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(54) **MOVING-PICTURE LAYERED CODING AND DECODING METHODS, APPARATUSES, AND PROGRAMS**

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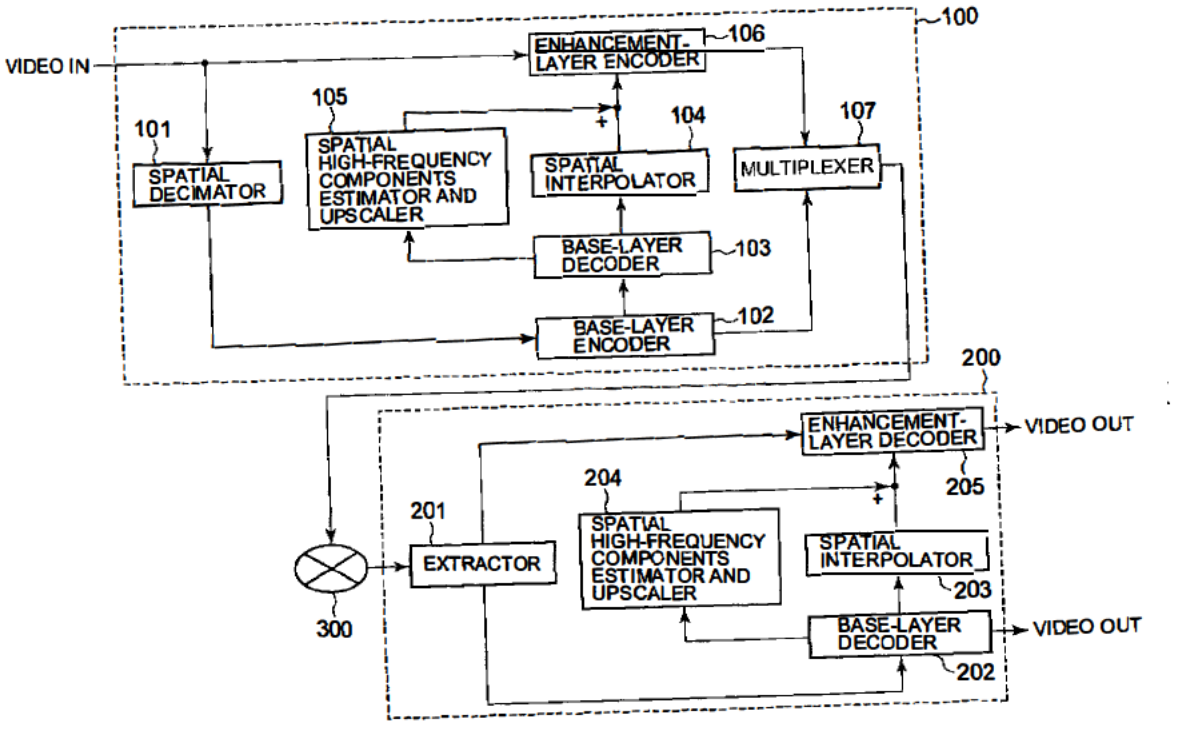
(57) **ABSTRACT**

An input video signal is encoded at a plurality of coding layers exhibiting different spatial resolutions. Decoded is a given signal coded at a lower coding layer lower than a specific coding layer among the plurality of coding layers to generate a decoded signal of the lower coding layer. Spatial interpolation is applied to the decoded signal of the lower coding layer to generate an upscaled decoded video signal. The spatial interpolation is an upscaling procedure to upscale the decoded signal of the lower coding layer into a spatial resolution of the specific coding layer. A spatial high-frequency components estimation and scale up procedure is applied to the decoded signal of the lower coding layer to generate a high-frequency components signal. The upscaled decoded video signal and the high-frequency components signal are subtracted from the input video signal exhibiting a spatial resolution of the specific coding layer to produce a predictive-error signal. Then, the predictive-error signal is encoded at the specific coding layer to generate an output bitstream. The decoding, spatial interpolating, spatial high-frequency components estimating and upscaling, and encoding procedures are executed at, at least, the specific coding layer among the plurality of coding layers except the lowest coding layer exhibiting the lowest spatial resolution thereamong.



Google
Exhibit 1046

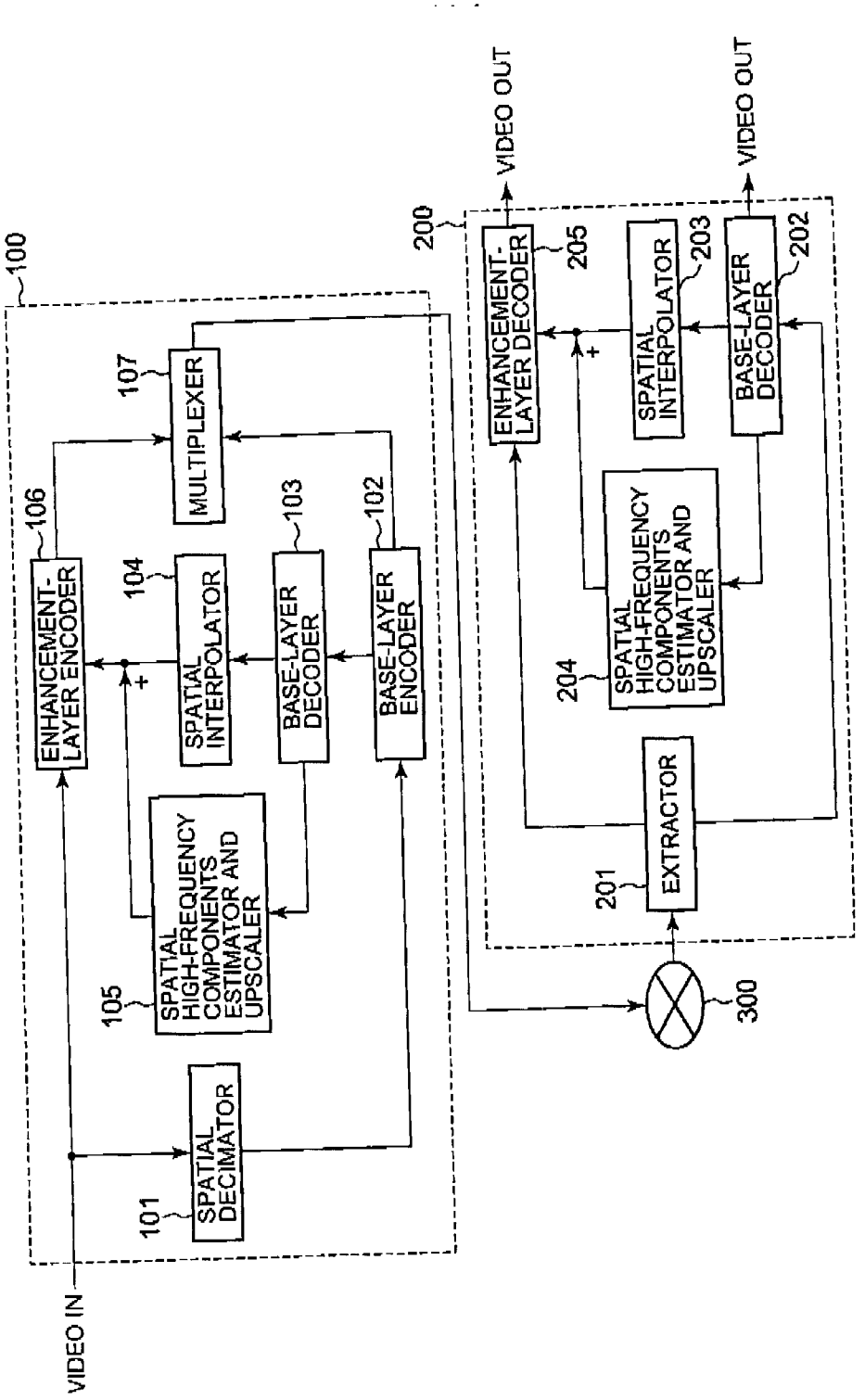

100
200
VIDEO IN
VIDEO OUT
VIDEO OUT
101
SPATIAL DECIMATOR
102
BASE-LAYER ENCODER
103
BASE-LAYER DECODER
104
SPATIAL INTERPOLATOR
105
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
106
ENHANCEMENT-LAYER ENCODER
107
MULTIPLEXER
201
EXTRACTOR
202
BASE-LAYER DECODER
203
SPATIAL INTERPOLATOR
204
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
205
ENHANCEMENT-LAYER DECODER
300

