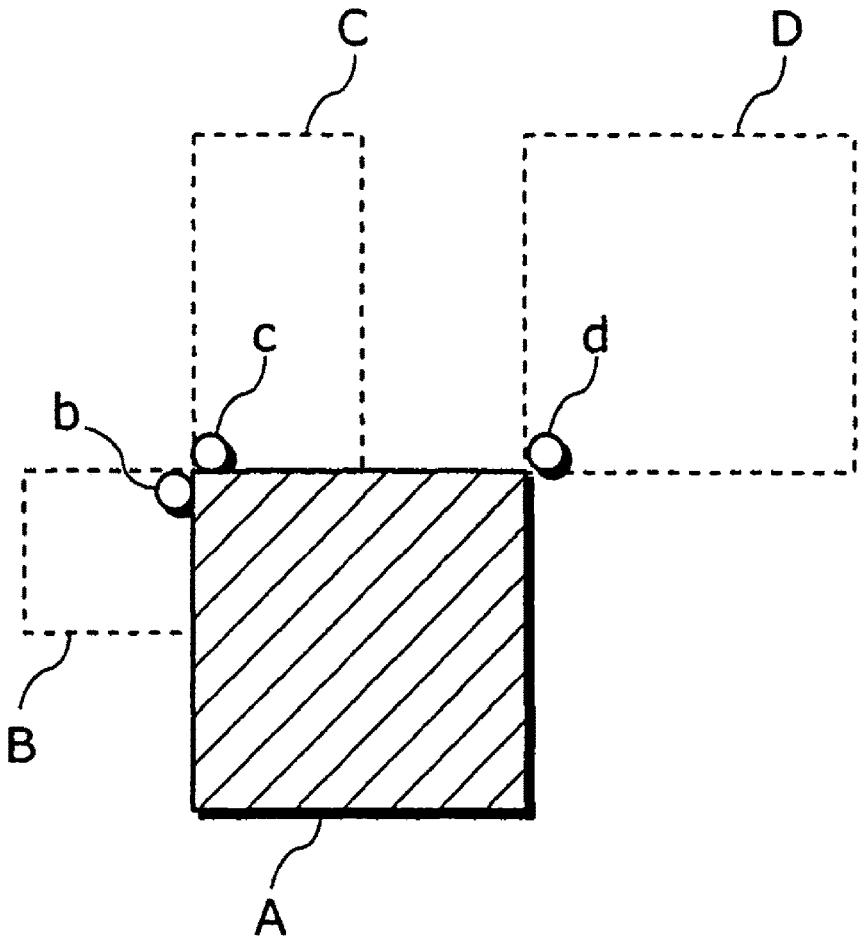


Fig. 5

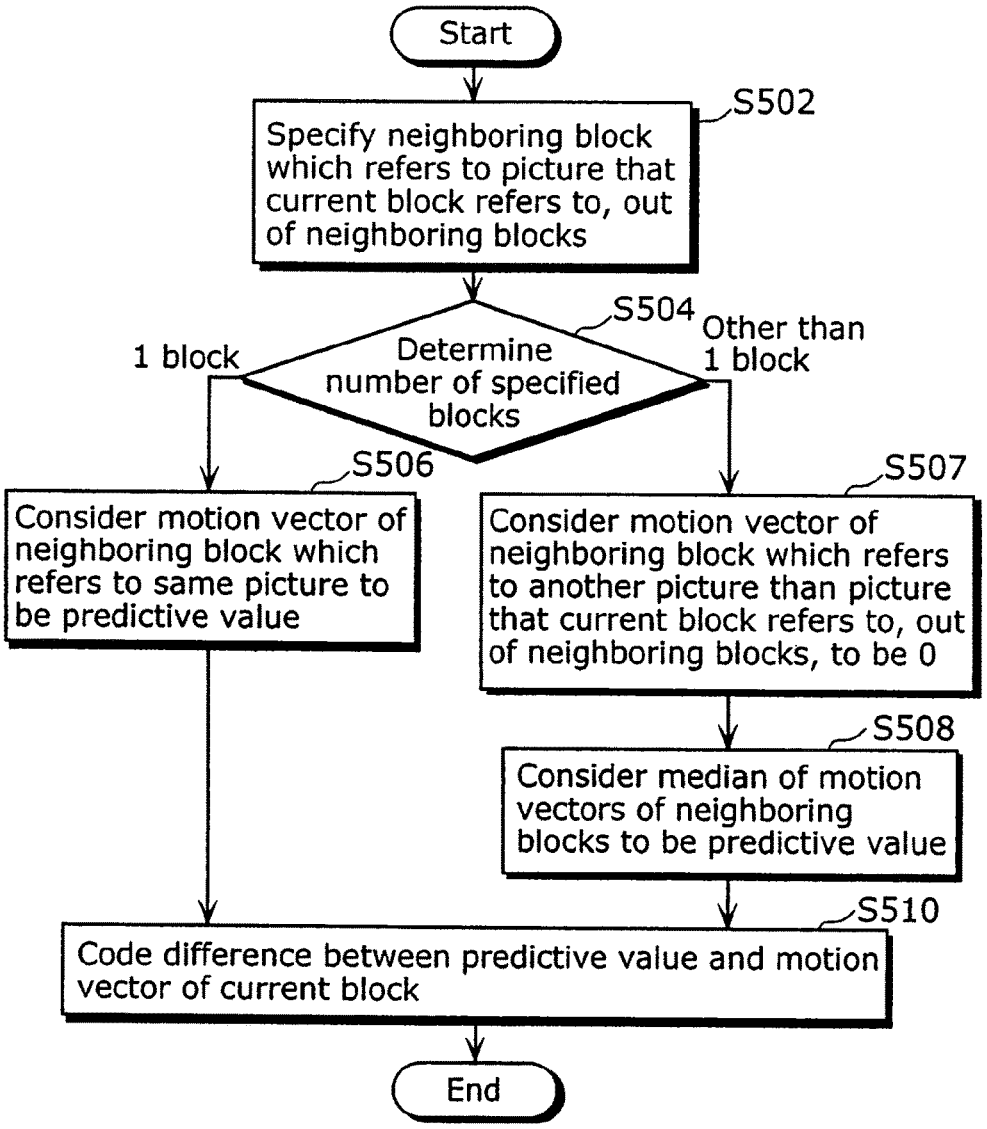
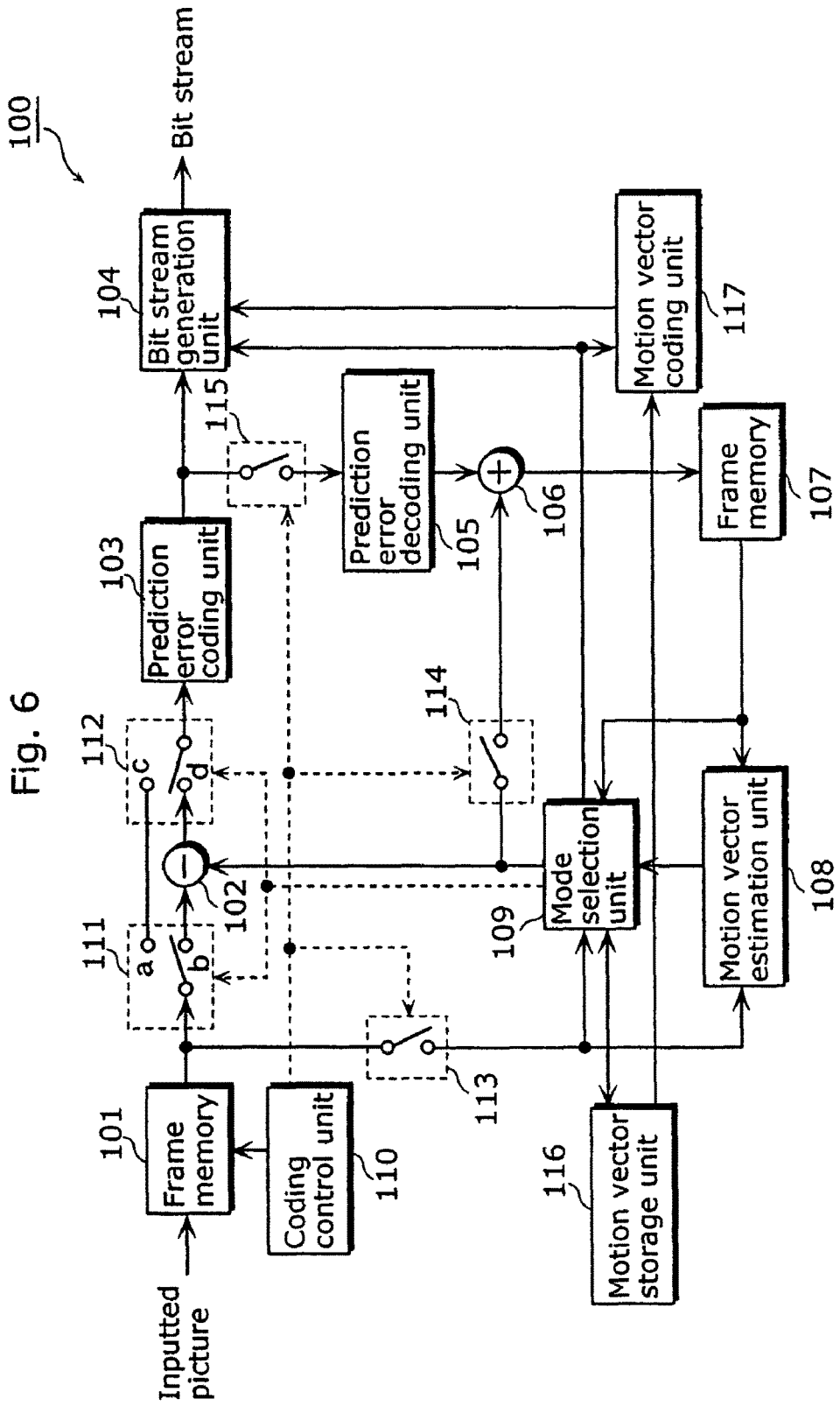

Start
S502
Specify neighboring block which refers to picture that current block refers to, out of neighboring blocks
S504
Determine number of specified blocks
1 block
Other than 1 block
S506
Consider motion vector of neighboring block which refers to same picture to be predictive value
S507
Consider motion vector of neighboring block which refers to another picture than picture that current block refers to, out of neighboring blocks, to be 0
S508
Consider median of motion vectors of neighboring blocks to be predictive value
S510
Code difference between predictive value and motion vector of current block
End

Fig. 6


100
Bit stream
Bit stream generation unit
104
Motion vector coding unit
117
115
Prediction error decoding unit
105
106
Frame memory
107
103
Prediction error coding unit
114
112
c
d
Mode selection unit
109
Motion vector estimation unit
108
111
a
b
102
113
101
Frame memory
Coding control unit
110
116
Motion vector storage unit
Inputted picture

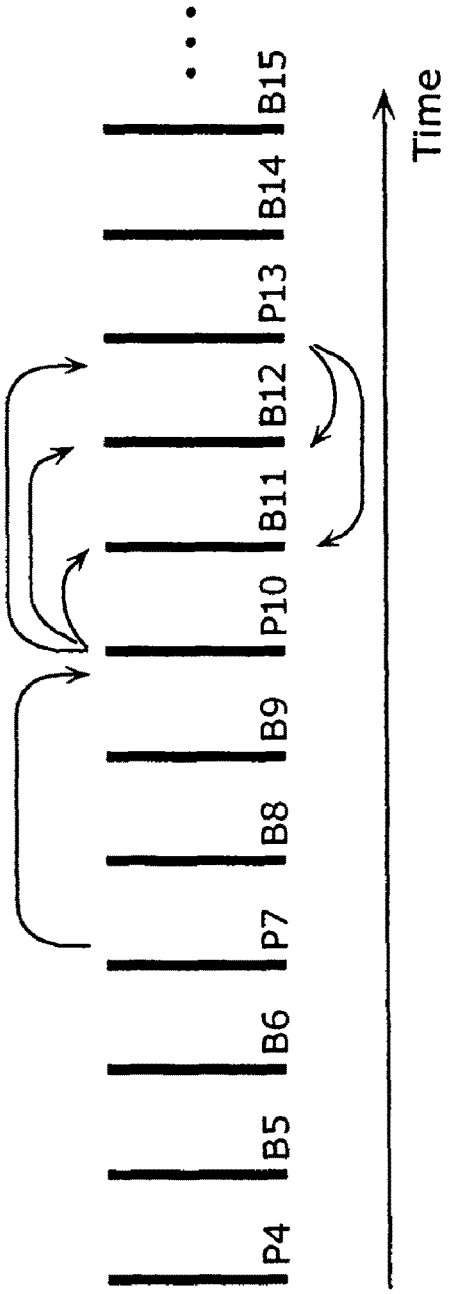

P4
B5
B6
P7
B8
B9
P10
B11
B12
P13
B14
B15
Time

Fig. 7A

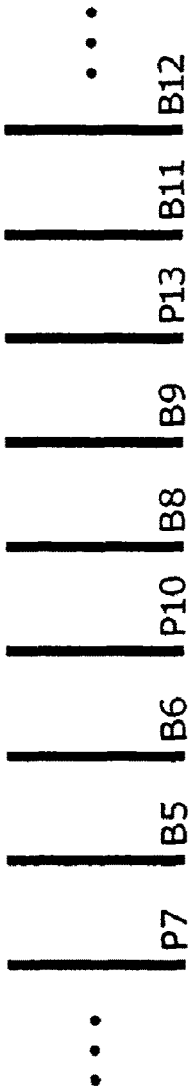
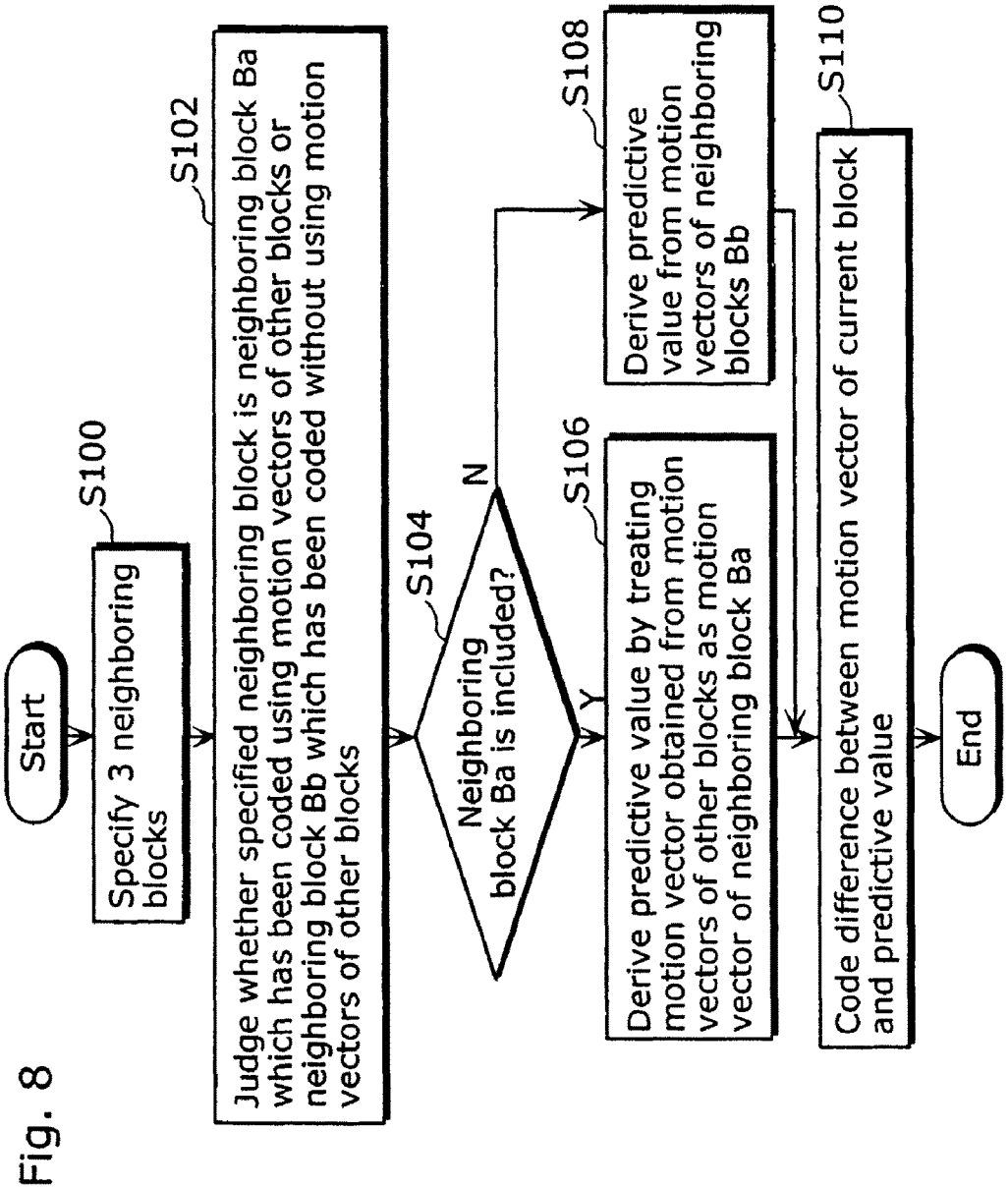

P7
B5
B6
P10
B8
B9
P13
B11
B12

Fig. 7B

Fig. 8


Start
S100
Specify 3 neighboring blocks
S102
Judge whether specified neighboring block is neighboring block Ba which has been coded using motion vectors of other blocks or neighboring block Bb which has been coded without using motion vectors of other blocks
S104
Neighboring block Ba is included?
N
Y
S106
Derive predictive value by treating motion vector obtained from motion vectors of other blocks as motion vector of neighboring block Ba
S108
Derive predictive value from motion vectors of neighboring blocks Bb
S110
Code difference between motion vector of current block and predictive value
End

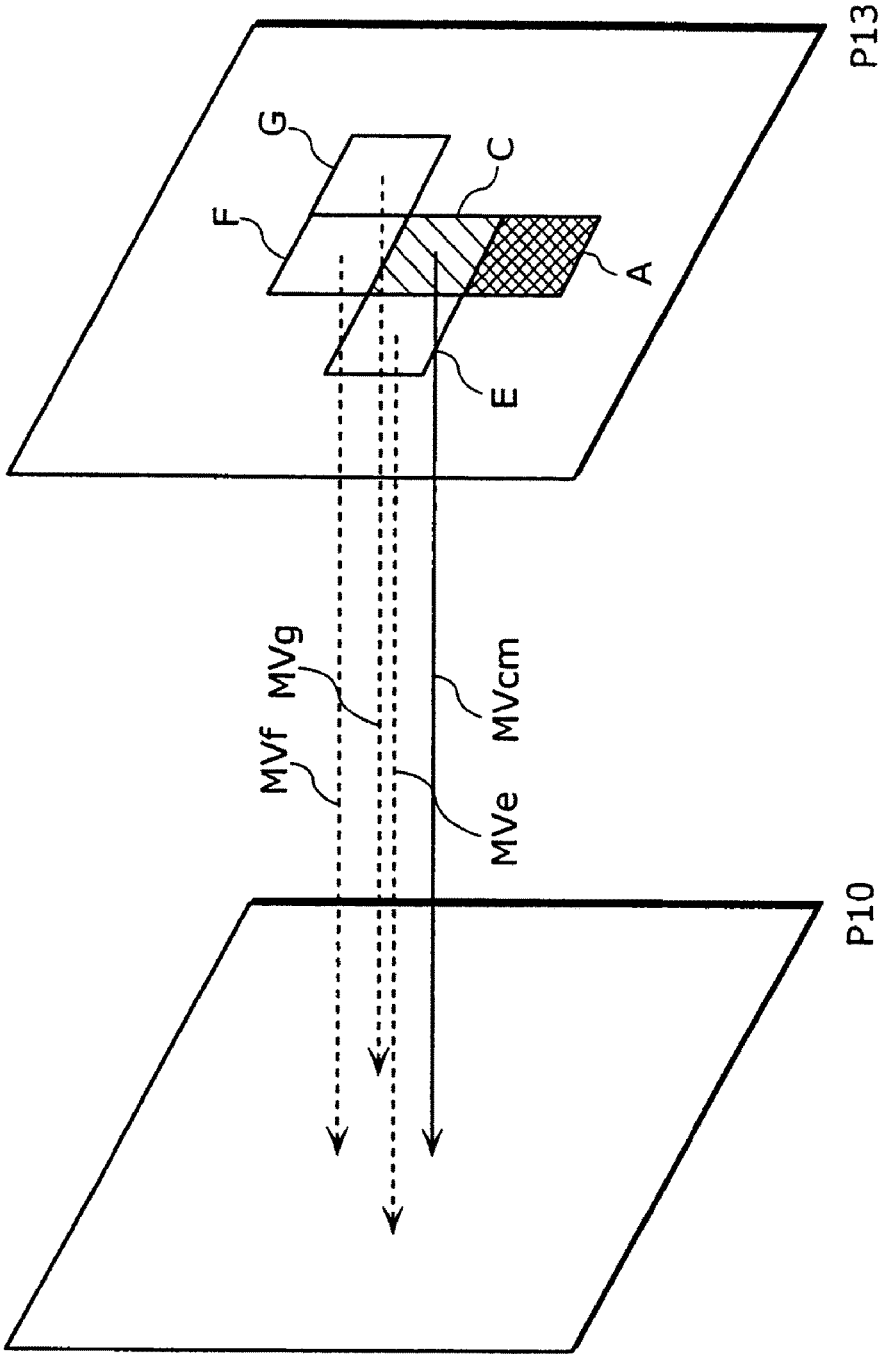



Fig. 9

Fig. 10

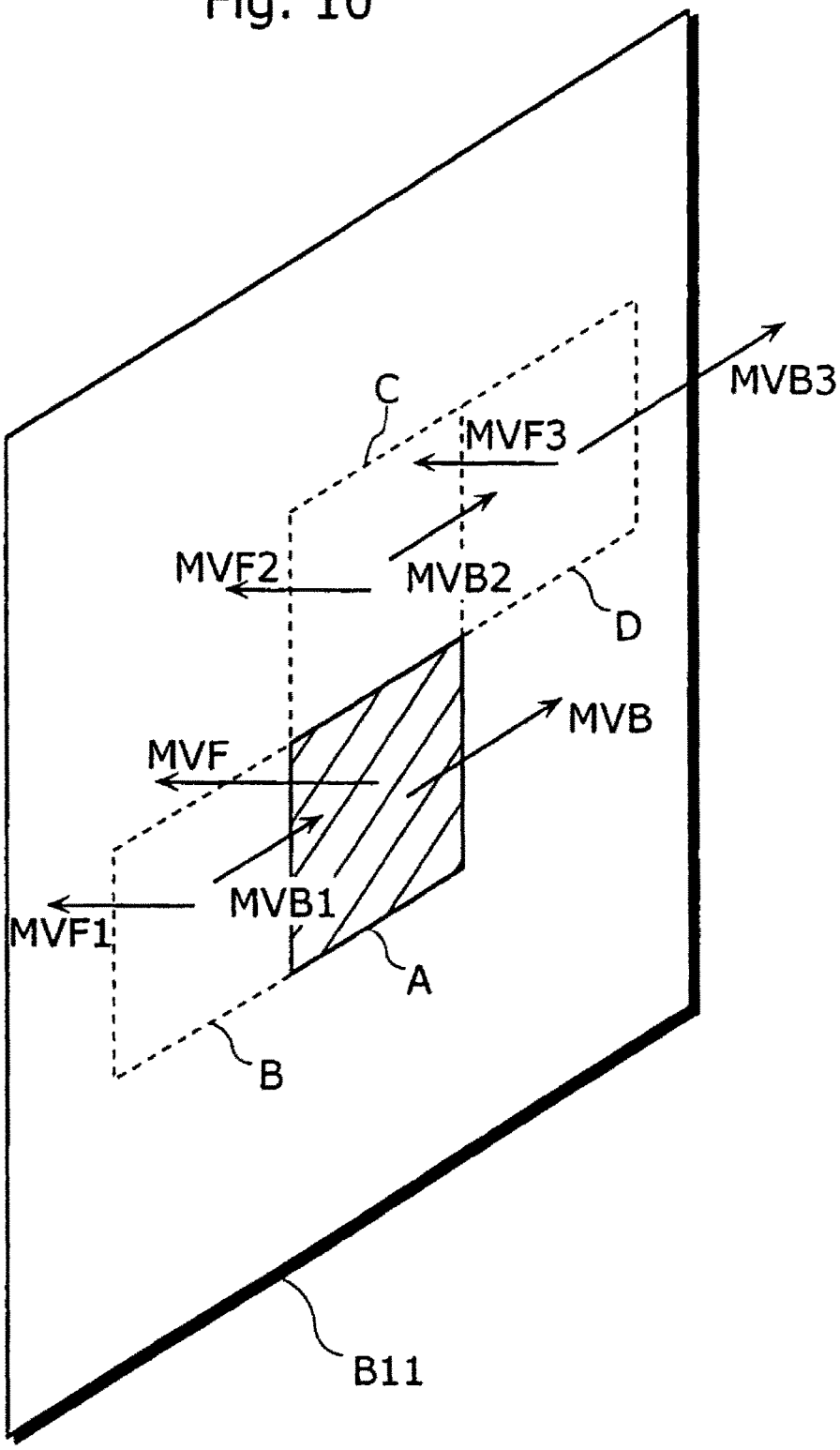


Fig. 11

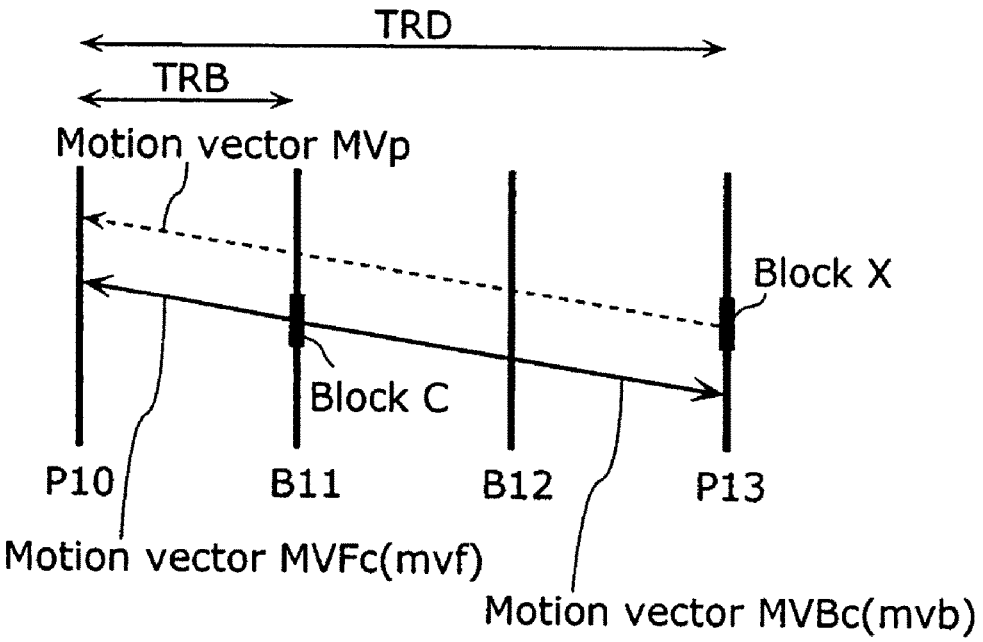

TRD
TRB
Motion vector MVp
Block X
Block C
P10
B11
B12
P13
Motion vector MVFc(mvf)
Motion vector MVBc(mvb)

Fig. 12

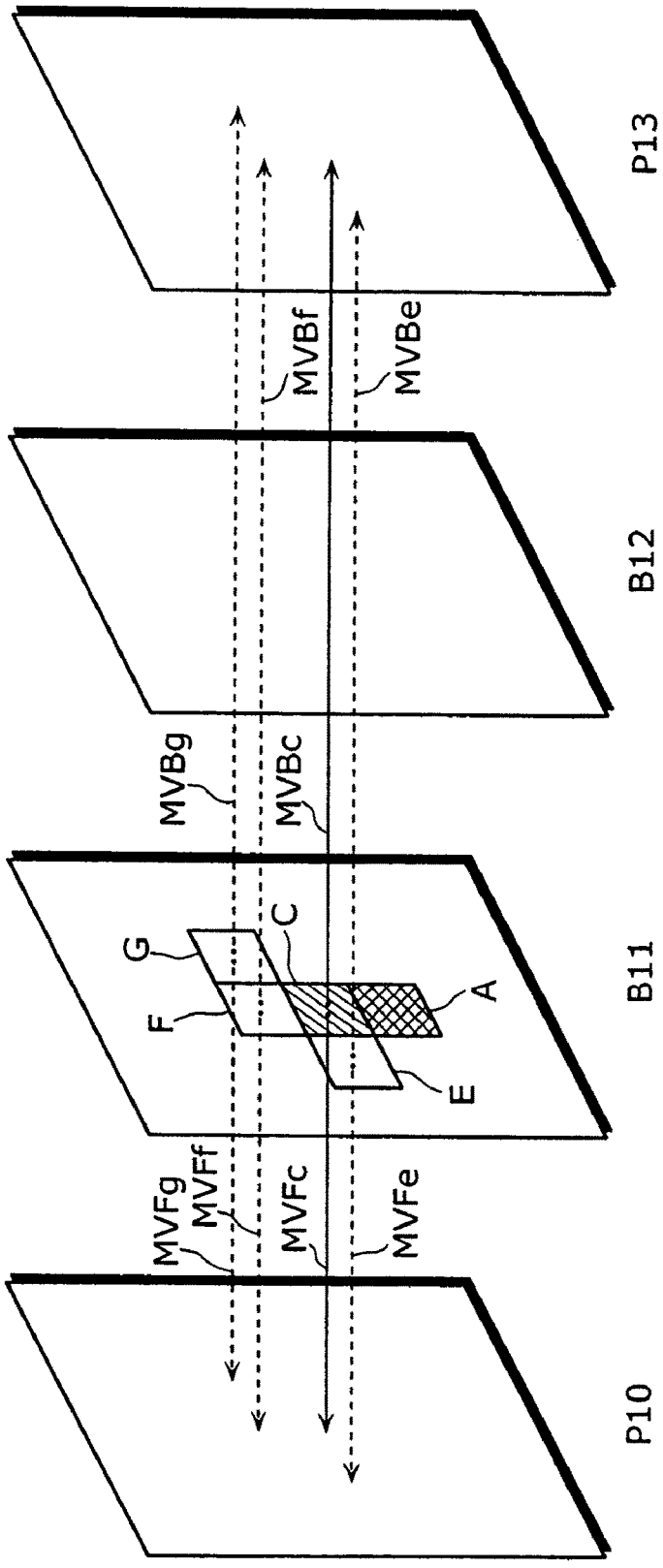


Fig. 13

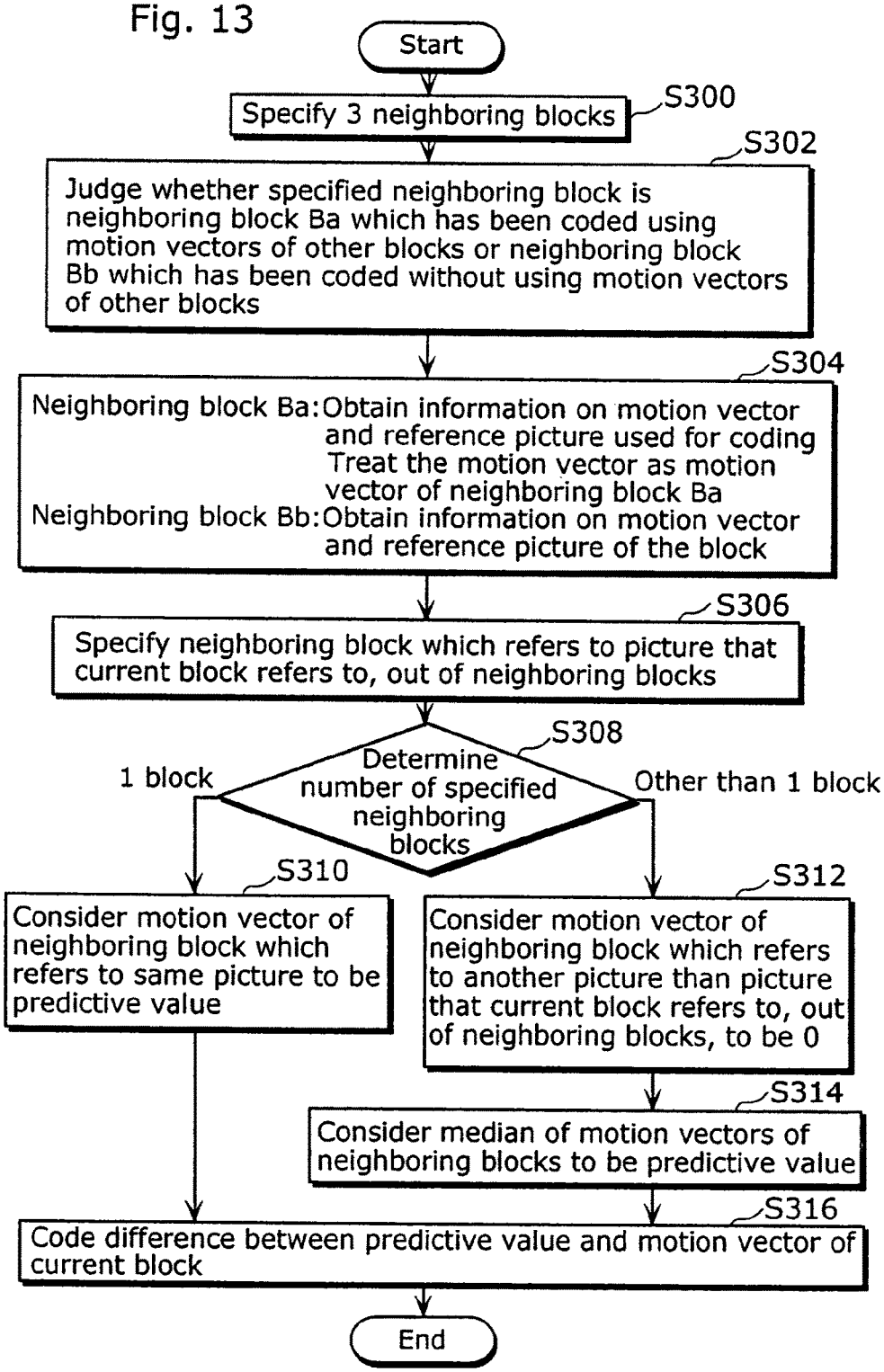
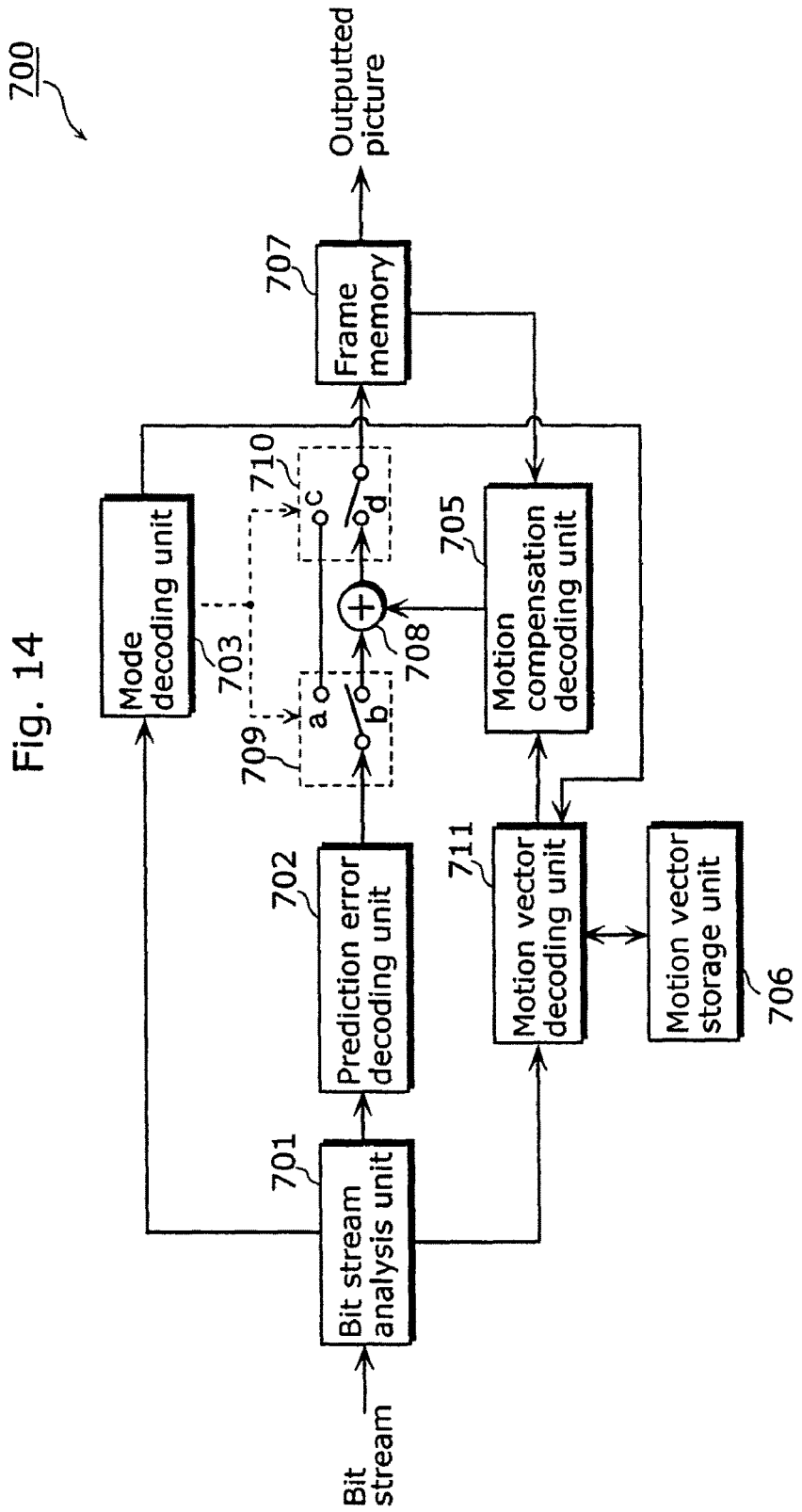