FIG. 1

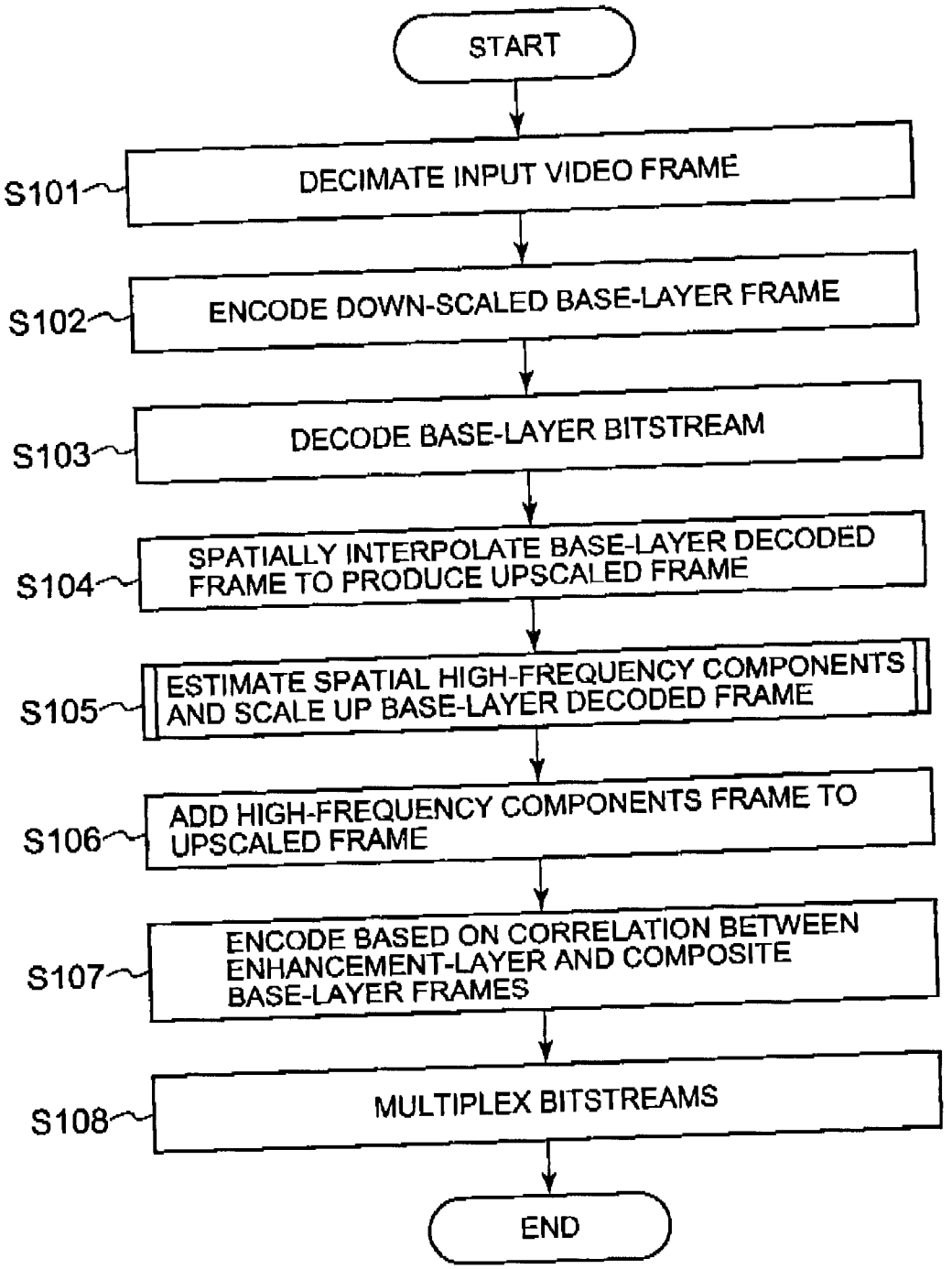

START
S101
DECIMATE INPUT VIDEO FRAME
S102
ENCODE DOWN-SCALED BASE-LAYER FRAME
S103
DECODE BASE-LAYER BITSTREAM
S104
SPATIALLY INTERPOLATE BASE-LAYER DECODED FRAME TO PRODUCE UPSCALED FRAME
S105
ESTIMATE SPATIAL HIGH-FREQUENCY COMPONENTS AND SCALE UP BASE-LAYER DECODED FRAME
S106
ADD HIGH-FREQUENCY COMPONENTS FRAME TO UPSCALED FRAME
S107
ENCODE BASED ON CORRELATION BETWEEN ENHANCEMENT-LAYER AND COMPOSITE BASE-LAYER FRAMES
S108
MULTIPLEX BITSTREAMS
END

FIG. 2

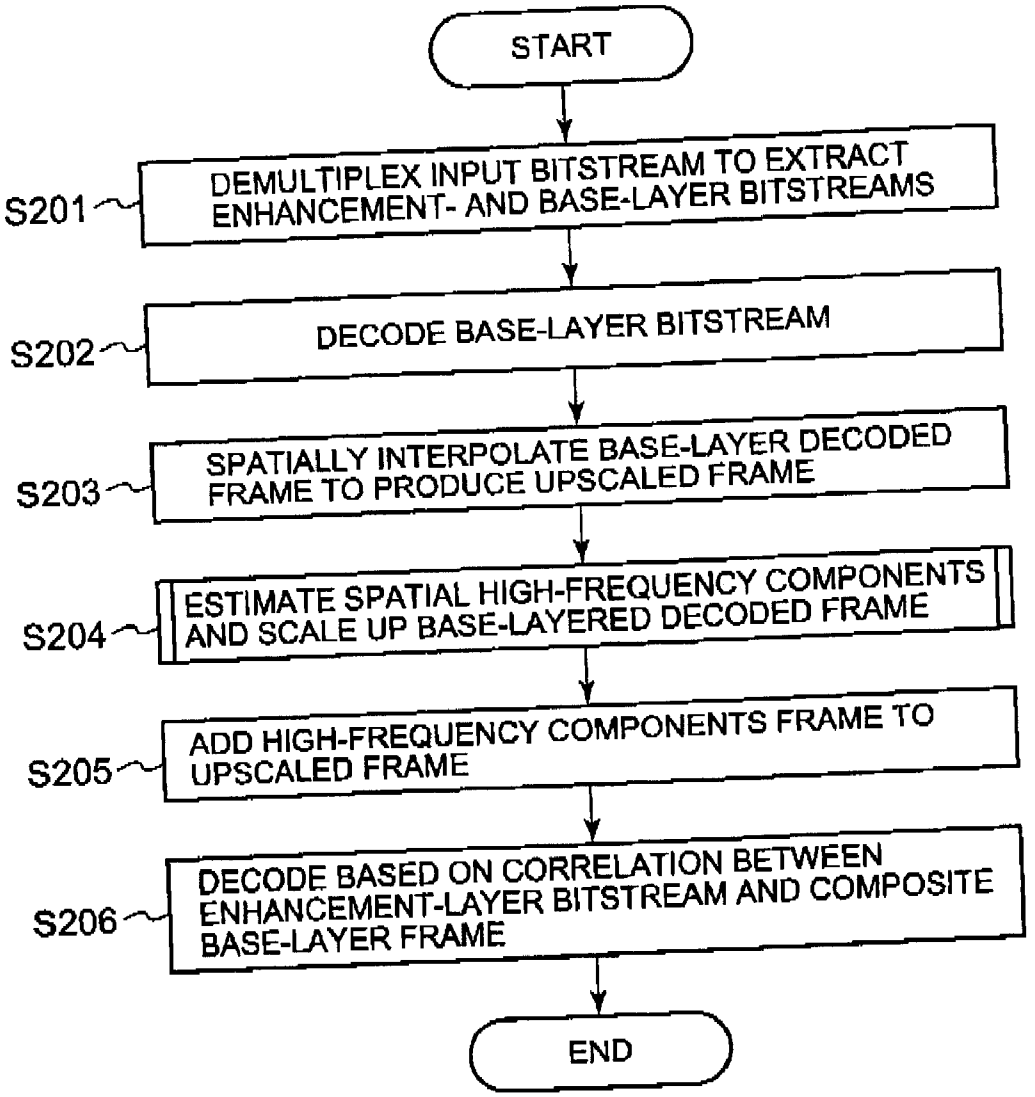

START
S201
DEMULTIPLEX INPUT BITSTREAM TO EXTRACT ENHANCEMENT- AND BASE-LAYER BITSTREAMS
S202
DECODE BASE-LAYER BITSTREAM
S203
SPATIALLY INTERPOLATE BASE-LAYER DECODED FRAME TO PRODUCE UPSCALED FRAME
S204
ESTIMATE SPATIAL HIGH-FREQUENCY COMPONENTS AND SCALE UP BASE-LAYERED DECODED FRAME
S205
ADD HIGH-FREQUENCY COMPONENTS FRAME TO UPSCALED FRAME
S206
DECODE BASED ON CORRELATION BETWEEN ENHANCEMENT-LAYER BITSTREAM AND COMPOSITE BASE-LAYER FRAME
END

FIG. 3

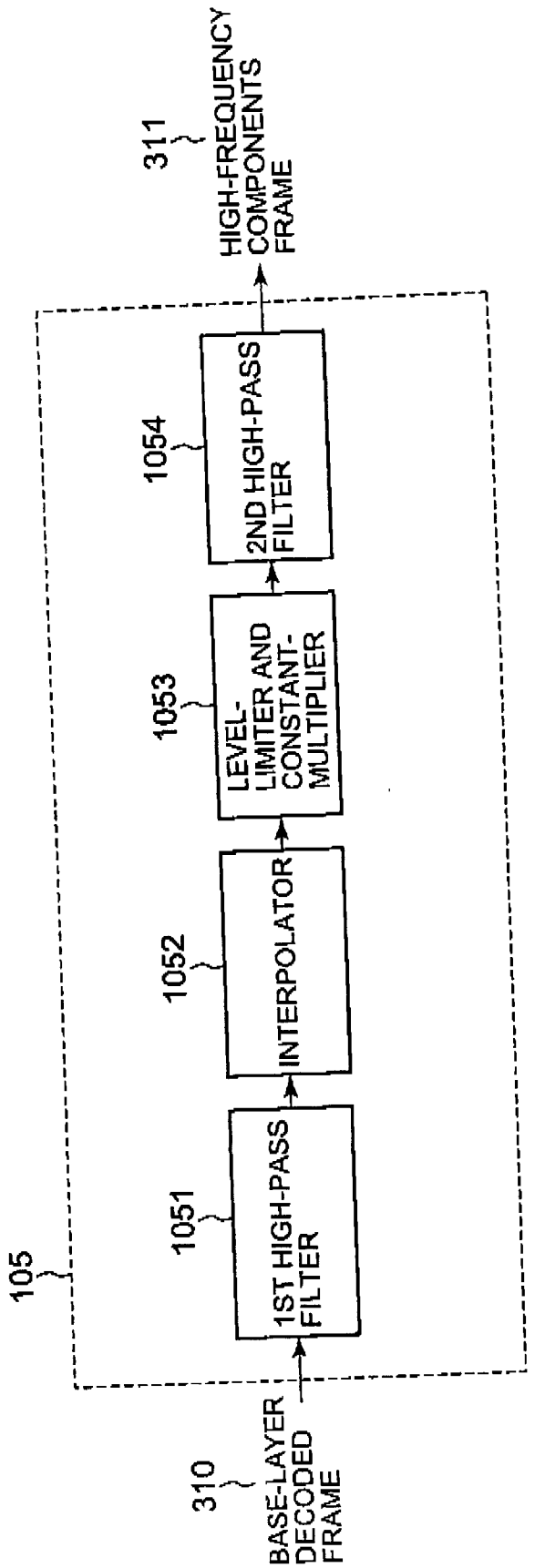

310
BASE-LAYER DECODED FRAME
105
1051
1ST HIGH-PASS FILTER
1052
INTERPOLATOR
1053
LEVEL-LIMITER AND CONSTANT-MULTIPLIER
1054
2ND HIGH-PASS FILTER
311
HIGH-FREQUENCY COMPONENTS FRAME

FIG. 4

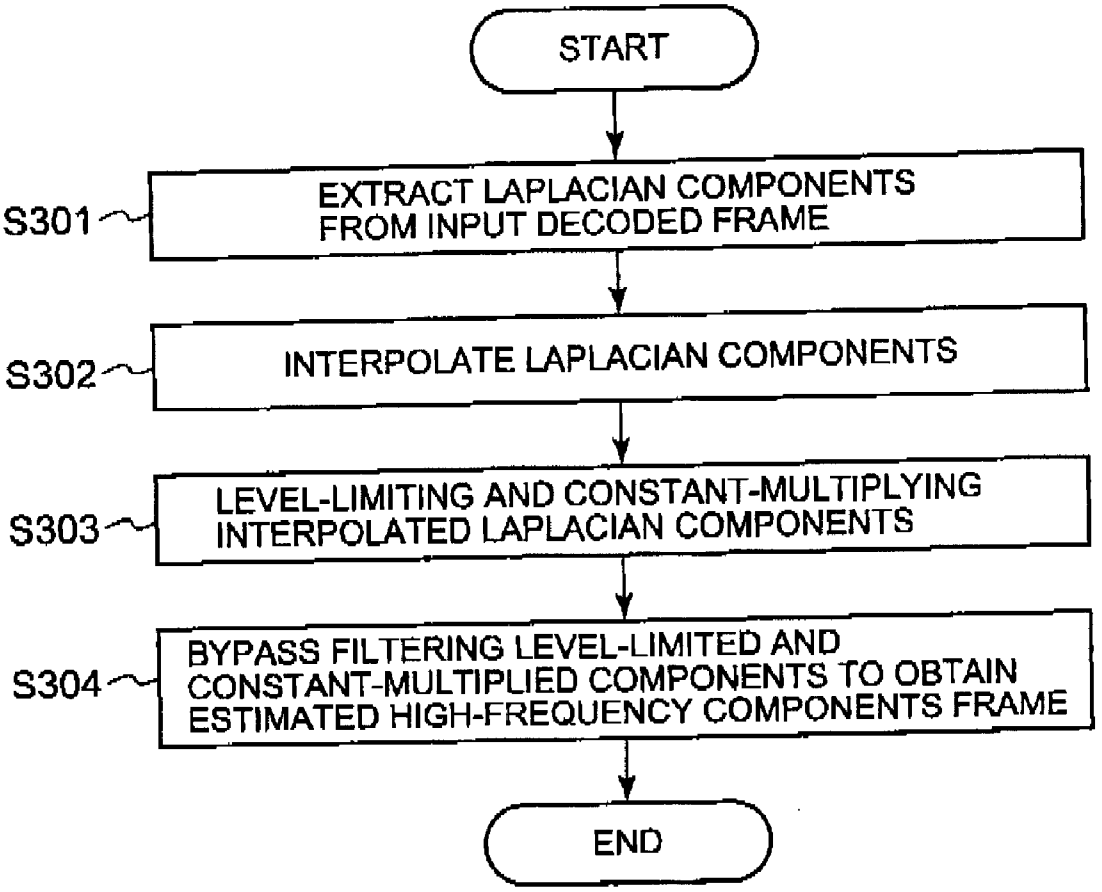

START
S301
EXTRACT LAPLACIAN COMPONENTS FROM INPUT DECODED FRAME
S302
INTERPOLATE LAPLACIAN COMPONENTS
S303
LEVEL-LIMITING AND CONSTANT-MULTIPLYING INTERPOLATED LAPLACIAN COMPONENTS
S304
BYPASS FILTERING LEVEL-LIMITED AND CONSTANT-MULTIPLIED COMPONENTS TO OBTAIN ESTIMATED HIGH-FREQUENCY COMPONENTS FRAME
END