Start
Specify 3 neighboring blocks
S300
S302
Judge whether specified neighboring block is neighboring block Ba which has been coded using motion vectors of other blocks or neighboring block Bb which has been coded without using motion vectors of other blocks
S304
Neighboring block Ba: Obtain information on motion vector and reference picture used for coding Treat the motion vector as motion vector of neighboring block Ba
Neighboring block Bb: Obtain information on motion vector and reference picture of the block
S306
Specify neighboring block which refers to picture that current block refers to, out of neighboring blocks
S308
Determine number of specified neighboring blocks
1 block
Other than 1 block
S310
Consider motion vector of neighboring block which refers to same picture to be predictive value
S312
Consider motion vector of neighboring block which refers to another picture than picture that current block refers to, out of neighboring blocks, to be 0
S314
Consider median of motion vectors of neighboring blocks to be predictive value
S316
Code difference between predictive value and motion vector of current block
End

Fig. 14


700
Outputted picture
707
Frame memory
710
c
d
705
Motion compensation decoding unit
Mode decoding unit
703
708
709
a
b
702
Prediction error decoding unit
711
Motion vector decoding unit
Motion vector storage unit
706
701
Bit stream analysis unit
Bit stream

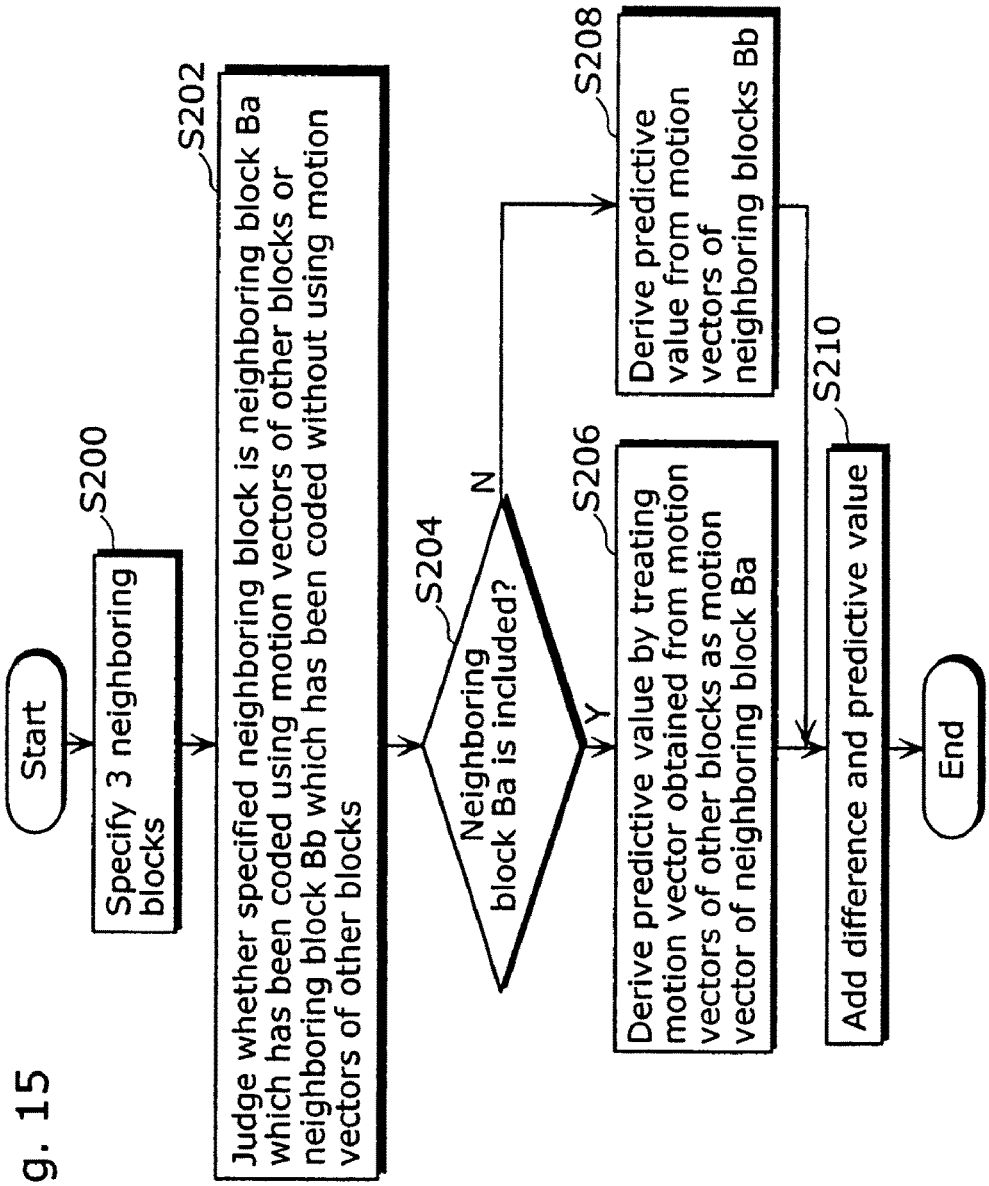

Start
S200
Specify 3 neighboring blocks
S202
Judge whether specified neighboring block is neighboring block Ba which has been coded using motion vectors of other blocks or neighboring block Bb which has been coded without using motion vectors of other blocks
S204
Neighboring block Ba is included?
N
Y
S206
Derive predictive value by treating motion vector obtained from motion vectors of other blocks as motion vector of neighboring block Ba
S208
Derive predictive value from motion vectors of neighboring blocks Bb
S210
Add difference and predictive value
End

Fig. 15

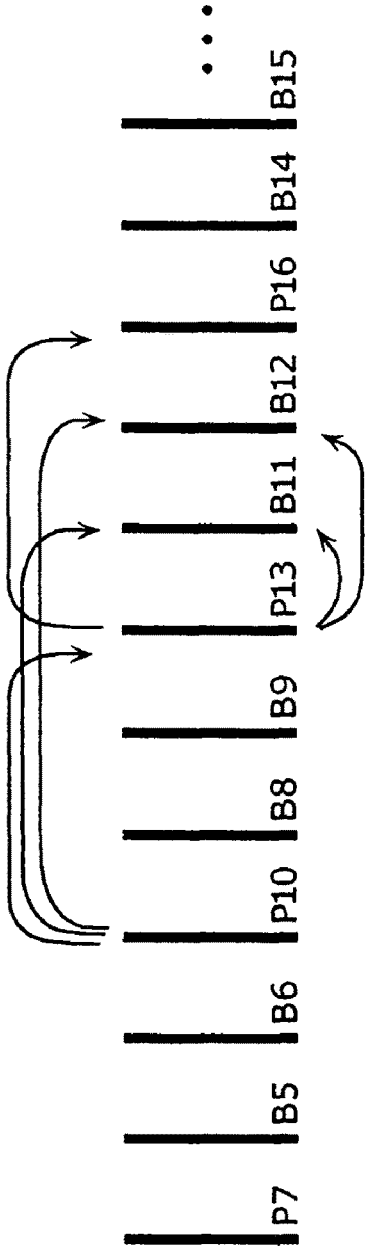



Fig. 16A

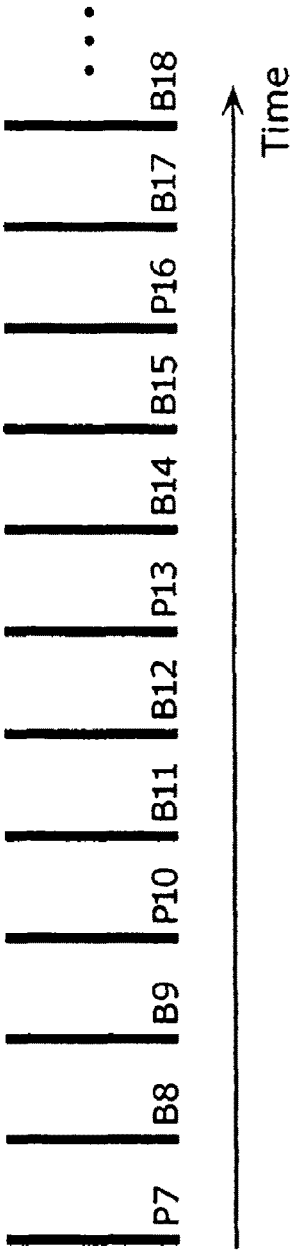



Fig. 16B

Fig. 17

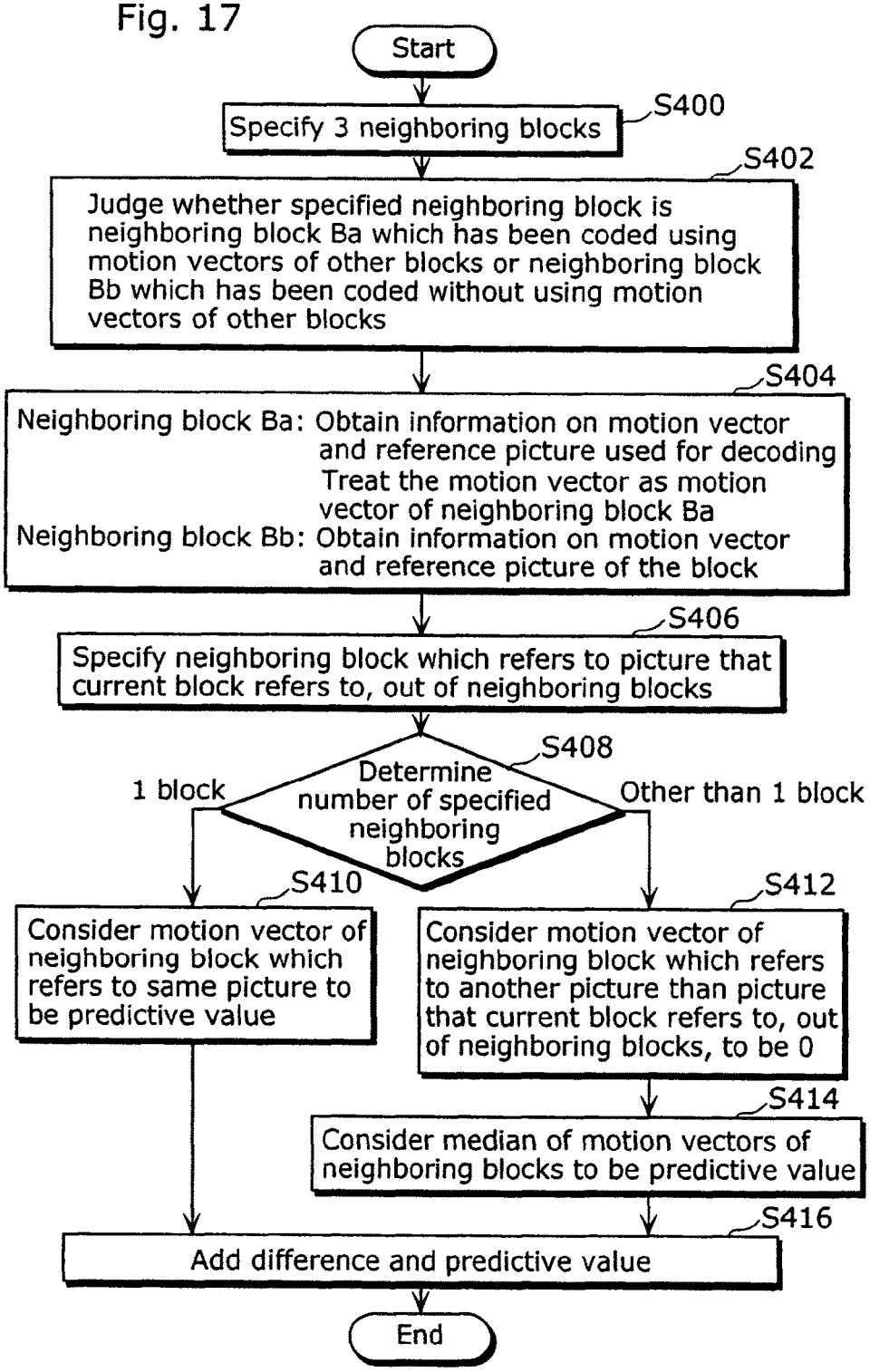

Start
Specify 3 neighboring blocks
S400
S402
Judge whether specified neighboring block is neighboring block Ba which has been coded using motion vectors of other blocks or neighboring block Bb which has been coded without using motion vectors of other blocks
S404
Neighboring block Ba: Obtain information on motion vector and reference picture used for decoding
Treat the motion vector as motion vector of neighboring block Ba
Neighboring block Bb: Obtain information on motion vector and reference picture of the block
S406
Specify neighboring block which refers to picture that current block refers to, out of neighboring blocks
S408
Determine number of specified neighboring blocks
1 block
Other than 1 block
S410
Consider motion vector of neighboring block which refers to same picture to be predictive value
S412
Consider motion vector of neighboring block which refers to another picture than picture that current block refers to, out of neighboring blocks, to be 0
S414
Consider median of motion vectors of neighboring blocks to be predictive value
S416
Add difference and predictive value
End

Fig. 18A

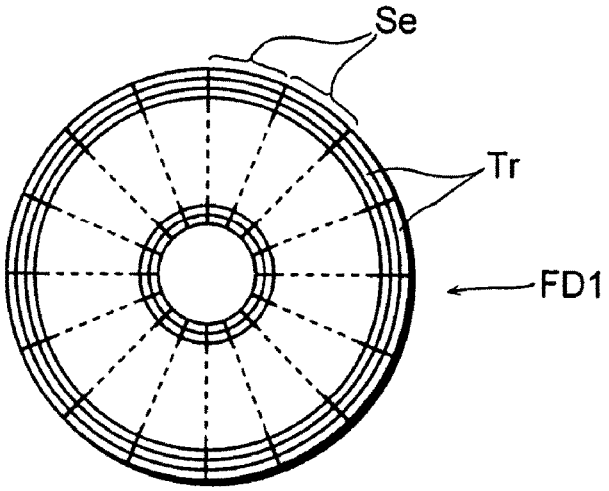



Fig. 18B

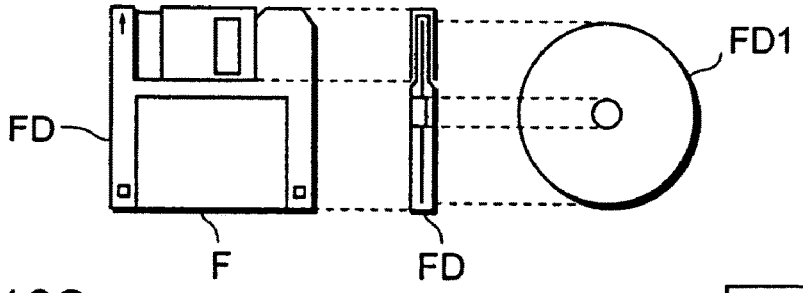
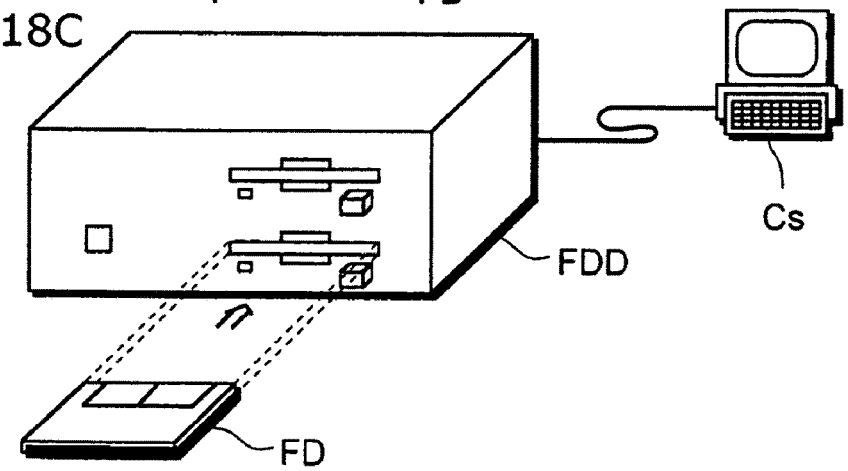



Fig. 18C



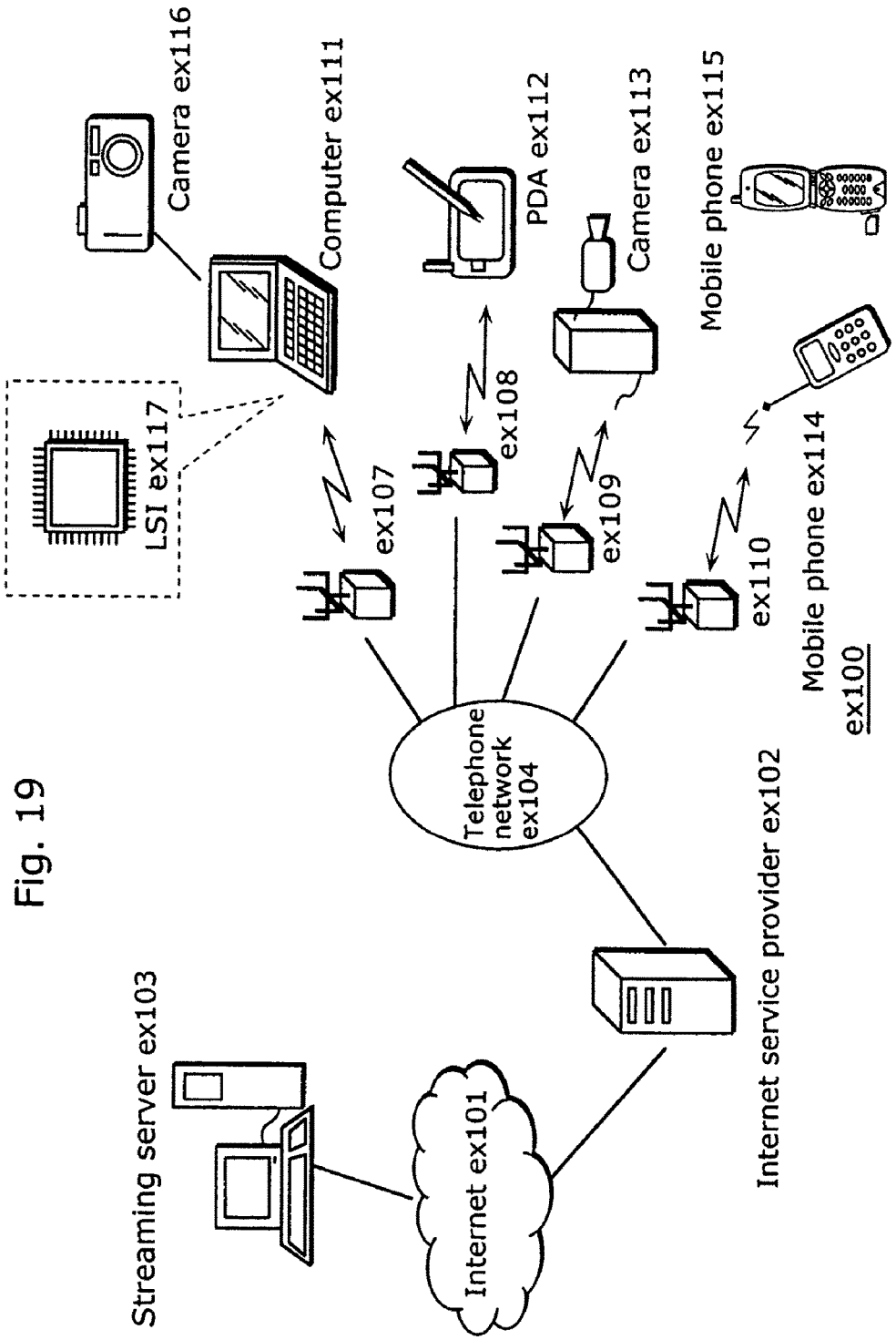

Camera ex116
Computer ex111
PDA ex112
Camera ex113
Mobile phone ex115
LSI ex117
ex107
ex108
ex109
ex110
Mobile phone ex114
Telephone network ex104
Internet service provider ex102
Streaming server ex103
Internet ex101
ex100