FIG. 5

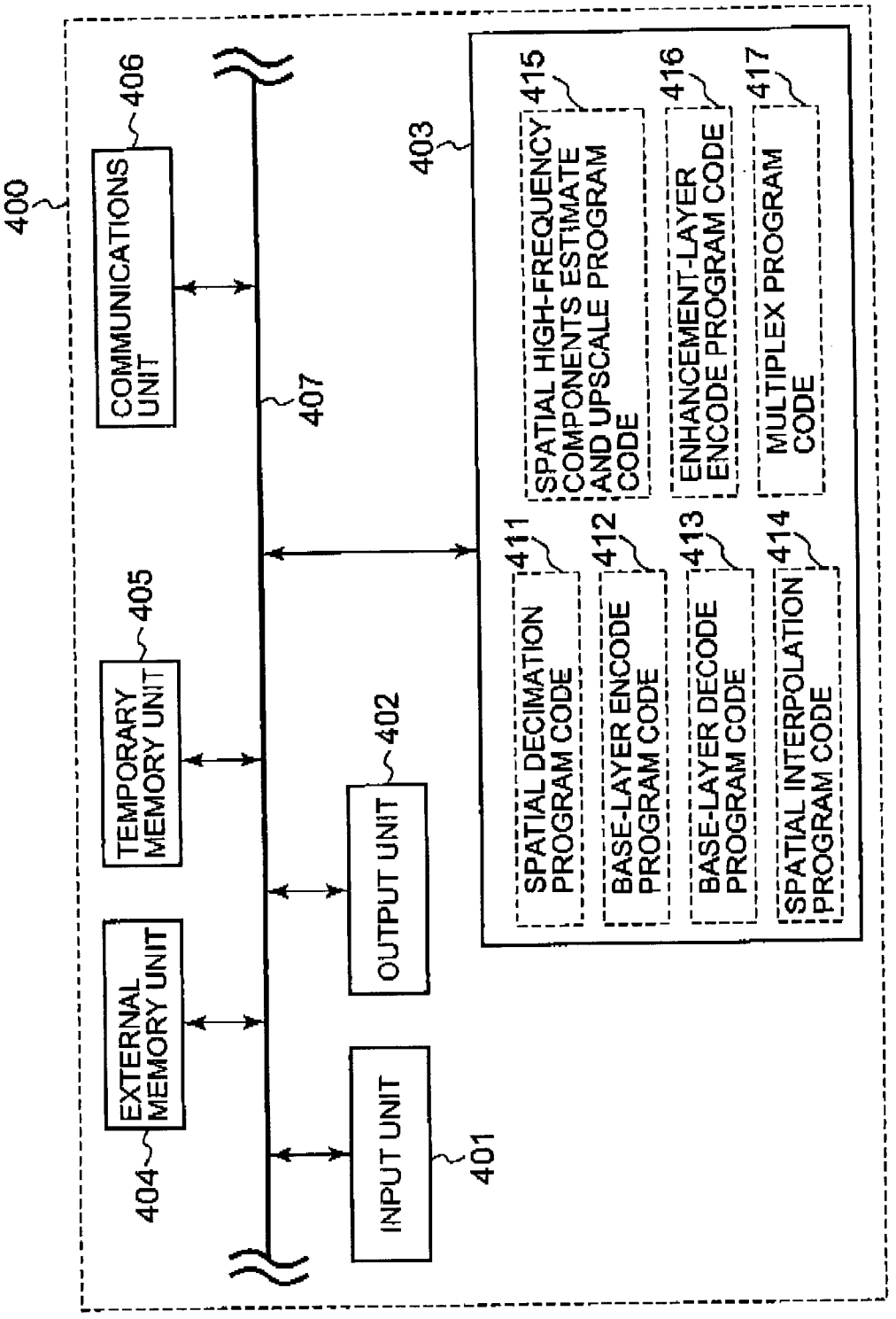

400
COMMUNICATIONS UNIT
406
TEMPORARY MEMORY UNIT
405
EXTERNAL MEMORY UNIT
404
OUTPUT UNIT
402
INPUT UNIT
401
407
403
SPATIAL DECIMATION PROGRAM CODE
411
BASE-LAYER ENCODE PROGRAM CODE
412
BASE-LAYER DECODE PROGRAM CODE
413
SPATIAL INTERPOLATION PROGRAM CODE
414
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATE AND UPSCALE PROGRAM CODE
415
ENHANCEMENT-LAYER ENCODE PROGRAM CODE
416
MULTIPLEX PROGRAM CODE
417

FIG. 6

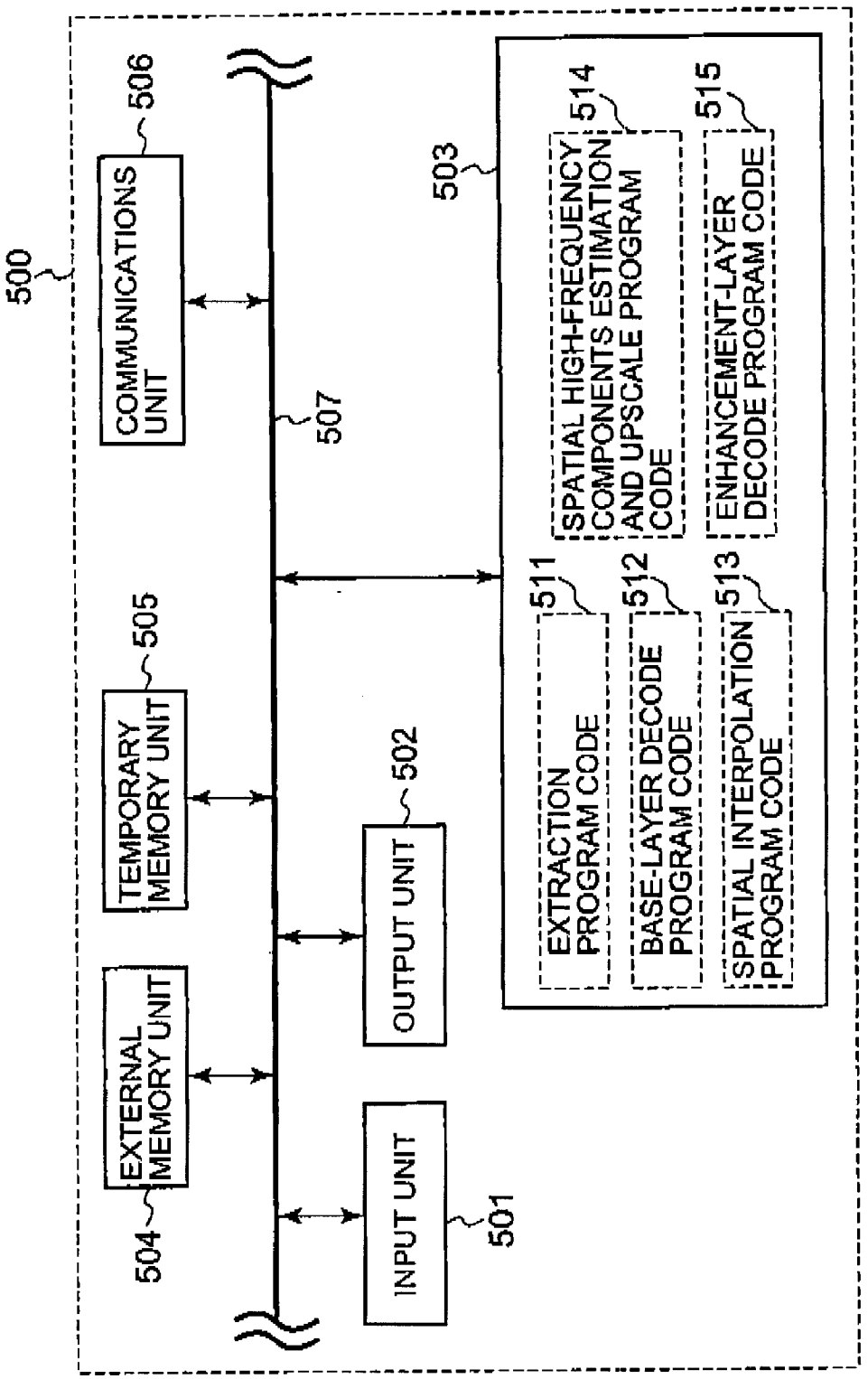

500
COMMUNICATIONS UNIT
506
507
503
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATION AND UPSCALE PROGRAM CODE
514
ENHANCEMENT-LAYER DECODE PROGRAM CODE
515
TEMPORARY MEMORY UNIT
505
EXTRACTION PROGRAM CODE
511
BASE-LAYER DECODE PROGRAM CODE
512
SPATIAL INTERPOLATION PROGRAM CODE
513
OUTPUT UNIT
502
EXTERNAL MEMORY UNIT
504
INPUT UNIT
501

FIG. 7

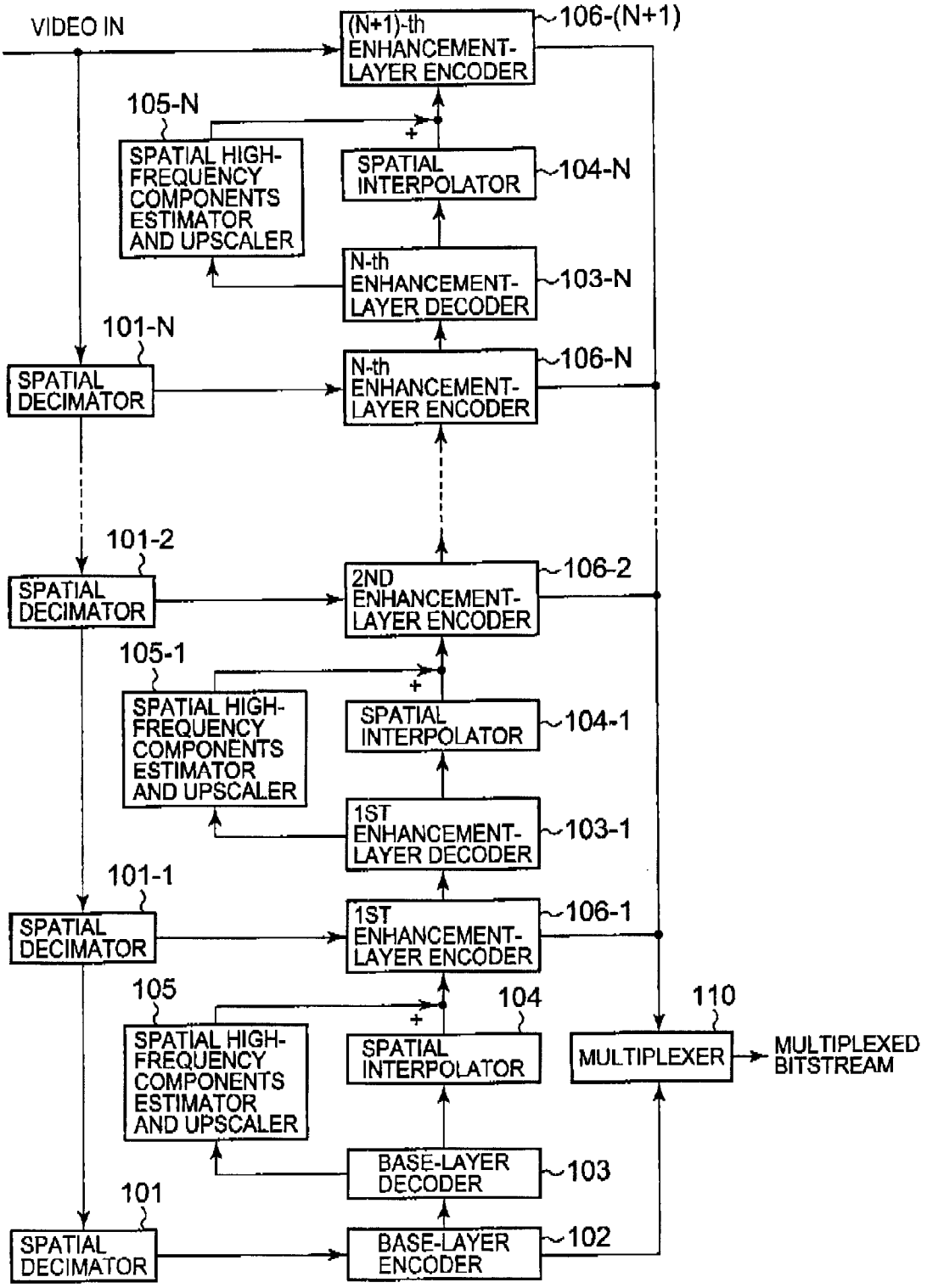

VIDEO IN
(N+1)-th ENHANCEMENT-LAYER ENCODER
106-(N+1)
105-N
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
104-N
N-th ENHANCEMENT-LAYER DECODER
103-N
101-N
SPATIAL DECIMATOR
N-th ENHANCEMENT-LAYER ENCODER
106-N
101-2
SPATIAL DECIMATOR
2ND ENHANCEMENT-LAYER ENCODER
106-2
105-1
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
104-1
1ST ENHANCEMENT-LAYER DECODER
103-1
101-1
SPATIAL DECIMATOR
1ST ENHANCEMENT-LAYER ENCODER
106-1
105
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
104
SPATIAL INTERPOLATOR
110
MULTIPLEXER
MULTIPLEXED BITSTREAM
BASE-LAYER DECODER
103
101
SPATIAL DECIMATOR
BASE-LAYER ENCODER
102

FIG. 8

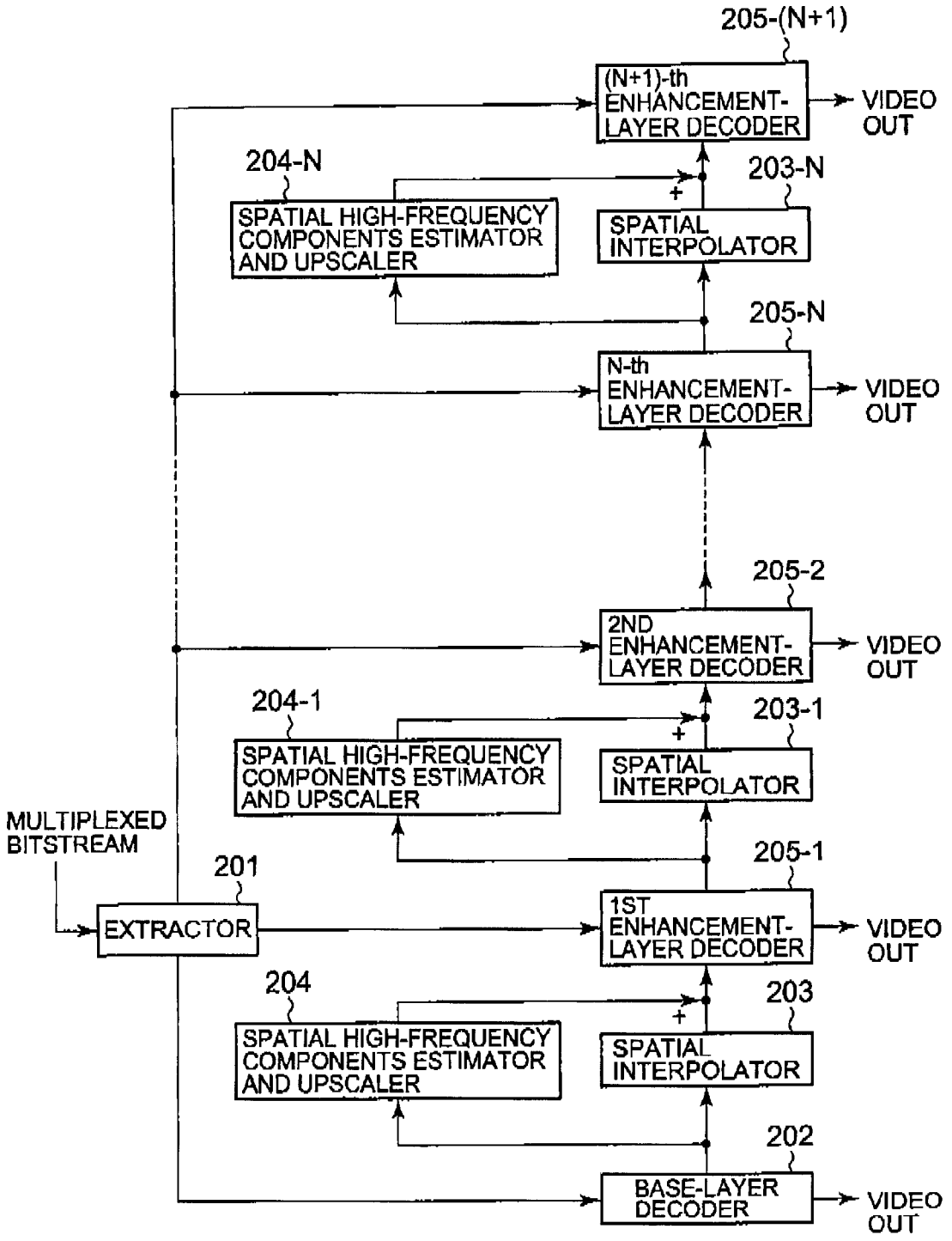

205-(N+1)
(N+1)-th ENHANCEMENT-LAYER DECODER
VIDEO OUT
204-N
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
203-N
SPATIAL INTERPOLATOR
205-N
N-th ENHANCEMENT-LAYER DECODER
VIDEO OUT
205-2
2ND ENHANCEMENT-LAYER DECODER
VIDEO OUT
204-1
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
203-1
SPATIAL INTERPOLATOR
MULTIPLEXED BITSTREAM
201
EXTRACTOR
205-1
1ST ENHANCEMENT-LAYER DECODER
VIDEO OUT
204
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
203
SPATIAL INTERPOLATOR
202
BASE-LAYER DECODER
VIDEO OUT