Fig. 19

Fig. 20

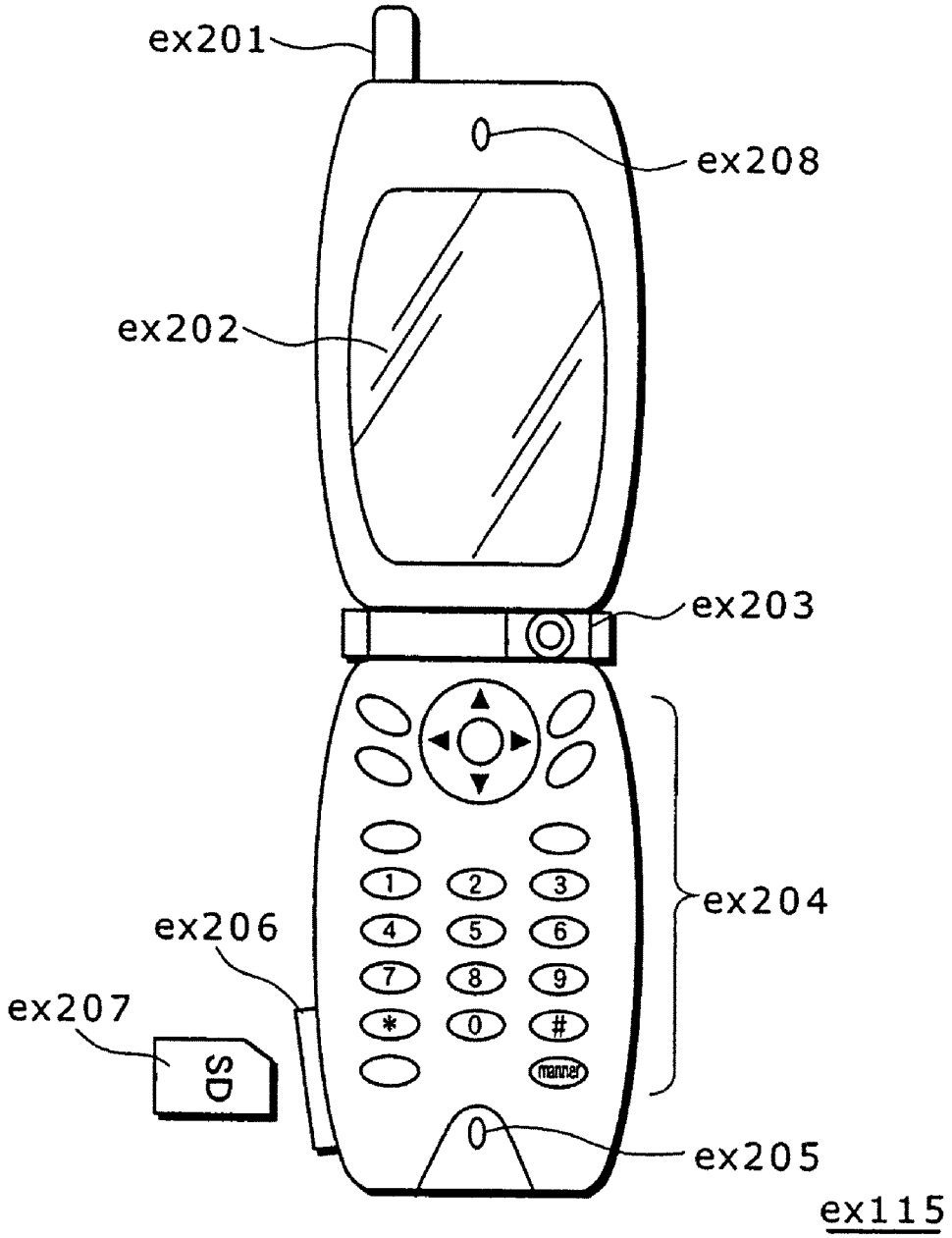


Fig. 21

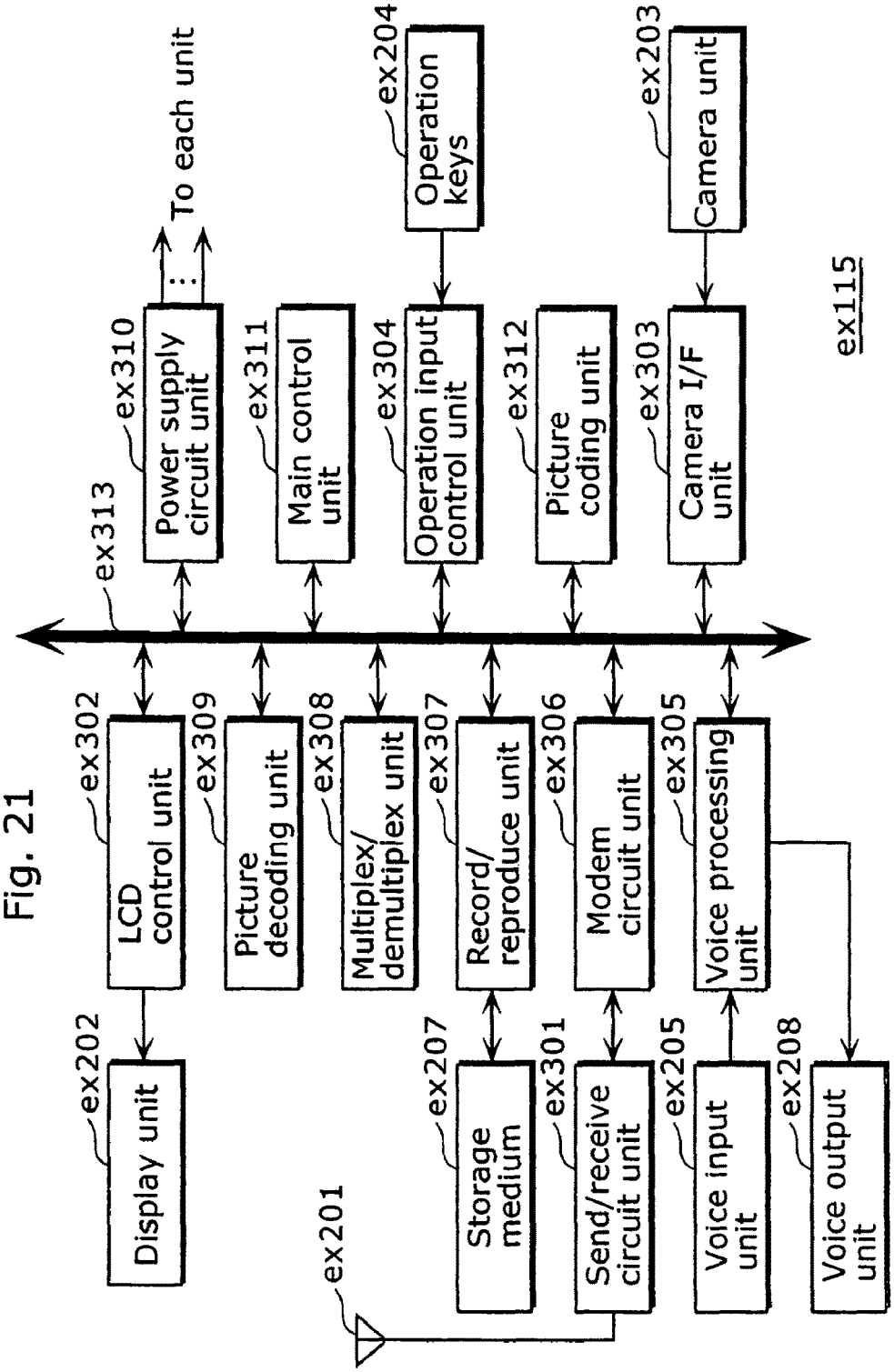
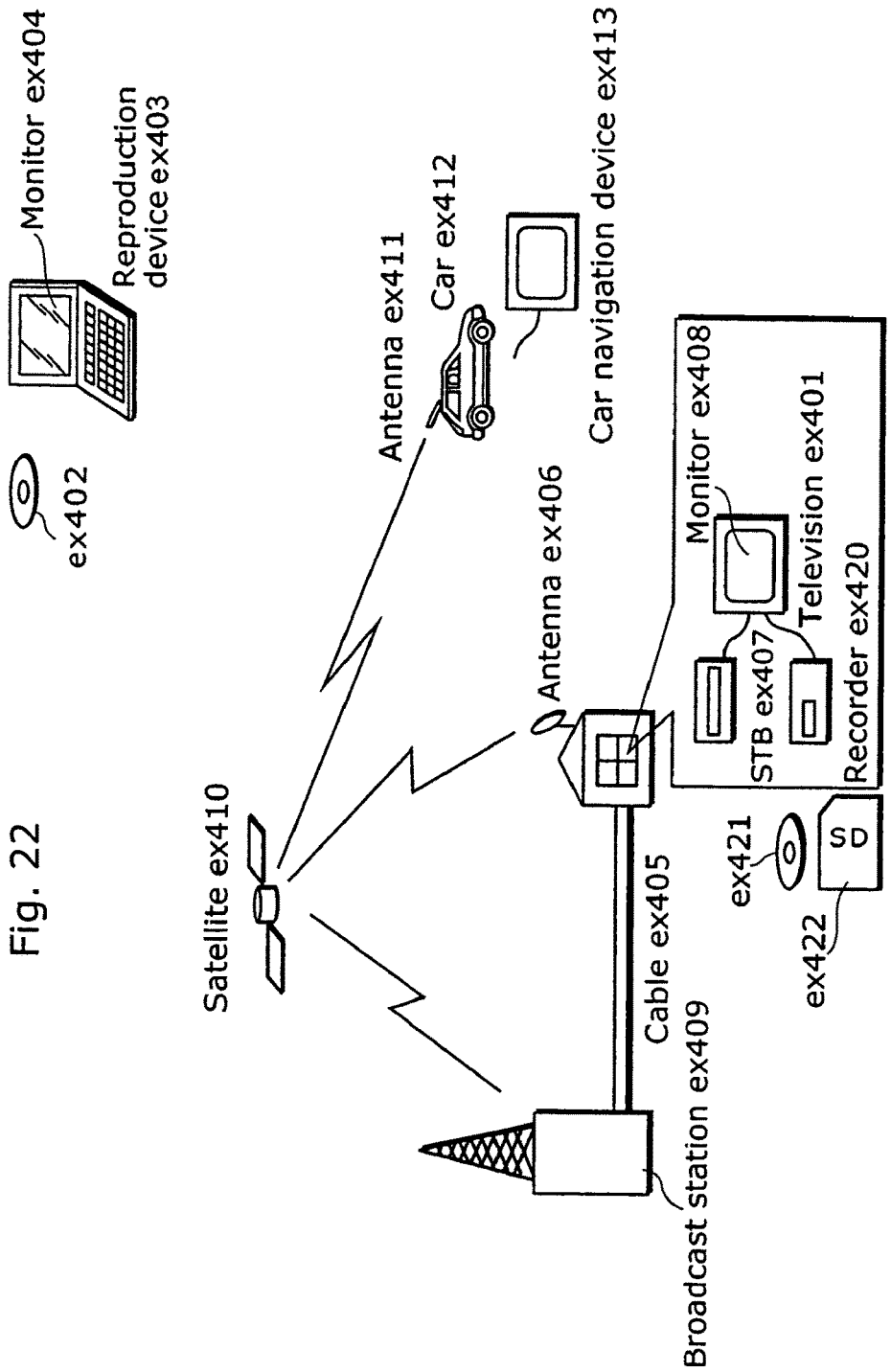

ex115
ex313
ex310
Power supply circuit unit
To each unit
ex311
Main control unit
ex304
Operation input control unit
ex204
Operation keys
ex312
Picture coding unit
ex303
Camera I/F unit
ex203
Camera unit
ex302
LCD control unit
ex309
Picture decoding unit
ex308
Multiplex/ demultiplex unit
ex307
Record/ reproduce unit
ex306
Modem circuit unit
ex305
Voice processing unit
ex202
Display unit
ex207
Storage medium
ex301
Send/receive circuit unit
ex205
Voice input unit
ex208
Voice output unit
ex201

Fig. 22


Monitor ex404
Reproduction device ex403
ex402
Antenna ex411
Car ex412
Car navigation device ex413
Satellite ex410
Antenna ex406
Monitor ex408
Television ex401
STB ex407
Recorder ex420
ex421
SD
ex422
Cable ex405
Broadcast station ex409

# MOTION VECTOR CODING METHOD AND MOTION VECTOR DECODING METHOD

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.**

[This] *The present application is a reissue application of U.S. application Ser. No. 11/979,033, which was filed on Oct. 30, 2007, and issued as U.S. Pat. No. 8,401,080 on Mar. 19, 2013, and which* is a continuation of Ser. No. 10/468,203, filed Aug. 18, 2003, now U.S. Pat. No. 7,362,807, which is the National Stage of International Application No. PCT/JP03/00055, *which claims priority to Japanese Application No. 2002-001983, filed Jan. 9, 2002, Japanese Application No. 2002-204714, filed Jul. 12, 2002 and Japanese Application No. 2002-346062, filed Nov. 28, 2002.*

## TECHNICAL FIELD

The present invention relates to a motion vector coding method and a motion vector decoding method using inter picture prediction coding.

## BACKGROUND ART

In the age of multimedia which integrally handles audio, video and other information, existing information media, i.e., newspapers, magazines, televisions, radios, telephones and other means through which information is conveyed to people, have recently come to be included in the scope of multimedia. Generally, multimedia refers to something that is represented by associating not only characters, but also graphics, voices, and especially pictures and the like together, but in order to include the aforementioned existing information media in the scope of multimedia, it appears as a prerequisite to represent such information in digital form.

However, when calculating the amount of information contained in each of the aforementioned information media as the amount of digital information, while the amount of information per character is 1~2 bytes, the amount of information to be required for voice is 64 Kbits or over per second (telephone quality), and 100 Mbits or over per second for moving pictures (current television reception quality), and it is not realistic for the aforementioned information media to handle such an enormous amount of information as it is in digital form. For example, although video phones are already in actual use via Integrated Services Digital Network (ISDN) which offers a transmission speed of 64 Kbps/s~1.5 Mbps/s, it is not practical to transmit video shot by television cameras directly through ISDN.

Against this backdrop, information compression techniques have become required, and moving picture compression techniques compliant with H.261 and H.263 standards internationally standardized by ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) are employed for video phones, for example (See, for example, Information technology—Coding of audio-visual objects—Part 2: video (ISO/IEC 14496-2), pp. 146-148, 1999. 12. 1). Moreover, according to information compression techniques compliant with the MPEG-1 standard, it is possible to store picture information in an ordinary music CD (compact disc) together with sound information.



Here, MPEG (Moving Picture Experts Group) is an international standard on compression of moving picture signals, and MPEG-1 is a standard for compressing television signal information approximately into one hundredth so that moving picture signals can be transmitted at a rate of 1.5 Mbps. Furthermore, since transmission speed within the scope of the MPEG-1 standard is limited primarily to about 1.5 Mbps, MPEG-2, which was standardized with a view to satisfy requirements for further improved picture quality, allows data transmission of moving picture signals at a rate of 2~15 Mbps. Furthermore, MPEG-4 which achieves a higher compression ratio than that of MPEG-1 and MPEG-2, allows coding, decoding and operation in an object unit, and realizes a new function required for the multimedia age, has been standardized by the working group (ISO/IEC JTC1/SC29/WG11) which has been engaged in the standardization of MPEG-1 and MPEG-2. MPEG-4 was initially aimed at standardization of a coding method for a low bit rate, but now it is extended to standardization of a more versatile coding method for moving pictures further including interlace images and higher bit rates.

In the above-mentioned moving picture coding, the amount of information is compressed by exploiting redundancies in the spatial and temporal directions. Here, inter picture prediction coding is used as a method of using the temporal redundancies. In the inter picture prediction coding, a picture is coded using a temporarily forward or backward picture as a reference picture. The motion (a motion vector) of the current picture to be coded from the reference picture is estimated, and the difference between the picture obtained by the motion compensation and the current picture is calculated. Then, the spatial redundancies are eliminated from this difference, so as to compress the information amount of the moving picture.

In a moving picture coding method in compliance with MPEG-1, MPEG-2, MPEG-4, H.263, H.26L or the like, a picture which is not inter picture prediction coded, namely, which is intra picture coded, is called an I-picture. Here, a picture means a single coding unit including both a frame and a field. Also, a picture which is inter picture prediction coded with reference to one picture is called a P-picture, and a picture which is inter picture prediction coded with reference to two previously processed pictures is called a B-picture.

FIG. **1** is a diagram showing a predictive relation between pictures in the above-mentioned moving picture coding method.

In FIG. **1**, a vertical line indicates one picture, with a picture type (I, P or B) indicated at the lower right thereof. Also, FIG. **1** indicates that a picture pointed by an arrow is inter picture prediction coded using a picture located at the other end of the arrowhead as a reference picture. For example, a B-picture which is the second from the left is coded using the first I-picture and the fourth P-picture as reference pictures.

In the moving picture coding method in compliance with MPEG-4, H.26L or the like, a coding mode called direct mode can be selected for coding a B-picture.

An inter picture prediction coding method in direct mode will be explained with reference to FIG. **2**.

FIG. **2** is an illustration for explaining the inter picture prediction coding method in direct mode.