FIG. 9

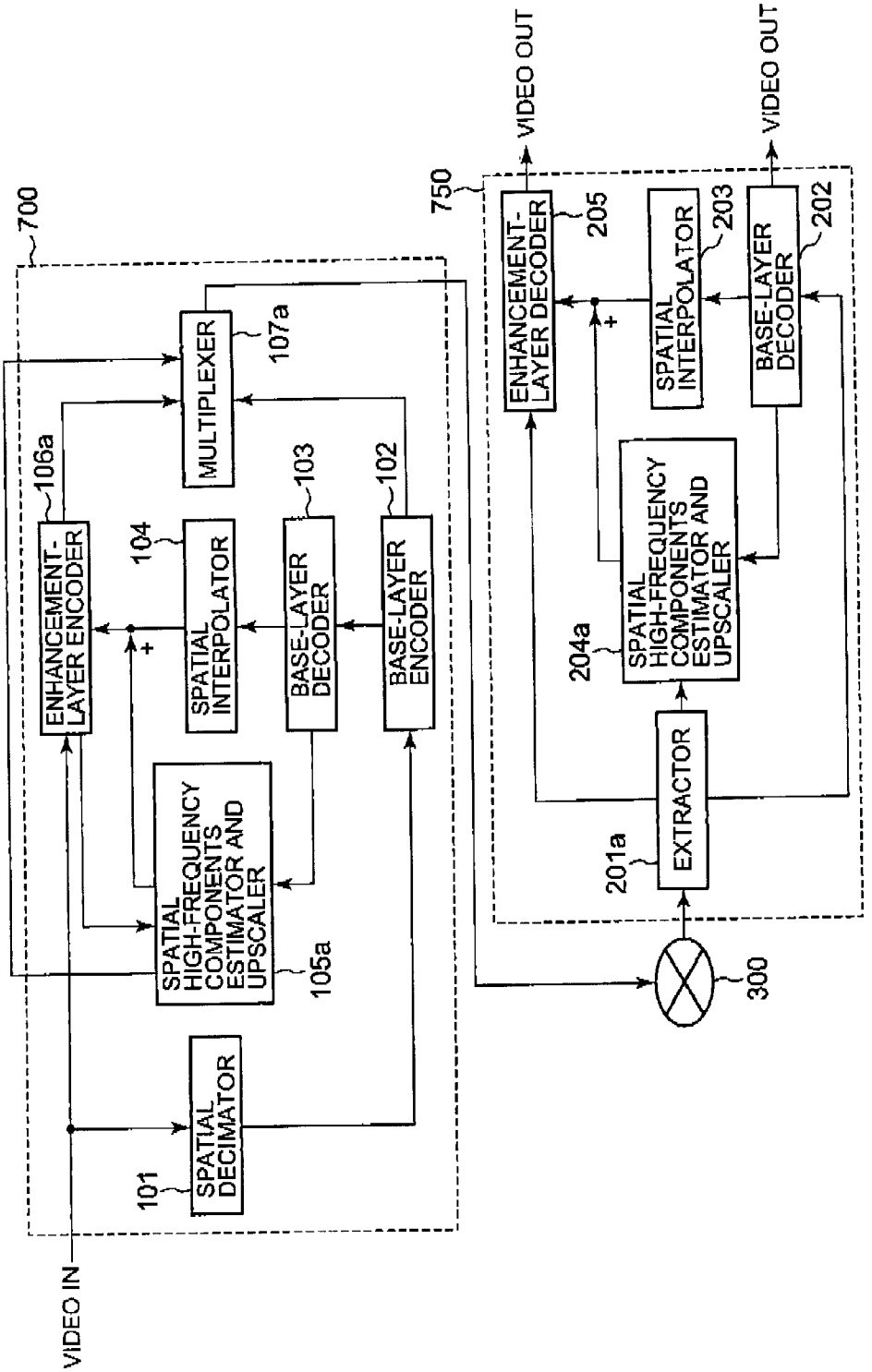

700
750
VIDEO IN
VIDEO OUT
VIDEO OUT
101
SPATIAL DECIMATOR
105a
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
BASE-LAYER ENCODER
102
BASE-LAYER DECODER
103
104
SPATIAL INTERPOLATOR
ENHANCEMENT-LAYER ENCODER
106a
MULTIPLEXER
107a
300
201a
EXTRACTOR
204a
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
BASE-LAYER DECODER
202
SPATIAL INTERPOLATOR
203
ENHANCEMENT-LAYER DECODER
205

FIG. 10

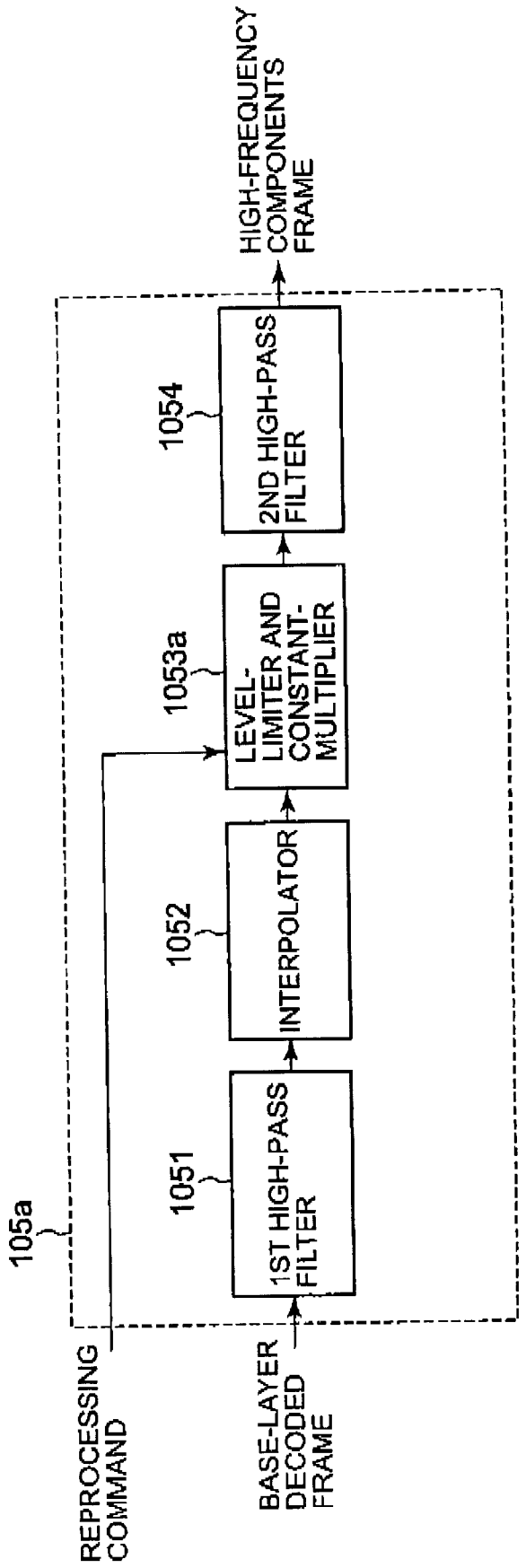

HIGH-FREQUENCY COMPONENTS FRAME
1054
2ND HIGH-PASS FILTER
1053a
LEVEL-LIMITER AND CONSTANT-MULTIPLIER
1052
INTERPOLATOR
1051
1ST HIGH-PASS FILTER
105a
REPROCESSING COMMAND
BASE-LAYER DECODED FRAME

FIG. 11

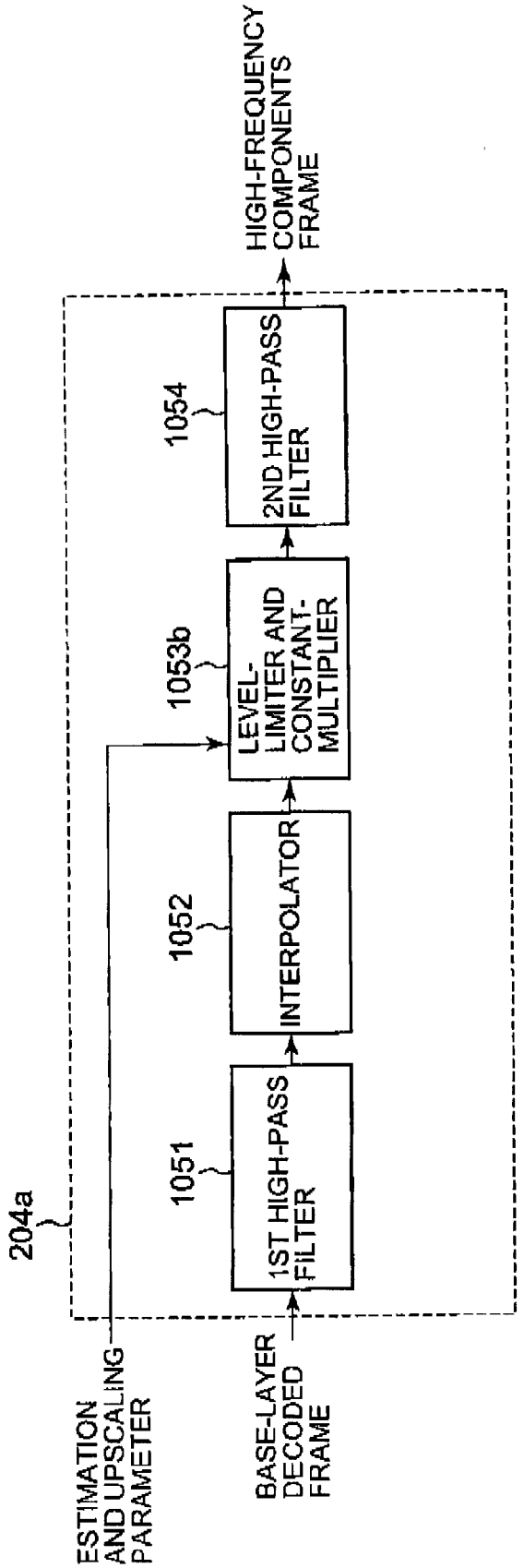

HIGH-FREQUENCY COMPONENTS FRAME
1054
2ND HIGH-PASS FILTER
1053b
LEVEL-LIMITER AND CONSTANT-MULTIPLIER
1052
INTERPOLATOR
1051
1ST HIGH-PASS FILTER
204a
ESTIMATION AND UPSCALING PARAMETER
BASE-LAYER DECODED FRAME

FIG. 12

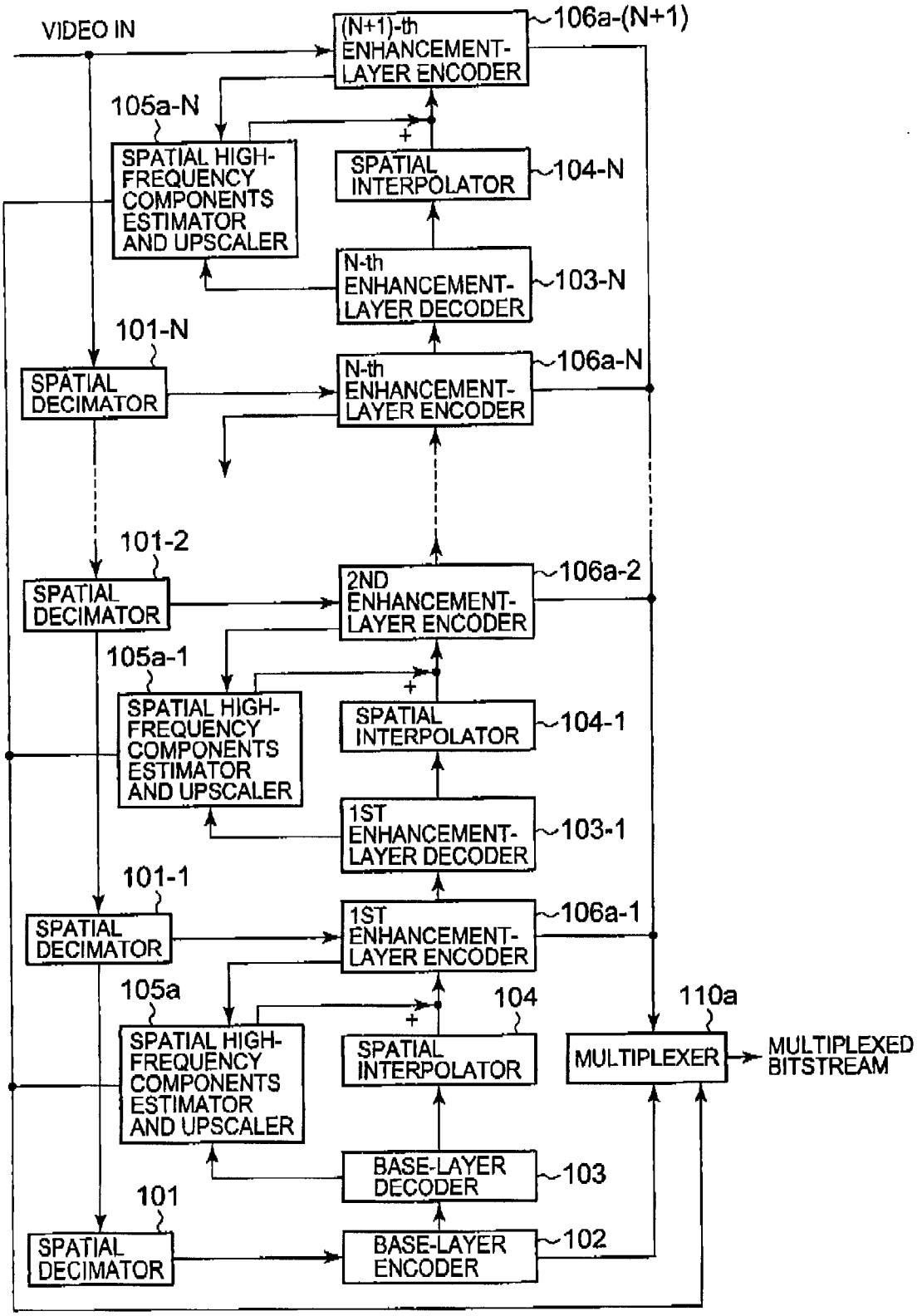

VIDEO IN
(N+1)-th ENHANCEMENT-LAYER ENCODER
106a-(N+1)
105a-N
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
104-N
N-th ENHANCEMENT-LAYER DECODER
103-N
101-N
SPATIAL DECIMATOR
N-th ENHANCEMENT-LAYER ENCODER
106a-N
101-2
SPATIAL DECIMATOR
2ND ENHANCEMENT-LAYER ENCODER
106a-2
105a-1
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
104-1
1ST ENHANCEMENT-LAYER DECODER
103-1
101-1
SPATIAL DECIMATOR
1ST ENHANCEMENT-LAYER ENCODER
106a-1
105a
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
104
SPATIAL INTERPOLATOR
110a
MULTIPLEXER
MULTIPLEXED BITSTREAM
BASE-LAYER DECODER
103
101
SPATIAL DECIMATOR
BASE-LAYER ENCODER
102

FIG. 13

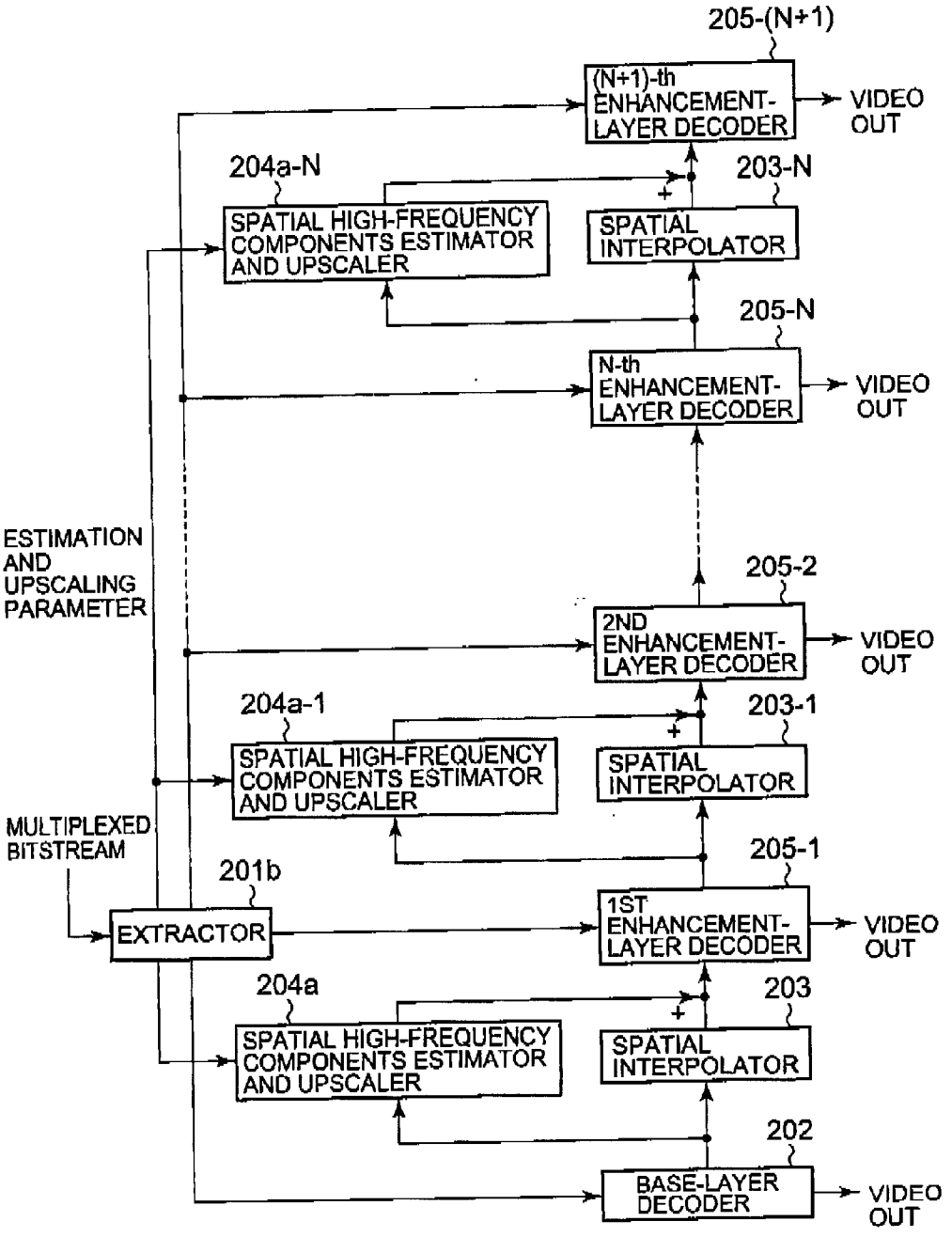

205-(N+1)
(N+1)-th ENHANCEMENT-LAYER DECODER
VIDEO OUT
204a-N
203-N
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
205-N
N-th ENHANCEMENT-LAYER DECODER
VIDEO OUT
ESTIMATION AND UPSCALING PARAMETER
205-2
2ND ENHANCEMENT-LAYER DECODER
VIDEO OUT
204a-1
203-1
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
MULTIPLEXED BITSTREAM
205-1
201b
EXTRACTOR
1ST ENHANCEMENT-LAYER DECODER
VIDEO OUT
204a
203
SPATIAL HIGH-FREQUENCY COMPONENTS ESTIMATOR AND UPSCALER
SPATIAL INTERPOLATOR
202
BASE-LAYER DECODER
VIDEO OUT

FIG. 14

MOVING-PICTURE LAYERED CODING AND DECODING METHODS, APPARATUSES, AND PROGRAMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims the benefit of priority from the prior Japanese Patent Application Nos. 2005-341502 filed on Nov. 28, 2005 and 2006-317155 filed on Nov. 24, 2006, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to layered coding and decoding methods, apparatuses, and programs for moving pictures based on spatial- and time-domain and also inter-layer correlation.

[0003] Several spatial- and time-domain resolution and SNR (Signal-to-Noise) scalable video coding schemes have been proposed and employed in a variety of fields. In particular, spatial-domain resolution scalable video coding schemes are most applicable to still and moving pictures.

[0004] A spatial-domain resolution scalable layered video coding scheme produces interlayer predictive signals for use in coding enhancement layers that exhibit higher spatial resolutions than base layers also to be coded. The interlayer predictive signals are produced through enhancement-layer motion compensation and time domain prediction with base-layer spatial decimation and interpolation.

[0005] The known layered video coding scheme, however, suffers elimination of high-frequency components, that are required In production of interlayer predictive signals, through base-layer spatial decimation.

[0006] In detail, the layered video coding scheme employs interframe prediction in enhancement-layer coding based on correlation between video frames subjected to enhancement-layer coding and locally decoded frames produced in decoding of base-layer coded frames.