It is now assumed that a block C in a picture B**3** is coded in direct mode. In this case, a motion vector MVp of a block X in a reference picture (a picture P**4** that is a backward

reference picture, in this case) which has been coded immediately before the picture B3 is exploited, where the block X is co-located with the block C. The motion vector MVp is a motion vector which was used when the block X was coded, and refers to a picture P1. The block C is bi-directionally predicted from the reference pictures, namely, the picture P1 and the picture P4, using motion vectors parallel to the motion vector MVp. The motion vectors used for coding the block C are, in this case, a motion vector MVFc for the picture P1 and a motion vector MVBc for the picture P4.

In the moving picture coding method in compliance with MPEG-4, H.26L or the like, a difference between a predictive value obtained from motion vectors of neighboring blocks and a motion vector of a current block to be coded is coded for coding the motion vector. In the following description, a "predictive value" indicates a predictive value of a motion vector. Since motion vectors of neighboring blocks have similar direction and motion in many cases, the amount of coding the motion vector can be reduced by coding the difference from the predictive value obtained from the motion vectors of the neighboring blocks.

Here, a motion vector coding method in MPEG-4 will be explained with reference to FIGS. 3A-3D.

FIGS. 3A-D are illustrations for explaining a method for coding a motion vector MV of a current block A to be coded in MPEG-4.

In FIGS. 3A~3D, blocks indicated by a thick line are macroblocks of 16×16 pixels, and there exist 4 blocks of 8×8 pixels in each macroblock. Here, it is assumed that a motion vector is obtained at a level of a block of 8×8 pixels.

As shown in FIG. 3A, as for a current block A located at the upper left in a macroblock, a difference between a predictive value and a motion vector MV of the current block A is coded, where the predictive value is calculated from a motion vector MVb of a neighboring block B to the left of the current block A, a motion vector MVc of a neighboring block C just above the current block A and a motion vector MVd of a neighboring block D above and to the right of the current block A.

Similarly, as shown in FIG. 3B, as for a current block A located at the upper right in a macroblock, a difference between a predictive value and a motion vector MV of the current block A is coded, where the predictive value is calculated from a motion vector MVb of a neighboring block B to the left of the current block A, a motion vector MVc of a neighboring block C just above the current block A and a motion vector MVd of a neighboring block D above and to the right of the current block A.

As shown in FIG. 3C, as for a current block A located at the lower left in a macroblock, a difference between a predictive value and a motion vector MV of the current block A is coded, where the predictive value is calculated from a motion vector MVb of a neighboring block B to the left of the current block A, a motion vector MVc of a neighboring block C just above the current block A and a motion vector MVd of a neighboring block D above and to the right of the current block A.

As shown in FIG. 3D, as for a current block A located at the lower right in a macroblock, a difference between a predictive value and a motion vector MV of the current block A is coded, where the predictive value is calculated from a motion vector MVb of a neighboring block B to the left of the current block A, a motion vector MVc of a neighboring block C above and to the left of the current block A and a motion vector MVd of a neighboring block D just above the current block A. Here, the predictive value is calculated using the medians obtained from the horizontal and vertical components of these three motion vectors MVb, MVc and MVd respectively.

Next, a motion vector coding method in H.26L which has been developed for standardization will be explained with reference to FIG. 4.

FIG. 4 is an illustration for explaining a method for coding a motion vector MV of a current block A in H.26L.

A current block A is a block of 4×4 pixels, 8×8 pixels or 16×16 pixels, and a motion vector of this current block A is coded using a motion vector of a neighboring block B including a pixel b located to the left of the current block A, a motion vector of a neighboring block C including a pixel c located just above the current block A and a motion vector of a neighboring block D including a pixel d located above and to the right of the current block A. Note that the sizes of the neighboring blocks B, C and D are not limited to those as shown in FIG. 4 by dotted lines.

FIG. 5 is a flowchart showing the procedure of coding the motion vector MV of the current block A using the motion vectors of the neighboring blocks as mentioned above.

First, the neighboring block which refers to the picture that the current block A refers to is specified out of the neighboring blocks B, C and D (Step S502), and the number of specified neighboring blocks is determined (Step S504).

When the number of the neighboring blocks determined in Step S504 is 1, the motion vector of that neighboring block which refers to the same picture is considered to be a predictive value of the motion vector MV of the current block A (Step S506).

When the number of the neighboring blocks determined in Step S505 is another value other than 1, the motion vector of the neighboring block which refers to another picture other than the picture that the current block A refers to, out of the neighboring blocks B, C and D, is considered to be 0 (Step S507). And the median of the motion vectors of the neighboring blocks B, C and D is considered to be a predictive value of the motion vector of the current block A (Step S508).

Using the predictive value derived in Step S506 or Step S508 in this manner, the difference between the predictive value and the motion vector MV of the current block A is calculated and the difference is coded (Step S510).

As described above, in the motion vector coding methods in compliance with MPEG-4 and H.26L, motion vectors of neighboring blocks are exploited when coding a motion vector of a current block to be coded.

However, there are cases where motion vectors of neighboring blocks are not coded. For example, they are cases where a neighboring block is intra picture coded, a B-picture is coded in direct mode, and a P-picture is coded in skip mode. In these cases, the neighboring blocks are coded using the motion vectors of other blocks except when they are intra picture coded, namely, the neighboring blocks are coded using their own motion vectors based on the result of motion estimation.

So, according to the above-mentioned traditional motion vector coding method, a motion vector of a current block is coded as follows: When there exists one neighboring block, out of three neighboring blocks, which has no motion vector based on the above result of motion estimation and has been coded using motion vectors of other blocks, the motion vector of that neighboring block is considered to be 0. When there exist two such neighboring blocks, the motion vector of the remaining one neighboring block is used as a predic-

tive value. And when there exist three neighboring blocks, the motion vector is coded considering a predictive value to be 0.

However, in direct mode or skip mode, motion compensation is actually performed as is the case where a motion vector of a neighboring block itself is used based on the estimation result, although the motion vector information is not coded. As a result, in the above traditional method, if a neighboring block is coded in direct mode or skip mode, the motion vector of the neighboring block is not used as a candidate for a predictive value. So, there is a problem of causing an inaccurate predictive value of a motion vector when coding the motion vector, and thus causing lower coding efficiency.

The present invention is conceived to solve this problem, and the object thereof is to provide a motion vector coding method and a motion vector decoding method for obtaining a more accurate predictive value for higher coding efficiency.

## DISCLOSURE OF INVENTION

In order to achieve the above object, the motion vector coding method according to the present invention is a motion vector coding method for coding a motion vector of a current block in a moving picture, comprising: a neighboring block specification step of specifying a neighboring block which is located in the neighborhood of the current block and has already been coded; a judgment step of judging whether or not the neighboring block has been coded using a motion vector of another block; a prediction step of deriving a predictive motion vector of the current block using a motion vector calculated from the motion vector of said another block as a motion vector of the neighboring block, when it is judged in the judgment step that the neighboring block has been coded using the motion vector of said another block; and a coding step of coding the motion vector of the current block using the predictive motion vector.

As a result, when a motion vector of a current block is coded using a predictive motion vector derived from motion vectors of neighboring blocks, if any of the neighboring blocks has been coded using motion vectors of other blocks, the motion vector of the neighboring block is not considered to be 0 but to be the motion vector calculated from the motion vectors of the other blocks. Therefore, a more accurate predictive motion vector can be obtained, and thus efficiency of coding the motion vector can be improved.

Also, the motion vector decoding method according to the present invention is a motion vector decoding method for decoding a coded motion vector of a current block in a moving picture, comprising: a neighboring block specification step of specifying a neighboring block which is located in the neighborhood of the current block and has already been decoded, a judgment step of judging whether or not the neighboring block has been coded using a motion vector of another block; a prediction step of deriving a predictive motion vector of the current block using a motion vector calculated from the motion vector of said another block as a motion vector of the neighboring block, when it is judged in the judgment step that the neighboring block has been coded using the motion vector of said another block; and a decoding step of decoding the coded motion vector of the current block using the predictive motion vector.

As a result, the motion vector which has been coded according to the motion vector coding method of the present invention can be properly decoded, and thus the practical value thereof is high.

Note that the present invention can also be realized as a moving picture coding apparatus and a program using the above-mentioned motion vector coding method, and a storage medium storing the program, and a motion picture decoding apparatus and a program using the above-mentioned motion vector decoding method, and a storage medium storing the program.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram showing a predictive relation between pictures in a moving picture coding method.

FIG. **2** is an illustration for explaining the inter picture prediction method in direct mode.

FIGS. **3**A-**3**D are illustrations for explaining a method for coding a motion vector of a current block in MPEG-4.

FIG. **4** is an illustration for explaining a method for coding a motion vector of a current block in H.26L.

FIG. **5** is a flowchart showing the coding procedure in H26L.

FIG. **6** is a block diagram showing a structure of a moving picture coding apparatus in a first embodiment of the present invention.

FIGS. **7**A and **7**B are diagrams showing how the pictures in a frame memory are inputted and outputted in the first embodiment.

FIG. **8** is a flowchart showing an operation of a motion vector coding unit in the first embodiment.

FIG. **9** is an illustration for explaining how to code a neighboring block in skip mode in the first embodiment.

FIG. **10** is an illustration for explaining inter picture prediction coding using bi-directional motion vectors in the first embodiment.

FIG. **11** is an illustration for explaining how to code a neighboring block in temporal direct mode in the first embodiment.

FIG. **12** is an illustration for explaining how to code a neighboring block in spatial direct mode in the first embodiment.

FIG. **13** is a flowchart showing another operation of the motion vector coding unit in the first embodiment.

FIG. **14** is a block diagram showing a structure of a moving picture decoding apparatus in a second embodiment of the present invention.

FIG. **15** is a flowchart showing an operation of a motion vector decoding unit in the second embodiment.

FIGS. **16**A and **16**B are illustrations for explaining how the pictures are inputted to and outputted from the moving picture decoding apparatus in the second embodiment.

FIG. **17** is a flowchart showing another operation of the motion vector decoding unit in the second embodiment.

FIGS. **18**A-**18**C are illustrations of a recording medium in a third embodiment of the present invention.

FIG. **19** is a block diagram showing an overall configuration of a content providing system in a fourth embodiment of the present invention.

FIG. **20** is a front view of a mobile phone in the fourth embodiment.

FIG. **21** is a block diagram of the mobile phone in the fourth embodiment.

FIG. **22** is a block diagram showing an overall configuration of a digital broadcasting system in the fourth embodiment.

## DETAILED DESCRIPTION OF THE INVENTION

(First Embodiment)

A moving picture coding apparatus in a first embodiment of the present invention will be explained with reference to the figures.

FIG. **6** is a block diagram of the moving picture coding apparatus in the first embodiment of the present invention.

This moving picture coding apparatus **100** aims at improving coding efficiency by improving accuracy of a predictive value of a motion vector, and includes a frame memory **101**, a difference calculation unit **102**, a prediction error coding unit **103**, a bit stream generation unit **104**, a prediction error decoding unit **105**, an addition unit **106**, a frame memory **107**, a motion vector estimation unit **108**, a mode selection unit **109**, a coding control unit **110**, switches **111**~**115**, a motion vector storage unit **116** and a motion vector coding unit **117**.

The frame memory **101** is a picture memory for holding inputted pictures on a picture-by-picture basis, and reorders the pictures inputted and obtained in order of time into coding order for output. The pictures are reordered under the control of the coding control unit **110**.

FIG. **7**A shows how the pictures are inputted in the frame memory **101**.

In FIG. **7**A, vertical lines show pictures, and an alphabet and a number at the lower right of each picture indicates a picture type (I, P or B) and a picture number in order of time. The pictures inputted to the frame memory **101** are reordered into coding order. The pictures are reordered into coding order based on the reference relations in inter picture prediction coding, that is, the pictures are reordered so that the pictures used as reference pictures are coded earlier than the pictures which refer to those reference pictures. For example, the reference relations of the pictures P**7**~P**13** are shown by arrows in FIG. **7**A. In FIG. **7**A, the arrowheads indicate the pictures which refer to reference pictures, and the other ends of the arrows indicate the reference pictures. In this case, the pictures shown in FIG. **7**A are reordered into those as shown in FIG. **7**B.

FIG. **7**B shows the pictures inputted as shown in FIG. **7**A and reordered. The pictures reordered in the frame memory **101** are read out on a macroblock basis. In this case, a macroblock is horizontal 16×vertical 16 pixels in size.

The difference calculation unit **102** obtains image data of every macroblock from the frame memory **101** via the switch **111**, and also obtains a motion compensation image from the mode selection unit **109**. Then, the difference calculation unit **102** calculates the difference between the image data and the motion compensation image on a macroblock basis to generate a prediction error image for output.

The prediction error coding unit **103** performs coding processing including frequency transformation like discrete cosine transformation and quantization on the image data obtained from the frame memory **101** via the switch **112** and the prediction error image obtained by the difference calculation unit **102**, so as to create coded data. For example, the frequency transformation and quantization are performed in a unit of horizontal 8×vertical 8 pixels. Then, the prediction error coding unit **103** outputs the coded data to the bit stream generation unit **104** and the prediction error decoding unit **105**.

The bit stream generation unit **104** performs variable length coding on the coded data outputted from the prediction error coding unit **103**, converts the data into that in a bit stream format for output, and further adds information on motion vectors inputted from the motion vector coding unit **117**, information on a coding mode inputted from the mode selection unit **109**, header information and others, so as to generate a bit stream.

The prediction error decoding unit **105** inversely quantizes the coded data outputted from the prediction error coding unit **103**, and then performs inverse frequency transformation such as inverse discrete cosine transformation so as to decode it into a prediction error image.

The addition unit **106** adds the motion compensation image to the prediction error image obtained as a result of decoding, and outputs a decoded picture that is image data indicating an image of one picture which has been coded and decoded.

The frame memory **107** is a picture memory which holds, on a picture-by-picture basis, pictures used as reference pictures when coding other pictures, out of the decoded pictures outputted from the addition unit **106**.

The motion vector estimation unit **108** estimates motion vectors of each block in a current macroblock to be coded, using the decoded pictures accumulated in the frame memory **107** as reference pictures. The estimated motion vectors are outputted to the mode selection unit **109**.

The mode selection unit **109** determines a coding mode of the macroblock using the motion vectors estimated by the motion vector estimation unit **108**. Here, the coding mode means a method for coding a macroblock. For example, when a current picture is a P-picture, the mode selection unit **109** determines a coding mode out of the following: intra picture coding, inter picture prediction coding using motion vectors, and skip mode (inter picture prediction coding in which no motion vector of a current block is coded because prediction coding is performed using a motion vector obtained from motion vectors of other blocks, and no coefficient value is coded because all the coefficient values are 0 as a result of the prediction error coding). Generally, a coding mode is determined so as to minimize a coding error using a predetermined bit amount.

The mode selection unit **109** outputs the determined coding mode to the bit stream generation unit **104**, and outputs the motion vectors used for that coding mode to the motion vector coding unit **117**, respectively. When the determined coding mode is inter picture prediction coding using motion vectors, the mode selection unit **109** further stores the motion vectors and the coding mode used for that inter picture prediction coding in the motion vector storage unit **116**.

Also, the mode selection unit **109** performs motion compensation based on the determined coding mode and the motion vectors estimated by the motion vector estimation unit **108** so as to create a motion compensation image, and outputs the motion compensation image to the difference calculation unit **102** and the addition unit **106**. However, if intra picture coding is selected, no motion compensation image is outputted. When selecting intra picture coding, the mode selection unit **109** further controls the switch **111** and the switch **112** to connect to a terminal "a" and a terminal "c" respectively, and when selecting inter picture prediction coding, it controls the switch **111** and the switch **112** to connect to a terminal "b" and a terminal "d" respectively. The above-mentioned motion compensation is performed on a block-by-block basis (8×8 pixels in this case).

The coding control unit **110** determines a picture type (I, P or B) used for coding an inputted picture, and controls the switches **113**, **114** and **115** depending on the picture type. Here, a picture type is generally determined using a method for allocating a picture type periodically, for example.

The motion vector storage unit **116** obtains the motion vectors used for inter picture prediction coding and the coding mode from the mode selection unit **109**, and stores them.

When the mode selection unit **109** selects inter picture prediction coding using motion vectors, the motion vector coding unit **117** codes a motion vector of a current block by the methods illustrated in FIGS. **3**A-**3**D and FIG. **4**. As described above, the motion vector coding unit **117** specifies three neighboring blocks of the current block, determines a predictive value based on the motion vectors of the neighboring blocks, and codes a difference between the predictive value and the motion vector of the current block to be coded.

When coding a motion vector of a current block, if a neighboring block is coded using motion vectors of other blocks, such as skip mode and direct mode, the motion vector coding unit **117** in the present embodiment does not consider the motion vector of the neighboring block to be 0 as the conventional art does, but treats a motion vector obtained from the motion vectors of the other blocks as the motion vector of the neighboring block when coding it.

FIG. **8** is a flowchart showing the general operation of the motion vector coding unit **117** in the present embodiment.

First, the motion vector coding unit **117** specifies three previously coded neighboring blocks of a current block (Step S**100**).

The motion vector coding unit **117** judges whether each of the specified neighboring blocks is a neighboring block Ba which has been coded using motion vectors of other blocks or a neighboring block Bb which has been coded without using motion vectors of other blocks (Step S**102**).

As a result, the motion vector coding unit **117** determines whether the specified three neighboring blocks include a neighboring block Ba or not (Step S**104**).

When it is judged in Step S**104** that the neighboring block Ba is included (Y in Step S**104**), the motion vector coding unit **117** derives a predictive value from the motion vectors of the three neighboring blocks by treating a motion vector obtained from the motion vectors of the other blocks as a motion vector of the neighboring block Ba for coding it, as mentioned above (Step S**106**).

On the other hand, when it is judged in Step S**104** that the neighboring block Ba is not included (N in Step s**104**), the motion vector coding unit **117** derives a predictive value from motion vectors obtained based on the motion estimation from respective three neighboring blocks Bb and the mode selection (Step S**108**).

Then, the motion vector coding unit **117** codes a difference between the motion vector of the current block and the predictive value derived in Steps S**106** or S**108** (Step S**110**). The motion vector coding unit **117** also outputs the motion vector coded as above to the bit stream generation unit **104**.

Here, the above-mentioned coding processing by the moving picture coding apparatus **100** will be explained specifically by taking coding of a picture P**13** and a picture B**11** as shown in FIGS. **7**A and **7**B as an example.

(Coding of Picture P**13**)

Since the picture P**13** is a P-picture, the moving picture coding apparatus **100** codes the picture **13** by inter picture prediction coding using another picture as a reference picture. In this case, the reference picture is a picture P**10**. This picture P**10** has been already coded, and the decoded picture thereof is stored in the frame memory **107**.

When coding a P-picture, the coding control unit **110** controls the switches **113**, **114** and **115** to be ON. Therefore, macroblocks in the picture P**13** which are read out from the frame memory **101** are obtained by the motion vector estimation unit **108**, the mode selection unit **109** and the difference calculation unit **102**.

The motion vector estimation unit **108** estimates the motion vector of each block in the macroblock using the decoded picture of the picture P**10** stored in the frame memory **107** as a reference picture, and outputs the estimated motion vector to the mode selection unit **109**.

The mode selection unit **109** determines a coding mode of the macroblock in the picture P**13** using the motion vector estimated by the motion vector estimation unit **108**. Since the picture P**13** is a P-picture, the mode selection unit **109** determines, as mentioned above, a coding mode out of the following: intra picture coding, inter picture prediction coding using motion vectors, and skip mode (an inter picture prediction coding in which no motion vector of a current block is coded because prediction coding is performed using a motion vector obtained from motion vectors of other blocks, and no coefficient value is coded because all the coefficient values are 0 as a result of the prediction error coding).

When the mode selection unit **109** selects inter picture prediction coding using motion vectors, the motion vector coding unit **117** in the present embodiment codes the motion vector of the current block in the picture P**13** by the method as illustrated in FIGS. **3**A-**3**D. When a neighboring block of the current block is coded in skip mode, the motion vector coding unit **117** does not consider the motion vector of the neighboring block to be 0, but treats a motion vector obtained from other blocks for coding the neighboring block as a motion vector of that block.

A method of coding a motion vector of a current block used when a neighboring block is coded in skip mode will be explained.

FIG. **9** is an illustration for explaining how to code a neighboring block C in skip mode.

As shown in FIG. **9**, when a neighboring block C in the picture P**13** is coded in skip mode, a median of a motion vector MVe of a block E, a motion vector MVf of a block F and a motion vector MVg of a block G, which are located in the neighborhood of the neighboring block C, is calculated, and the neighboring block C is coded using a motion vector MVcm indicating the median. Here, a median of motion vectors is obtained by calculating medians of horizontal and vertical components of the motion vectors respectively, for example.

When coding the motion vector of the current block A as shown in FIG. **9**, the motion vector coding unit **117** specifies the three neighboring blocks B, C and D of the current block A (as for the locations of the blocks B, C and D, see FIGS. **3**A-**3**D and FIG. **4**), and judges whether or not each of the neighboring blocks B, C and D is a block which has been coded using motion vectors of other blocks. As a result, when it is judged that only the neighboring block C is coded in skip mode, that is, coded using other blocks, the motion vector coding unit **117** treats the median (a motion vector MVcm) calculated from the motion vectors of the other blocks E, F and G for coding the neighboring block C as a motion vector of the neighboring block C, as mentioned above, and calculates the median of the motion vector MVcm and the motion vectors of the neighboring blocks B and D so as to consider it as a predictive value of the motion

vector of the current block A. Then, the motion vector coding unit **117** codes a difference between the predictive value and the motion vector of the current block A.

The motion vector storage unit **116** stores coding modes of coded blocks. The motion vector coding unit **117** judges whether each of the neighboring blocks B, C and D is a block coded using motion vectors of other blocks or not based on the coding modes stored in the motion vector storage unit **116**. The motion vector storage unit **116** further stores motion vectors of blocks which have been coded without using motion vectors of other blocks but using their own motion vectors estimated from reference pictures. To be more specific, the motion vector storage unit **116** stores the motion vectors MVe, MVf and MVg of the blocks E, F and G, and the motion vector coding unit **117** calculates the above-mentioned motion vector MVcm of the neighboring block C using these motion vectors stored in the motion vector storage unit **116** when coding the motion vector of the current block A. Note that as for a picture which has been coded using motion vectors of other blocks, a motion vector thereof which is obtained by calculating a median of the motion vectors of the other blocks may be stored in the motion vector storage unit **116** in advance. In this case, since the motion vector storage unit **116** stores the motion vector MVcm in advance, the motion vector coding unit **117** does not need to calculate the motion vector MVcm of the neighboring block C but can use the motion vector MVcm stored in the motion vector storage unit **116** directly as a motion vector of the neighboring block C, when coding the motion vector of the current block A.

On the other hand, a prediction error image indicating a difference between a current macroblock in the picture P**13** and a motion compensation image is coded by the prediction error coding unit **103** and generated as coded data, and information on the motion vector coded as mentioned above is added to the coded data by the bit stream generation unit **104**. However, a difference between a macroblock which has been coded in skip mode and a motion compensation image is 0, and information on the motion vector is not added to the coded data.

The remaining macroblocks in the picture P**13** are coded in the same manner. After completing coding of all the macroblocks in the picture P**13**, coding of the picture B**11** follows.

(Coding of Picture B**11**)

Since the picture B**11** is a B-picture, the moving picture coding apparatus **100** codes the picture B**11** by inter picture prediction coding using two other pictures as reference pictures. In this case, the reference pictures are the picture P**10** located forward of the picture B**11** and the picture P**13** located backward of the picture B**11**. These pictures P**10** and P**13** have been already coded, and the decoded pictures thereof are stored in the frame memory **107**.

When coding a B-picture, the coding control unit **110** controls the switch **113** to be ON and the switches **114** and **115** to be OFF. Therefore, macroblocks in the picture B**11** which are read out from the frame memory **101** are obtained by the motion vector estimation unit **108**, the mode selection unit **109** and the difference calculation unit **102**.

The motion vector estimation unit **108** estimates the forward motion vector and the backward motion vector of each block in a macroblock using a decoded picture of the picture P**10** stored in the frame memory **107** as a forward reference picture and a decoded picture of the picture P**13** as a backward reference picture, and outputs the estimated forward and backward motion vectors to the mode selection unit **109**.

The mode selection unit **109** determines a coding mode of the macroblock in the picture B**11** using the forward and backward motion vectors estimated by the motion vector estimation unit **108**. Since the picture B**11** is a B-picture, the mode selection unit **109** determines a coding mode out of the following: intra picture coding, inter picture prediction coding using forward motion vectors, inter picture prediction coding using backward motion vectors, inter picture prediction coding using bi-directional motion vectors, and direct mode (inter picture prediction coding in which motion compensation is performed using a motion vector obtained from motion vectors of other blocks and no motion vector is coded), for example.

When the mode selection unit **109** selects inter picture prediction coding using motion vectors, the motion vector coding unit **117** in the present embodiment codes the motion vectors of the current block in the picture B**11** by the method as illustrated in FIGS. **3**A-**3**D.

More specifically, when the mode selection unit **109** selects inter picture prediction coding using bi-directional motion vectors, the motion vector coding unit **117** codes the motion vectors of the current block in the following manner.

FIG. **10** is an illustration for explaining inter picture prediction coding using bi-directional motion vectors.

When coding motion vectors of a current block A, the motion vector coding unit **117** codes a forward motion vector MVF and a backward motion vector MVB.

To be more specific, the motion vector coding unit **117** considers a median of forward motion vectors MVF**1**, MVF**2** and MVF**3** of the neighboring blocks B, C and D to be a predictive value of the forward motion vector MVF, and codes a difference between the forward motion vector MVF and the predictive value thereof. The motion vector coding unit **117** also considers a median of backward motion vectors MVB**1**, MVB**2** and MVB**3** of the neighboring blocks B, C and D to be a predictive value of the backward motion vector MVB, and codes a difference between the backward motion vector MVB and the predictive value thereof. Here, the median of the motion vectors is obtained by calculating medians of horizontal and vertical components of the motion vectors respectively, for example.

When coding motion vectors of a current block in a B-picture, if a neighboring block has been coded in direct mode, the motion vector coding unit **117** in the present embodiment does not consider the motion vectors of the neighboring block to be 0, but considers motion vectors obtained from other blocks as motion vectors of the neighboring block. There are two types of direct modes: temporal direct mode and spatial direct mode.

First, how to code motion vectors of a current block when a neighboring block is coded in temporal direct mode will be explained.

FIG. **11** is an illustration for explaining how to code the neighboring block in temporal direct mode.

As shown in FIG. **11**, when the neighboring block C in the picture B**11** is coded in direct mode, a motion vector MVp of a block X, which is co-located with the neighboring block C, in the picture P**13** that is a just previously coded backward reference picture, is used. The motion vector MVp is a motion vector used for coding the block X, and is stored in the motion vector storage unit **116**. This motion vector MVp refers to the picture P**10**. The neighboring block C is coded by bi-directional prediction from the reference pictures, the picture P**10** and the picture P**13**, using motion vectors parallel to the motion vector MVp. In this case, the motion

vectors used for coding the neighboring block C are a motion vector MVFc for the picture P**10** and a motion vector MVBc for the picture P**13**.

In this case where the forward motion vector MVFc is mvf, the backward motion vector MVBc is mvb, the motion vector MVp is mvp, the temporal distance between the backward reference picture (picture P**13**) for the current picture (picture B**11**) and the reference picture (picture P**10**) pointed by the block in the backward reference picture is TRD, and the temporal distance between the current picture (picture B**11**) and the reference picture (picture P**10**) pointed by the block in the backward reference picture is TRB, mvf and mvb are respectively calculated by Equation 1 and Equation 2.

$$mvf=mvp\times TRB/TRD \quad \text{Equation 1}$$

$$mvb=(TRB-TRD)\times xmvp/TRD \quad \text{Equation 2}$$

where mvf and mvb respectively represent horizontal components and vertical components of the motion vectors. And the plus values indicate the direction of the motion vector MVp, and the minus values indicate the direction opposite to that of the motion vector MVp.

The neighboring block C is coded using the motion vectors MVFc and MVBc obtained as mentioned above.

When coding the motion vectors MVF and MVB of the current block A as shown in FIG. **10**, the motion vector coding unit **117** specifies the three neighboring blocks B, C and D of the current block A, and judges whether or not each of the neighboring blocks B, C and D is a block which has been coded using a motion vector of another block. As a result, when it is judged that only the neighboring block C is coded in temporal direct mode, that is, coded using the motion vector of the other block, the motion vector coding unit **117** treats the motion vectors MVFc and MVBc calculated from the motion vector MVp of the block X that is the other block for coding the neighboring block C as motion vectors of the neighboring block C, and calculates the medians of the motion vectors MVFc and MVBc and the motion vectors of the neighboring blocks B and D so as to derive predictive values of the motion vectors of the current block A. A forward predictive value and a backward predictive value are derived separately. Then, the motion vector coding unit **117** codes differences between the predictive values and the motion vectors MVF and MVB of the current block A, respectively.

The motion vector storage unit **116** stores coding modes of coded blocks, and based on the coding modes stored in this motion vector storage unit **116**, the motion vector coding unit **117** judges whether or not each of the neighboring blocks B, C and D has been coded using motion vectors of other blocks. The motion vector storage unit **116** further stores motion vectors of blocks which have been coded without using motion vectors of other blocks but using their own motion vectors estimated from reference pictures. In other words, when coding the motion vectors of the current block A, the motion vector coding unit **117** uses the motion vectors stored in the motion vector storage unit **116** as they are for the neighboring blocks B and D, but for the neighboring block C, it reads out the motion vector MVp of the block X stored in the motion vector storage unit **116** to calculate the motion vectors MVFc and MVBc. Note that the motion vector storage unit **116** may store in advance motion vectors calculated from motion vectors of other blocks in order to code a block which has been coded using the motion vectors of the other blocks. In this case, the motion vector storage unit **116** stores in advance the motion vectors MVFc and MVBc. Therefore, when coding the motion vectors of the current block A, the motion vector coding unit **117** does not need to read out the motion vector MVp of the block X so as to calculate the motion vectors MVFc and MVBc of the neighboring block C using Equation 1 and Equation 2, but can use the motion vectors MVFc and MVBc stored in the motion vector storage unit **116** directly as the motion vectors of the neighboring block C.

Next, a method for coding motion vectors of a current block in a case where a neighboring block is coded in spatial direct mode will be explained.

FIG. **12** is an illustration for explaining how to code a neighboring block in spatial direct mode.

As shown in FIG. **12**, when a neighboring block C of the picture B**11** is coded in spatial direct mode, it is coded using motion vectors MVFc and MVBc calculated based on medians in the forward and backward directions respectively which are obtained from the motion vectors MVFe and MVBe of the block E, the motion vectors MVFf and MVBf of the block F and the motion vectors MVFg and MVBg of the block G, where the blocks E, F and G are located in the neighborhood of the neighboring block C.

When coding the motion vectors MVF and MVB of the current block A as shown in FIG. **10**, the motion vector coding unit **117** specifies the three neighboring blocks B, C and D in the neighborhood of the current block A, and judges whether each of the neighboring blocks B, C and D is a block which has been coded using motion vectors of other blocks or not. As a result, when the motion vector coding unit **117** judges that only the neighboring block C has been coded in spatial direct mode, that is, using motion vectors of other blocks, it treats the motion vectors MVFc and MVBc calculated from the blocks E, F and G which are the other blocks used for coding the neighboring block C as the motion vectors of the neighboring block C, calculates the medians of the motion vectors MVFc and MVBc and the motion vectors of the neighboring blocks B and D, and thus derives predictive values of the motion vectors of the current block A, as shown in FIG. **12**. Then, the motion vector coding unit **117** codes differences between the predictive values and the motion vectors MVF and MVB of the current block A.

The motion vector storage unit **116** stores motion vectors of blocks which have been coded without using motion vectors of other blocks but using their own motion vectors estimated from reference pictures. In other words, it stores two motion vectors in the forward and backward directions for each of the blocks E, F and G. When coding the motion vectors of the current block A, the motion vector coding unit **117** calculates the motion vectors MVFc and MVBc of the neighboring block C using these motion vectors stored in the motion vector storage unit **116**. Note that the motion vector storage unit **116** may store in advance two motion vectors in the forward and backward directions which are calculated based on medians obtained from motion vectors of other blocks in order to code a block which has been coded using the motion vectors of the other blocks. In this case, the motion vector storage unit **116** stores in advance the motion vectors MVFc and MVBc. Therefore, when coding the motion vectors of the current block A, the motion vector coding unit **117** does not need to calculate the motion vectors MVFc and MVBc of the neighboring block C, but can use the motion vectors MVFc and MVBc stored in the motion vector storage unit **116** directly as the motion vectors of the neighboring block C.

As described above, when the neighboring block C is coded in the above temporal direct mode, the motion vectors

of the backward reference picture (the picture P**13** in the above case) of the current picture needs to be stored in the motion vector storage unit **116**, but when the neighboring block C is coded in spatial direct mode, the storage thereof can be omitted.

Here, when coding motion vectors of a current block, the moving picture coding apparatus **100** performs an exceptional processing if a neighboring block of the current block is not inter picture prediction coded, as mentioned above, but intra picture coded.

For example, when there exists one block which has been intra picture coded in the three neighboring blocks, the motion vector coding unit **117** of the moving picture coding apparatus **100** performs processing considering the motion vectors of the block to be 0. When there exist two neighboring blocks which have been intra picture coded, the motion vector coding unit **117** uses the motion vectors of the remaining one neighboring block as predictive values of motion vectors of a current block. Further, when all of the three neighboring blocks have been intra picture coded, the motion vector coding unit **117** performs coding processing of the motion vectors of the current block considering the predictive values thereof to be 0.

On the other hand, the prediction error image indicating a difference between a current macroblock in the picture B**11** and the motion compensation image has been coded by the prediction error coding unit **103** and generated as coded data, and information on the motion vectors which have been coded as mentioned above is added to the coded data by the bit stream generation unit **104**. However, information on motion vectors of a macroblock which has been coded in direct mode is not added to the coded data.

Coding processing of the remaining macroblocks in the picture B**11** is performed in the same manner. After the processing is completed for all the macroblocks in the picture B**11**, the coding processing of the picture B**12** follows.

As described above, according to the motion vector coding method of the present invention, a motion vector of each current block is coded using a predictive value derived from motion vectors of the previously coded neighboring blocks and the motion vector of the current block. If any of the neighboring blocks has been coded using a motion vector calculated from motion vectors of other blocks, for example, in skip mode or direct mode, a predictive value is derived using, as a motion vector of the neighboring block, the motion vector calculated from the motion vectors of the other blocks for coding that neighboring block.

Accordingly, when a motion vector of a current block is coded using a predictive value derived from a motion vector of a neighboring block, if the neighboring block is coded using motion vectors of other blocks, the motion vector of the neighboring block is not considered as 0 like the conventional art, but the motion vector calculated from the motion vectors of the other blocks is used as the motion vector of the neighboring block. As a result, accuracy of the above predictive value is improved, and thus efficiency of coding motion vectors can be improved.

Note that in the present embodiment, a case has been explained where a macroblock is coded in every horizontal 16×vertical 16 pixels, motion compensation is performed in every block of horizontal 8×vertical 8 pixels, and a block prediction error image is coded in every horizontal 8×vertical 8 pixels, but this processing may be performed in other units of pixels.

Also, in the present embodiment, a case has been explained where a median calculated from motion vectors of previously coded three neighboring blocks is used as a predictive value for coding a motion vector, but any other number of neighboring blocks other than three may be applied, and the predictive value may be determined by any other method. For example, a motion vector of an immediately left block may be used as a predictive value, or an average, instead of a median, may be used.

Also, in the present embodiment, locations of neighboring blocks for coding a motion vector has been explained using FIGS. **3**A-**3**D and FIG. **4**, but any other locations may be applied.

Also, in the present embodiment, a method for coding a current block using motion vectors of other blocks has been explained by taking skip mode and temporal and spatial direct modes as examples, but any other method may be used.

Also, in the present embodiment, a case has been explained where a difference between a motion vector of a current block and a predictive value obtained from motion vectors of neighboring blocks so as to code the motion vector, but any other method other than obtaining of a difference may be used to code the motion vector.

Also, in the present embodiment, a case has been explained where when a neighboring block is coded in spatial direct mode, a median of motion vectors of previously coded three blocks in the neighborhood of the neighboring block is calculated and is treated as a motion vector of the neighboring block, but any other number of blocks other than three may be used, and any other method may be used to determine the motion vector. For example, a motion vector of an immediately left block may be used as a motion vector of a neighboring block, or an average, instead of a median, may be used.

Also, in the present embodiment, when a block in a B-picture is coded in spatial direct mode, two motion vectors of the block in the forward and backward directions are calculated, but two motion vectors in the forward direction only or two motion vectors in the backward direction only may be calculated. In this case, the B-picture refers to two pictures in the forward direction only or two pictures in the backward direction.

Also, in the present embodiment, a case has been explained where one predetermined picture is referred to in coding a P-picture (a picture P**10** is referred to in coding a picture P**13**, for example) and two predetermined pictures are referred to in coding a B-picture (pictures P**10** and P**13** are referred to in coding a picture B**11**), but these P-picture and B-picture may be coded by selecting reference pictures for every macroblock or block from among a plurality of pictures. In such a case, a predictive value of a motion vector can be generated in the manner as shown in FIG. **13**.

FIG. **13** is a flowchart showing an operation the motion vector coding unit **117** conducts in deriving a predictive value of a motion vector of a current block to code the motion vector, when reference pictures are selected for every block.

First, the motion vector coding unit **117** specifies previously coded three neighboring blocks of a current block (Step S**300**).

Then, the motion vector coding unit **117** judges whether each of the specified neighboring blocks is a neighboring block Ba which has been coded using motion vectors of other blocks or a neighboring block Bb which has been coded without using motion vectors of other blocks (Step S**302**).

Here, as for the neighboring block Ba, the motion vector coding unit **117** obtains information indicating motion vec-

tors used for coding the block Ba and reference pictures for the neighboring block Ba, and treats those motion vectors used for coding the block Ba as motion vectors thereof. As for the neighboring block Bb, the motion vector coding unit **117** obtains information indicating motion vectors of the neighboring block Bb and reference pictures for the neighboring block Bb (Step S**304**).

Next, the motion vector coding unit **117** specifies, out of the three neighboring blocks, a neighboring block which refers to the picture that a current block refers to based on the information obtained in Step S**304** (Step S**306**), and determines the number of the specified neighboring blocks (Step S**308**).

Then, if the number of the neighboring blocks judged in Step S**308** is 1, the motion vector coding unit **117** considers the motion vector of the neighboring block which refers to the same picture to be a predictive value of the motion vector MV of the current block (Step S**310**).

If the number of the neighboring blocks judged in Step S**308** is not **1**, the motion vector coding unit **117** considers the motion vectors of the neighboring blocks which refer to another picture other than the current block refers to, out of the three neighboring blocks, to be 0 (Step S**312**), and considers a median of the motion vectors of the three neighboring blocks to be a predictive value of the motion vector MV of the current block (Step S**314**).

Using the predictive value derived in Step S**310** or Step S**314** as mentioned above, the motion vector coding unit **117** calculates a difference between the predictive value and the motion vector MV of the current block, and codes the difference (Step S**316**).

Also, when a motion vector is coded using a motion vector of a spatially adjacent block as a predictive value, an amount of motion vectors of 1 macroblock line (a portion of 1 macroblock high and a screen wide) needs to be stored in the motion vector storage unit **116** for coding the motion vector, if the motion vectors which have been actually used for motion compensation in skip mode or direct mode are stored in the motion vector storage unit **116**. This applies to the case where the motion vectors which have been actually used for motion compensation in skip mode or direct mode are stored in the motion vector storage unit **116**. That is why when the neighboring blocks explained in connection with FIGS. **3**A-**3**D and FIG. **4** of the present embodiment are used, there are past 1 macroblock slices of blocks which are referred to as neighboring blocks for coding the motion vector, with the current macroblock as a starting point.

(Second Embodiment)

A moving picture decoding apparatus **700** in the second embodiment of the present invention will be explained with reference to the figures.

FIG. **14** is a block diagram showing the structure of the moving picture decoding apparatus **700** in the second embodiment of the present invention.

The moving picture decoding apparatus **700** as shown in FIG. **14** decodes moving pictures coded by the moving picture coding apparatus **100** in the first embodiment, and includes a bit stream analysis unit **701**, a prediction error decoding unit **702**, a mode decoding unit **703**, a motion compensation decoding unit **705**, a motion vector storage unit **706**, a frame memory **707**, an addition unit **708**, switches **709** and **710**, and a motion vector decoding unit **711**.

The bit stream analysis unit **701** extracts various data from the inputted bit stream. Here, various data includes information on coding mode, information on motion vectors, and so on. The extracted coding mode information is outputted to the mode decoding unit **703**. The extracted motion vector information is outputted to the motion vector decoding unit **711**. Further, the extracted coded prediction error data is outputted to the prediction error decoding unit **702**.

The prediction error decoding unit **702** decodes the inputted coded prediction error data to generate a prediction error image. The generated prediction error image is outputted to the switch **709**. When the switch **709** is connected to the terminal "b", the prediction error image is outputted to the addition unit **708**.

The mode decoding unit **703** controls the switch **709** and the switch **710** with reference to the coding mode information extracted from the bit stream. If the coding mode is intra picture coding, the mode decoding unit **703** controls the switches **709** and **710** to connect to the terminal "a" and the terminal "c", respectively, and if the coding mode is inter picture coding, it controls the switches **709** and **710** to connect to the terminal "b" and the terminal "d", respectively. The mode decoding unit **703** further outputs the coding mode information to the motion vector decoding unit **711**.

The motion vector decoding unit **711** decodes the motion vector information outputted from the bit stream analysis unit **701**.

To be more specific, when the coding mode information indicates inter picture prediction coding using motion vectors, the motion vector decoding unit **711** derives a predictive value for a current block to be decoded using the motion vectors of previously decoded neighboring blocks, in the same manner as described in connection with FIGS. **3**A-**3**D and FIG. **4**. For example, as shown in FIGS. **3**A-**3**D, the motion vector decoding unit **711** derives a predictive value for a current block A from the motion vector MVb of the neighboring block B, the motion vector MVc of the neighboring block C and the motion vector MVd of the neighboring block D. Here, the predictive value is calculated based on a median calculated from each of the horizontal components and vertical components of the three previously decoded motion vectors MVb, MVc and MVd. Then, the motion vector decoding unit **711** adds the predictive value to the difference that is the motion vector information outputted from the bit stream analysis unit **701** so as to determine the motion vector MV of the current block A. When the coding mode information is any of the above-mentioned skip mode, temporal direct mode, and spatial direct mode, the motion vector decoding unit **711** determines the motion vector using only the motion vectors of the previously decoded neighboring blocks.

FIG. **15** is a flowchart showing the general operation of the motion vector decoding unit **711** in the present embodiment.

First, the motion vector decoding unit **711** specifies previously decoded three neighboring blocks of a current block to be decoded (Step S**200**).

Then, the motion vector decoding unit **711** judges whether each of the specified neighboring blocks is a neighboring block which has been coded using motion vectors of other blocks or a neighboring block Bb which has been coded without using motion vectors of other blocks (Step S**202**).

As a result, the motion vector decoding unit **711** determines whether or not a neighboring block Ba is included in the specified three neighboring blocks (Step S**204**).

When it is judged in Step S**204** that a neighboring block Ba is included (Y in Step S**204**), the motion vector decoding unit **711** derives a predictive value from the motion vectors of the three neighboring blocks by treating a motion vector

calculated from motion vectors of other blocks for decoding the neighboring block Ba as a motion vector of the neighboring block Ba, as mentioned above (Step S206).

On the other hand, when it is judged in Step S206 that a neighboring block Ba is not included (N in Step S204), the motion vector decoding unit 711 derives a predictive value from the motion vectors obtained respectively based on the estimation results of the three neighboring blocks Bb (Step S208).

Then, the motion vector decoding unit 711 adds the predictive value derived in Step S206 or S208 to the difference that is the motion vector information outputted from the bit stream analysis unit 701, so as to decode the coded motion vector of the current block (Step S210). The motion vector decoding unit 711 also outputs the decoded motion vector to the motion compensation decoding unit 705.

The motion vector storage unit 706 stores the motion vector decoded in the motion vector decoding unit 711 and the coding mode obtained in the mode decoding unit 703.

The motion compensation decoding unit 705 obtains a motion compensation image of every macroblock from the frame memory 707 based on the motion vector decoded in the motion vector decoding unit 711.

The addition unit 708 adds the inputted prediction error image and the motion compensation image to generate the decoded image, and outputs the generated decoded image to the frame memory 707.

The frame memory 707 stores the decoded image generated by the addition unit 708 on every picture basis.

The operation of this moving picture decoding apparatus 700, particularly the general operation thereof, will be explained first.

FIGS. 16A and 16B are illustrations for explaining input to and output from the moving picture decoding apparatus 700.

As shown in FIG. 16A, the moving picture decoding apparatus 700 obtains the bit stream outputted from the moving picture coding apparatus 100 in the first embodiment in output order, and decodes the pictures included in the bit stream in sequence. Then, as shown in FIG. 16B, the moving picture decoding apparatus 700 reorders the decoded pictures in display order for output.

The decoding processing performed by the above moving picture decoding apparatus 700 will be explained below by taking decoding of the picture P13 and the picture B11 as shown in FIGS. 16A and 16B as a specific example.

(Decoding of Picture P13)

First, the bit stream analysis unit 701 of the moving picture decoding apparatus 700 obtains the bit stream regarding the picture P13, and extracts the mode selection information and the motion vector information and the coded prediction error data from the bit stream.

The mode decoding unit 703 controls the switches 709 and 710 with reference to the mode selection information extracted from the bit stream of the picture P13.

A case where the mode selection information indicates inter picture prediction coding will be explained below.

The motion vector decoding unit 711 performs the above decoding processing on the motion vector information extracted from the bit stream of the picture P13 on a block-by-block basis based on the mode selection information indicating inter picture prediction coding outputted from the mode decoding unit 703.

Here, when decoding the motion vector of the current block in the picture P13, the motion vector decoding unit 711 specifies previously decoded three neighboring blocks of the current block, and judges whether each of these neighboring blocks has been coded using motion vectors of other blocks or not. When any of the neighboring blocks is a block which has been coded using motion vectors of other blocks, namely, in skip mode, the motion vector decoding unit 711 treats a motion vector calculated from the motion vectors of the other blocks for decoding the neighboring block as a motion vector of the neighboring block, in the same manner as the motion vector coding unit 117 in the first embodiment does. To be more specific, the motion vector decoding unit 711 calculates the median of the motion vectors of the previously decoded three blocks in the neighborhood of that neighboring block, and treats it as a motion vector of the neighboring block.

Also, the motion vector storage unit 706 stores the mode selection information outputted from the mode decoding unit 703, and the motion vector decoding unit 711 judges whether or not each of the neighboring blocks is a block which has been coded using motion vectors of other blocks based on the mode selection information stored in the motion vector storage unit 706. The motion vector storage unit 706 further stores the motion vectors of the other blocks used for decoding the neighboring block. To be more specific, the motion vector storage unit 706 stores the motion vectors of the three blocks in the neighborhood of the neighboring block which has been coded in skip mode. When decoding the motion vector of the current block, the motion vector decoding unit 711 calculates a median from the motion vectors of the above three blocks stored in the motion vector storage unit 706. Note that the motion vector storage unit 706 may store in advance a motion vector of a block which has been coded using motion vectors of other blocks, by calculating a median of the motion vectors for decoding the block. In this case, when decoding the motion vector of the current block, the motion vector decoding unit 711 does not need to obtain the motion vector of the neighboring block which has been coded in skip mode, but can use the motion vector stored in the motion vector storage unit 706 directly as a motion vector of the neighboring block.

On the other hand, the coded prediction error data of the current macroblock in the picture P13 is decoded in the prediction error decoding unit 702 and generated as a prediction error image, and the switches 709 and 710 are connected to the addition unit 708. Therefore, the motion compensation image generated based on the motion vector decoded in the motion vector decoding unit 711 is added to the prediction error image and outputted to the frame memory 707.

Also, when decoding a motion vector of a P-picture, the motion vector decoding unit 711 stores its motion vector and a coding mode obtained from the mode decoding unit 703 in the motion vector storage unit 706 for decoding the following pictures and blocks.

The remaining macroblocks in the picture P13 are decoded in sequence. After decoding of all of the macroblocks in the picture P13 is completed, decoding of the picture B11 follows.

(Decoding of Picture B11)

First, the bit stream analysis unit 701 of the moving picture decoding apparatus 700 obtains the bit stream of the picture B11, and extracts the mode selection information and the motion vector information and the coded prediction error data from the bit stream.

The mode decoding unit 703 controls the switches 709 and 710 with reference to the mode selection information extracted from the bit stream of the picture B11.

A case where the mode selection information indicates inter picture prediction coding will be explained below.

The motion vector decoding unit **711** performs the above decoding processing on the motion vector information extracted from the bit stream of the picture B**11** on a block-by-block basis based on the mode selection information indicating inter picture prediction coding outputted from the mode decoding unit **703**.

When decoding a motion vector of a current block in the picture B**11**, the motion vector decoding unit **711** specifies previously decoded three neighboring blocks of the current block, and judges whether or not each of these neighboring blocks has been coded using motion vectors of other blocks. When any of the neighboring blocks is a block which has been coded using motion vectors of other blocks, namely, in temporal or spatial direct mode, the motion vector decoding unit **711** treats a motion vector obtained using the motion vectors of the other blocks for decoding the neighboring block as a motion vector thereof, in the same manner as the motion vector coding unit **117** in the first embodiment does.

More specifically, when the neighboring block has been coded in temporal direct mode, the motion vector decoding unit **711** reads out from the motion vector storage unit **706** a motion vector of a block, which is co-located with a neighboring block which has been coded in direct mode, in a just previously decoded reference picture (picture P**13**). For example, as shown in FIG. **11**, if the neighboring block C has been coded in temporal direct mode, the motion vector decoding unit **711** reads out the decoded motion vector of the block X in the picture P**13** from the motion vector storage unit **706**. Then, the motion vector decoding unit **711** calculates a forward motion vector MVFc and a backward motion vector MVBc used for coding the neighboring block C using Equation 1 and Equation 2, and uses these motion vectors MVFc and MVBc as motion vectors of the neighboring block C.

In the above case, the motion vector decoding unit **711** reads out from the motion vector storage unit **706** the motion vector MVp of the block X in the picture P**13** which is co-located with the neighboring block C which has been coded in direct mode. However, as for a block which has been coded using motion vectors of other blocks, the motion vector storage unit **706** may store the motion vector of the block calculated from the motion vectors of the other blocks for decoding the block. In this case, the motion vector storage unit **706** stores the motion vectors MVFc and MVBc in advance. Therefore, when decoding the motion vector of the current block A, the motion vector decoding unit **711** does not need to calculate the motion vectors MVFc and MVBc for the neighboring block C by reading out the motion vector MVp of the block X and using Equation 1 and Equation 2, but can use the motion vectors MVFc and MVBc stored in the motion vector storage unit **706** directly as motion vectors of the neighboring block C.

On the other hand, when a neighboring block has been coded in spatial direct mode, the motion vector decoding unit **711** treats motion vectors calculated using motion vectors of other blocks in the neighborhood of the neighboring block as motion vectors thereof. For example, in the situation as shown in FIG. **12**, the motion vector decoding unit **711** calculates medians from the motion vectors of the previously decoded three blocks E, F and G in the neighborhood of the neighboring block C which has been coded in spatial direct mode, and treats the forward motion vector MVFc and the backward motion vector MVBc indicated by the medians as motion vectors of the neighboring block C.

Also, the motion vector storage unit **706** stores motion vectors used for decoding a block which has been coded without using motion vectors of other blocks. To be more specific, in the situation as shown in FIG. **12**, the motion vector storage unit **706** stores the motion vectors of the three blocks E, F and G in the neighborhood of the neighboring block C which has been coded in spatial direct mode. Therefore, when decoding the motion vector of the current block A, the motion vector decoding unit **711** calculates the motion vectors MVFc and MVBc for the neighboring block from the motion vectors of the above three blocks E, F and G stored in the motion vector storage unit **706**. Note that the motion vector storage unit **706** may store in advance motion vectors obtained by calculating medians for decoding a block which has been coded using motion vectors of other blocks. In this case, in the situation as shown in FIG. **12**, the motion vector storage unit **706** stores the motion vectors MVFc and MVBc in advance. Therefore, when decoding the motion vectors of the current block A, the motion vector decoding unit **711** does not need to calculate the motion vectors of the neighboring block C which has been coded in spatial direct mode, but can use the motion vectors MVFc and MVBc stored in the motion vector storage unit **706** directly as motion vectors of the neighboring block C.

Here, when motion vectors of a current block to be decoded are decoded, if previously decoded neighboring block of the current block has been processed in intra picture coding, not in inter picture coding as mentioned above, the moving picture decoding apparatus **700** performs exceptional processing.

For example, when one of three neighboring blocks has been intra picture coded, the motion vector decoding unit **711** of the moving picture decoding apparatus **700** performs processing considering the motion vectors of the neighboring block to be 0. When two neighboring blocks have been intra picture coded, the motion vector decoding unit **711** uses the motion vectors of the remaining one neighboring block as predictive values of the motion vectors of the current block. Further, when all the three neighboring blocks have been intra picture coded, the motion vector decoding unit **711** decodes the motion vectors of the current block considering predictive values thereof to be 0.

On the other hand, the coded prediction error data for the current macroblock in the picture B**11** has been decoded in the prediction error decoding unit **702** and generated as a prediction error image, and the switches **709** and **710** are connected to the addition unit **708**. Therefore, the motion compensation image generated based on the motion vector decoded by the motion vector decoding unit **711** is added to the prediction error image and outputted to the frame memory **707**.

Decoding processing of the remaining macroblocks in the picture B**11** is performed in the same manner. After the processing is completed for all the macroblocks in the picture B**11**, the decoding processing of the picture B**12** follows.

As described above, according to the motion vector decoding method of the present invention, a predictive value is derived from motion vectors of previously decoded neighboring blocks, and a motion vector of each current block is decoded using the predictive value and the difference. If any of the neighboring blocks has been coded using motion vectors of other blocks, for example, in skip mode or direct mode, a predictive value is derived using, as a motion vector of the neighboring block, a motion vector calculated from the motion vectors of the other blocks for decoding that neighboring block.

Accordingly, motion vectors which have been coded in the manner as shown in the first embodiment can be decoded properly.

Note that, in the present embodiment, a case has been explained where a median calculated from motion vectors of previously decoded three neighboring blocks is used as a predictive value for decoding a motion vector, but any other number of neighboring blocks than three may be applied, and the predictive value may be determined by any other method. For example, a motion vector of an immediately left block may be used as a predictive value, or an average, instead of a median, may be used.

Also, in the present embodiment, locations of neighboring blocks for decoding a motion vector has been explained using FIG. **3** and FIG. **4**, but any other locations may be applied.

Also, in the present embodiment, a method for coding a current block using motion vectors of other blocks has been explained by taking skip mode and temporal and spatial direct modes as examples, but any other mode may be used.

Also, in the present embodiment, a case has been explained where a motion vector is decoded by adding a predictive value obtained from motion vectors of neighboring blocks and a difference as indicated in a bit stream, but any other method than addition may be used to decode the motion vector.

Also, in the present embodiment, a case has been explained where when a neighboring block has been coded in spatial direct mode, a median of motion vectors of previously coded three blocks in the neighborhood of the neighboring block is calculated and is treated as a motion vector of the neighboring block, but any other number of blocks than three may be used, and any other method may be used to determine the motion vector. For example, a motion vector of an immediately left block may be used as a motion vector of the neighboring block, or an average, instead of a median, may be used.

Also, in the present embodiment, when there exists a neighboring block which has been coded in spatial direct mode, two motion vectors of the block in the forward and backward directions are calculated, but two motion vectors in the forward direction only or two motion vectors in the backward direction only may be calculated. In this case, a current B-picture to be decoded refers to two pictures in the forward direction only or two pictures in the backward direction only.

Also, in the present embodiment, a case has been explained where one predetermined picture is referred to in decoding a P-picture (the picture P**10** is referred to in decoding the picture P**13**, for example) and two predetermined pictures are referred to in decoding a B-picture (the pictures P**10** and P**13** are referred to in decoding the picture B**11**), but these P-picture and B-picture may be decoded by selecting reference pictures from among a plurality of pictures on every macroblock or block basis. In such a case, a predictive value of a motion vector can be generated in the manner as shown in FIG. **17**.

FIG. **17** is a flowchart showing an operation of the motion vector decoding unit **711** for deriving a predictive value of a motion vector of a current block to be decoded and decoding the motion vector using the predictive value when a reference picture is selected on a block-by-block basis.

First, the motion vector decoding unit **711** specifies previously decoded three neighboring blocks of the current block (Step S**400**).

Then, the motion vector decoding unit **711** judges whether each of the specified neighboring blocks is a neighboring block Ba which has been coded using motion vectors of other blocks, or a neighboring block Bb which has been coded without using motion vectors of other blocks (Step S**402**).

Here, as for the neighboring block Ba, the motion vector decoding unit **711** obtains information indicating a motion vector used for decoding the neighboring block Ba and which reference picture it refers to, and treats the motion vector used for the decoding as a motion vector of the neighboring block Ba. As for the neighboring block Bb, the motion vector decoding unit **711** obtains information indicating the motion vector of the neighboring block Bb and which reference picture it refers to (Step S**404**).

Next, the motion vector decoding unit **711** specifies the neighboring block which refers to the picture that the current block refers to, out of the three neighboring blocks, based on the information obtained in Step S**404** (Step S**406**), and determines the number of the specified neighboring blocks (Step S**408**).

If the number of the neighboring blocks determined in Step S**408** is 1, the motion vector decoding unit **711** considers the motion vector of that one neighboring block which refers to the same picture to be a predictive value of the motion vector of the current block (Step S**410**).

If the number of the neighboring blocks determined in Step S**408** is another number than one, the motion vector decoding unit **711** considers the motion vector of the neighboring block, out of the three neighboring blocks, which refers to another picture other than the current block refers to to be 0 (Step S**412**), and considers the median of the motion vectors of the three neighboring blocks as a predictive value of the motion vector of the current block (Step S**414**).

As described above, the coded motion vector of the current block is decoded by adding the difference to the predictive value derived in Step S**410** or Step S**414**.

Also, when a motion vector is decoded using a motion vector of a spatially adjacent block as a predictive value, an amount of motion vectors of 1 macroblock line (a portion of 1 macroblock high and a screen wide) needs to be stored in the motion vector storage unit **706** for decoding the motion vector, if the motion vectors which have been actually used for motion compensation in skip mode or direct mode are stored in the motion vector storage unit **706**. This applies to the case where the motion vectors which have been actually used for motion compensation in skip mode or direct mode are stored in the motion vector storage unit **706**. That is why when the neighboring blocks explained in connection with FIGS. **3**A-**3**D and FIG. **4** of the present embodiment are used, there are past 1 macroblock slice of blocks which are referred to as neighboring blocks for decoding the motion vector, with the current macroblock as a starting point.

(Third Embodiment)

In addition, if a program for realizing the motion vector coding method or the motion vector decoding method as shown in each of the above-mentioned embodiments is recorded on a storage medium such as a flexible disk, it becomes possible to perform the processing as shown in each of the above embodiments easily in an independent computer system.

FIGS. **18**A-**18**C are illustrations of a storage medium that stores a program for realizing the motion vector coding method and the motion vector-decoding method executed by the moving picture coding apparatus **100** in the first embodiment and the moving picture decoding apparatus **200** in the second embodiment by a computer system.

FIG. **18**B shows the front view and the cross-sectional view of the appearance of a flexible disk FD, and a disk FD**1**, and FIG. **18**A shows an example of a physical format of the disk FD**1** as a recording medium itself.

The disk FD**1** is contained in a case F, a plurality of tracks Tr are formed concentrically on the surface of the disk FD**1** in the radius direction from the periphery, and each track is divided into **16** sectors Se in the angular direction. Therefore, in the flexible disk storing the above-mentioned program, the motion vector coding method and the motion vector decoding method as the above program are recorded in an area allocated for it on the disk FD **1**.

FIG. **18**C shows the structure for recording and reproducing the program on and from the flexible disk FD.

For recording the program on the flexible disk FD, the computer system Cs writes the motion vector coding method or the motion vector decoding method as the program on the flexible disk FD via a flexible disk drive FDD. For constructing the above motion vector coding method and the motion vector decoding method in the computer system Cs by the program recorded on the flexible disk FD, the program is read out from the flexible disk FD via the flexible disk drive FDD and transferred to the computer system Cs.

Note that the above explanation is made on the assumption that a recording medium is a flexible disk FD, but the same processing can also be performed using an optical disk. In addition, the recording medium is not limited to these, but any other mediums such as an IC card and a ROM cassette can be used in the same manner if a program can be recorded on them.

(Fourth Embodiment)

Further, the applications of the motion vector coding method and the motion vector decoding method as shown in the above embodiments and a system using them will be explained here.

FIG. **19** is a block diagram showing the overall configuration of a content providing system ex**100** for realizing content distribution service. The area for providing communication service is divided into cells of desired size, and base stations ex**107**~ex**110** which are fixed wireless stations are placed in respective cells.

In this content providing system ex**100**, various devices such as a computer ex**111**, a PDA (personal digital assistant) ex**112**, a camera ex**113**, a mobile phone ex**114** and a camera-equipped mobile phone ex**115** are connected to the Internet ex**101**, via an Internet service provider ex**102**, a telephone network ex**104** and base stations ex**107**~ex**110**, for example.

However, the content providing system ex**100** is not limited to the combination as shown in FIG. **19**, and may be connected to a combination of any of them. Also, each device may be connected directly to the telephone network ex**104**, not through the base stations ex**107**~ex**110** which are the fixed wireless stations.

The camera ex**113** is a device such as a digital video camera capable of shooting moving pictures. The mobile phone may be any of a mobile phone of a PDC (Personal Digital Communications) system, a CDMA (Code Division Multiple Access) system, a W-CDMA (Wideband-Code Division Multiple Access) system or a GSM (Global System for Mobile Communications) system, a PHS (Personal Handyphone System) and the like.

Also, a streaming server ex**103** is connected to the camera ex**113** via the base station ex**109** and the telephone network ex**104**, which enables live distribution or the like using the camera ex**113** based on the coded data transmitted from the user. Either the camera ex**113** or the server for transmitting the data may code the data shot by the camera. Also, the moving picture data shot by a camera ex**116** may be transmitted to the streaming server ex**103** via the computer ex**111**. The camera ex**116** is a device such as a digital camera capable of shooting still and moving pictures. In this case, either the camera ex**116** or the computer ex**111** may code the moving picture data. An LSI ex**117** included in the computer ex**111** or the camera ex**116** performs coding processing. Note that software for coding and decoding pictures may be integrated into any type of a storage medium (such as a CD-ROM, a flexible disk and a hard disk) that is a recording medium which can be read by the computer ex**111** or the like. Furthermore, the camera-equipped mobile phone ex**115** may transmit the moving picture data. This moving picture data is the data coded by the LSI included in the mobile phone ex**115**.

In this content providing system ex**100**, contents (such as a music live video) shot by users using the camera ex**113**, the camera ex**116** or the like are coded in the same manner as the above embodiments and transmitted to the streaming server ex**103**, while the streaming server ex**103** makes stream distribution of the above content data to the clients at their request. The clients include the computer ex**111**, the PDA ex**112**, the camera ex**113**, the mobile phone ex**114** and so on capable of decoding the above-mentioned coded data. The content providing system ex**100** is a system in which the clients can thus receive and reproduce the coded data, and further can receive, decode and reproduce the data in real time so as to realize personal broadcasting.

When each device in this system performs coding or decoding, the moving picture coding apparatus or the moving picture decoding apparatus as shown in each of the above-mentioned embodiments may be used.

A mobile phone will be explained as an example thereof.

FIG. **20** is a diagram showing a mobile phone ex**115** which uses the motion vector coding method and the motion vector decoding method as explained in the above embodiments. The mobile phone ex**115** has an antenna ex**201** for sending and receiving radio waves between the base station ex**110**, a camera unit ex**203** such as a CCD camera capable of shooting video and still pictures, a display unit ex**202** such as a liquid crystal display for displaying the data obtained by decoding video shot by the camera unit ex**203**, video received by the antenna ex**201**, or the like, a main body including a set of operation keys ex**204**, a voice output unit ex**208** such as a speaker for outputting voices, a voice input unit ex**205** such as a microphone for inputting voices, a storage medium ex**207** for storing coded or decoded data, such as data of moving or still pictures shot by the camera, and data of text, moving pictures or still pictures of received e-mails, and a slot unit ex**206** for attaching the storage medium ex**207** into the mobile phone ex**115**. The storage medium ex**207** includes a flash memory element, a kind of EEPROM (Electrically Erasable and Programmable Read Only Memory) that is an electrically erasable and rewritable nonvolatile memory, in a plastic case such as an SD card.

Further, the mobile phone ex**115** will be explained with reference to FIG. **21**. In the mobile phone ex**115**, a main control unit ex**311** for overall controlling each unit of the main body including the display unit ex**202** and the operation keys ex**204** is connected to a power supply circuit unit ex**310**, an operation input control unit ex**304**, a picture coding unit ex**312**, a camera interface unit ex**303**, an LCD (Liquid Crystal Display) control unit ex**302**, a picture decoding unit ex**309**, a multiplex/demultiplex unit ex**308**, a record/reproduce unit ex**307**, a modem circuit unit ex**306** and a voice processing unit ex**305** to each other via a synchronous bus ex**313**.

When a call-end key or a power key is turned ON by a user's operation, the power supply circuit unit ex**310** supplies respective units with power from a battery pack so as to activate the camera-equipped digital mobile phone ex**115** for a ready state.

In the mobile phone ex**115**, under the control of the main control unit ex**311** including a CPU, ROM, RAM and the like, the voice processing unit ex**305** converts the voice signals received by the voice input unit ex**205** in conversation mode into digital voice data, the modem circuit unit ex**306** performs spread spectrum processing of the digital voice data, and the send/receive circuit unit ex**301** performs digital-to-analog conversion and frequency transformation of the data, so as to transmit the result via the antenna ex**201**. Also, in the mobile phone ex**115**, the data received by the antenna ex**201** in conversation mode is amplified and performed of frequency transformation and analog-to-digital conversion, the modem circuit unit ex**306** performs inverse spread spectrum processing of the data, and the voice processing unit ex**305** converts it into analog voice data, so as to output the result via the voice output unit ex**208**.

Furthermore, when transmitting an e-mail in data communication mode, the text data of the e-mail inputted by operating the operation keys ex**204** on the main body is sent out to the main control unit ex**311** via the operation input control unit ex**304**. In the main control unit ex**311**, after the modem circuit unit ex**306** performs spread spectrum processing of the text data and the send/receive circuit unit ex**301** performs digital-to-analog conversion and frequency transformation of it, the result is transmitted to the base station ex**110** via the antenna ex**201**.

When picture data is transmitted in data communication mode, the picture data shot by the camera unit ex**203** is provided to the picture coding unit ex**312** via the camera interface unit ex**303**. When the picture data is not transmitted, the picture data shot by the camera unit ex**203** can also be displayed directly on the display unit **202** via the camera interface unit ex**303** and the LCD control unit ex**302**.

The picture coding unit ex**312**, including the picture coding apparatus explained in the present invention, compress and codes the picture data provided from the camera unit ex**203** by the coding method used for the picture coding apparatus as shown in the above-mentioned embodiments so as to transform it into coded picture data, and sends it out to the multiplex/demultiplex unit ex**308**. At this time, the mobile phone ex**115** sends out the voices received by the voice input unit ex**205** during picture pickup by the camera unit ex**203** to the multiplex/demultiplex unit ex**308** as digital voice data via the voice processing unit ex**305**.

The multiplex/demultiplex unit ex**308** multiplexes the coded picture data provided from the picture coding unit ex**312** and the voice data provided from the voice processing unit ex**305** by a predetermined method, the modem circuit unit ex**306** performs spread spectrum processing of the resulting multiplexed data, and the send/receive circuit unit ex**301** performs digital-to-analog conversion and frequency transformation on the result for transmitting via the antenna ex**201**.

As for receiving data of a moving picture file which is linked to a Website or the like in data communication mode, the modem circuit unit ex**306** performs inverse spread spectrum processing of the data received from the base station ex**110** via the antenna ex**201**, and sends out the resulting multiplexed data to the multiplex/demultiplex unit ex**308**.

In order to decode the multiplexed data received via the antenna ex**201**, the multiplex/demultiplex unit ex**308** demultiplexes the multiplexed data into a coded bit stream of picture data and a coded bit stream of voice data, and provides the coded picture data to the picture decoding unit ex**309** and the voice data to the voice processing unit ex**305** respectively via the synchronous bus ex**313**.

Next, the picture decoding unit ex**309**, including the picture decoding apparatus explained in the present invention, decodes the coded bit stream of the picture data by the decoding method paired with the coding method as shown in the above-mentioned embodiments, so as to generate reproduced moving picture data, and provides this data to the display unit ex**202** via the LCD control unit ex**302**, and thus moving picture data included in a moving picture file linked to a Website, for instance, is displayed. At the same time, the voice processing unit ex**305** converts the voice data into analog voice data, and provides this data to the voice output unit ex**208**, and thus voice data included in a moving picture file linked to a Website, for instance, is reproduced.

The present invention is not limited to the above-mentioned system. Ground-based or satellite digital broadcasting has been in the news lately, and at least either the picture coding apparatus or the picture decoding apparatus in the above-mentioned embodiments can be incorporated into such a digital broadcasting system as shown in FIG. **22**. More specifically, a coded bit stream of video information is transmitted from a broadcast station ex**409** to or communicated with a broadcast satellite ex**410** via radio waves. Upon receipt of it, the broadcast satellite ex**410** transmits radio waves for broadcasting, a home antenna ex**406** with a satellite broadcast reception function receives the radio waves, and an apparatus such as a television (receiver) ex**401** or a set top box (STB) ex**407** decodes the coded bit stream for reproduction. The picture decoding apparatus as shown in the above-mentioned embodiments can be implemented in the reproduction device ex**403** for reading a coded bit stream recorded on a storage medium ex**402** such as a CD and DVD that is a recording medium and decoding it. In this case, the reproduced video signals are displayed on a monitor ex**404**. It is also conceived to implement the picture decoding apparatus in the set top box ex**407** connected to a cable ex**405** for a cable television or the antenna ex**406** for satellite and/or ground-based broadcasting so as to reproduce them on a monitor ex**408** of the television. The picture decoding apparatus may be incorporated into the television, not in the set top box. Or, a car ex**412** having an antenna ex**411** can receive signals from the satellite ex**410**, the base station ex**107** or the like for reproducing moving pictures on a display apparatus such as a car navigation device ex**413** or the like in the car ex**412**.

Furthermore, the picture coding apparatus as shown in the above-mentioned embodiments can code picture signals for recording them on a recording medium. As a concrete example, there is a recorder ex**420** such as a DVD recorder for recording picture signals on a DVD disk ex**421** and a disk recorder for recording them on a hard disk. They can also be recorded on an SD card ex**422**. If the recorder ex**420** includes the picture decoding apparatus as shown in the above-mentioned embodiments, the picture signals recorded on the DVD disk ex**421** or the SD card ex**422** can be reproduced for display on the monitor ex**408**.

Note that as the structure of the car navigation device ex**413**, the structure without the camera unit ex**203**, the camera interface unit ex**303** and the picture coding unit ex**312**, out of the units as shown in FIG. **21**, is conceivable. The same applies to the computer ex**111**, the television (receiver) ex**401** and others.

In addition, three types of implementations can be conceived for a terminal such as the above-mentioned mobile phone ex114; a sending/receiving terminal equipped with both an encoder and a decoder, a sending terminal equipped with an encoder only, and a receiving terminal equipped with a decoder only.

As described above, it is possible to use the motion vector coding method or the motion vector decoding method as shown in the above embodiments in any of above-mentioned devices and systems, and thus the effects explained in the above embodiments can be obtained.

Industrial Applicability

The motion vector coding method and the motion vector decoding method according to the present invention are suitable for use in a moving picture coding apparatus for coding moving pictures, a moving picture decoding apparatus for decoding coded moving pictures, and a system including these apparatuses, such as a content providing system for providing contents like digital works, for example, and a digital broadcasting system.

The invention claimed is:

1. A motion vector decoding method for decoding a coded motion vector of a current block in a moving picture, comprising:

specifying [a] *three* neighboring [block] *blocks* which [is] *are* located in a neighborhood of the current block and [is] *are* previously decoded;

deriving a predictive motion vector of the current block; *and*

decoding the coded motion vector of the current block using the predictive motion vector[;] *to derive a final motion vector of the current block, wherein deriving the final motion vector of the current block comprises:*

*adding the predictive motion vector of the current block to a decoded difference motion vector of the current block to derive the final motion vector of the current block,*

wherein, [in the] deriving [of] the predictive motion vector of the current block[, when] *comprises:*

*responsive to determining that at least one of* the *three* neighboring [block] *blocks* is [decoded based on a motion vector of another block] *coded in a skip mode or a direct mode, deriving* the predictive motion vector of the current block [is derived] based on [the] *a* motion vector of [the] another block *different from the three neighboring blocks, and*

*responsive to determining that none of the three neighboring blocks are coded in the skip mode or the direct mode, deriving the predictive motion vector of the current block based on one or more motion vectors of the three neighboring blocks.*

2. The motion vector decoding method according to claim 1, wherein the another block is located temporally at a forward or backward position relatively to *one of* the *three* neighboring [block] *blocks.*

3. The motion vector decoding method according to claim 1, wherein the another block is located in the moving picture including the *three* neighboring [block] *blocks.*

*4. The motion vector decoding method according to claim 1, wherein the another block is located temporally at a forward position relatively to one of the three neighboring blocks.*

*5. The method of claim 1, further comprising generating a motion compensation image for the current block based on the final motion vector of the current block.*

*6. The method of claim 1, wherein deriving the predictive motion vector of the current block based on one or more motion vectors of the three neighboring blocks comprises deriving the predictive motion vector based on a median calculated from components of the one or more motion vectors of the three neighboring blocks.*

*7. A motion vector decoding method for decoding a coded motion vector of a current block in a moving picture, comprising:*

*specifying three neighboring blocks which are located in a neighborhood of the current block and are previously decoded;*

*deriving, using one or more processing devices, a predictive motion vector of the current block;*

*decoding, using the one or more processing devices, the coded motion vector of the current block using the predictive motion vector to derive a final motion vector of the current block, wherein deriving the final motion vector of the current block comprises:*

*adding the predictive motion vector of the current block to a decoded difference motion vector of the current block to derive the final motion vector of the current block,*

*wherein, deriving the predictive motion vector of the current block comprises:*

*responsive to determining that at least one of the three neighboring blocks is coded in a skip mode or a direct mode, deriving the predictive motion vector of the current block based on a motion vector of another block different from the three neighboring blocks, and*

*responsive to determining that none of the three neighboring blocks are coded in the skip mode or the direct mode, deriving the predictive motion vector of the current block based on one or more motion vectors of the three neighboring blocks; and*

*storing results of the decoding in a tangible storage device.*

* * * * *