[0007] In this procedure, high-frequency components, like those carried by video frames to be subjected to enhancement-layer coding, are eliminated from video frames subjected to base-layer coding. The elimination may occur due to limited bandwidth in production of base-layer frames with a spatial scale down procedure. It may also occur through a coding procedure, e.g., quantization, when such high-frequency components are treated as less important components through base-layer coding.

[0008] The elimination of high-frequency components results in insufficient predictive coding to produce inaccurate enhancement-layer predictive frames based on correlation between enhancement and base layers. This mostly occurs for zones in a video frame that carries high-frequency components continuously, such as, an edge portion, due to the problem in that such high-frequency components are eliminated from video frames subjected to base-layer coding, as discussed above.

[0009] Even when predictive coding is done (although insufficiently) in spite of elimination of such high-frequency components through base-layer spatial decimation, another problem arises in which enhancement-layer predictive-coded frames carrying high-frequency components suffer increase in signal level or data amount, especially, for zones in a video frame that carries high-frequency components continuously, compared to zones that mainly carry low-frequency components.

SUMMARY OF THE INVENTION

[0010] A purpose of the present invention is to provide layered coding and decoding methods, apparatuses, and programs with accurate interframe predictive coding with a smaller data amount.

[0011] The present invention provides a layered coding apparatus for encoding an input video signal at a plurality of coding layers exhibiting different spatial resolutions comprising: a decoder to decode a given signal coded at a lower coding layer lower than a specific coding layer among the plurality of coding layers, thus generating a decoded signal of the lower coding layer; a spatial interpolator to apply spatial interpolation to the decoded signal of the lower coding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upscaling procedure to upscale the decoded signal of the lower coding layer into a spatial resolution of the specific coding layer; a spatial high-frequency components estimator and upscaler to apply a spatial high-frequency components estimation and scale up procedure to the decoded signal of the lower coding layer, thus generating a high-frequency components signal; and an encoder to subtract the upscaled decoded video signal and the high-frequency components signal from the input video signal exhibiting a spatial resolution of the specific coding layer to produce a predictive-error signal, and encode the predictive-error signal at the specific coding layer, thus generating an output bitstream, wherein the decoder, the spatial interpolator, the spatial high-frequency components estimator and upscaler, and the encoder function at, at least, the specific coding layer among the plurality of coding layers except the lowest coding layer exhibiting the lowest spatial resolution thereamong.

[0012] Moreover, the present invention provides a layered decoding apparatus for decoding an input bitstream comprising: a spatial interpolator to apply spatial interpolation to a given signal decoded at a lower decoding layer lower than a specific decoding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upsealing procedure to upscale the given decoded signal into a spatial resolution of the specific decoding layer; a spatial high-frequency components estimator and upscaler to apply a spatial high-frequency components estimation and scale up procedure to the given decoded signal at the lower decoding layer, thus generating a high-frequency components signal; and a decoder to decode the input bitstream to obtain a predictive error-signal and add the upscaled decoded video signal and the high-frequency components signal to the predictive-error signal, thus generating a reproduced video signal, wherein the spatial interpolator, the spatial high-frequency components estimator and upscaler, and the decoder function at the specific decoding layer that corresponds to at least one specific coding layer among a plurality of coding layers exhibiting different spatial resolutions except the lowest coding layer exhibiting the lowest spatial

resolution thereamong, wherein the input bitstream has been obtained by encoding a predictive-error signal at, at least, the specific coding layer, the predictive-error signal being obtained by subtracting an upscaled decoded video signal and a high-frequency components signal from a video signal exhibiting a spatial resolution of the specific coding layer, the upscaled decoded video signal having been obtained by applying spatial interpolation to a signal decoded at a lower coding layer lower than the specific coding layer, the spatial interpolation being an upscaling procedure to upscale the signal decoded at the lower coding layer into a spatial resolution of the specific coding layer, and the high-frequency components signal having been obtained by applying a spatial high-frequency components estimation and scale up procedure to the signal decoded at the lower coding layer.

BRIEF DESCRIPTION OF DRAWINGS

[0013] FIG. **1** shows block diagrams of a layered coding apparatus and a layered decoding apparatus according to the present invention;

[0014] FIG. **2** shows a flowchart of a layered coding procedure executed by the layered coding apparatus shown In FIG. **1**;

[0015] FIG. **3** shows a flowchart of a layered decoding procedure executed by the layered decoding apparatus shown In FIG. **1**;

[0016] FIG. **4** shows a block diagram of a spatial high-frequency components estimator and upscaler shown in FIG. **1**;

[0017] FIG. **5** shows a flowchart of a spatial high-frequency components estimating and upscaling procedure executed by the spatial high-frequency components estimator and upscaler shown in FIG. **1**;

[0018] FIG. **6** shows a data processing system that executes a layered coding program according to the present invention;

[0019] FIG. **7** shows a data processing system that executes a layered decoding program according to the present invention;

[0020] FIG. **8** shows a block diagram of a multilayer coding apparatus according to the present invention;

[0021] FIG. **9** shows a block diagram of a multilayer decoding apparatus according to the present invention;

[0022] FIG. **10** shows block diagrams of a layered coding apparatus and a layered decoding apparatus according to the present invention;

[0023] FIG. **11** shows a block diagram of a spatial high-frequency components estimator and upscaler of the layered coding apparatus shown In FIG. **10**;

[0024] FIG. **12** shows a block diagram of a spatial high-frequency components estimator and upscaler of the layered decoding apparatus shown in FIG. **11**;

[0025] FIG. **13** shows a block diagram of a multilayer coding apparatus according to the present invention; and

[0026] FIG. **14** shows a block diagram of a multilayer decoding apparatus according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0027] Several preferred embodiments according to the present invention will be described in detail with reference to the drawings.

[0028] The same reference signs and numerals are used for the same or analogous components through the drawings in the following disclosure.

[0029] Described first with reference to FIGS. **1** to **3** are layered coding and decoding apparatuses according to the present invention.

[0030] Shown in FIG. **1** are block diagrams of a layered coding apparatus **100** and a layered decoding apparatus **200**.

[0031] The layered coding apparatus **100** is electrically connected to the layered decoding apparatus **200** via a transfer cable or other media **300**. Input to the layered coding apparatus **100** is a video signal carrying moving pictures. The video signal is subjected to a coding procedure at the coding apparatus **100**.

[0032] Output from the layered coding apparatus **100** is a bitstream which is then supplied to the layered decoding apparatus **200** via the transfer cable or media **300**. Data necessary for a decoding procedure are extracted from the bitstream and subjected to the procedure at the decoding apparatus **200**. A decoded video signal is output from the apparatus **200** at a spatial resolution and a frame rate suitable for a display apparatus (not shown).

[0033] Not only from the layered coding apparatus **100**, the layered decoding apparatus **200** can receive bitstream from any source.

[0034] The layered coding apparatus **100** is equipped with, at least, a spatial decimator **101** (for spatial scale down), a base-layer encoder **102**, a base-layer decoder **103**, a spatial interpolator **104** (for spatial scale up), a spatial high-frequency components estimator and upscaler **105**, an enhancement-layer encoder **106**, and a multiplexer **107**.

[0035] The function of each unit of the layered coding apparatus **100** will be described with reference to the block diagram shown in FIG. **1** and also a flowchart shown in FIG. **2**.

[0036] The spatial decimator **101** receives enhancement-layer picture element signals that carry enhancement-layer video frames (or fields in option) involved in the input moving-picture video signal. The video frames exhibit a spatial resolution for enhancement-layer coding. The decimator **101** decimates each video frame in spatial resolution (step **S101**) or scales down the video frame, thus producing a decimated (down-scaled) base-layer video frame. The base-layer video frame exhibits a spatial resolution lower than that of the input video signal. In other words, the base-layer video frame exhibits a spatial resolution lower than for enhancement-layer coding, so as to be subjected to base-layer coding. It is preferable for the spatial scale down procedure to include spatial bandwidth limitation to suppress spatial aliasing. The base-layer video frame for base-layer coding is then supplied to the base-layer encoder **102**.

[0037] The base-layer encoder **102** performs base-layer coding to the down-scaled base-layer video frame (step **S102**), thus generating a base-layer bitstream which is then

supplied to the base-layer decoder **103** and the multiplexer **107**. The base-layer coding at the base-layer encoder **102** may be any base-layer coding technique based on correlation in both of the spatial and time domains. In other words, the encoder **102** may be equipped, at least, with circuitry for motion estimation, motion compensation, orthogonal transform, quantization, inverse orthogonal transform, dequantization, entropy coding, etc., under MPEG standards for example, based on frame correlation in the spatial and time domains.

[**0038**] The base-layer decoder **103** decodes the base-layer bitstream generated by the base-layer encoder **102** (step **5103**), thus generating a base-layer decoded video frame (a locally decoded signal). Decoding of the base-layer bitstream can be done with any known decoding technique. The base-layer decoded frame is then supplied to the spatial interpolator **104** and the spatial high-frequency components estimator and upscaler **105**.

[**0039**] The spatial interpolator **104** applies a spatial interpolation (scale up) procedure to the base-layer decoded video frame (locally decoded signal), thus generating an upscaled video frame (step S**104**). The upscaled video frame exhibits a spatial resolution corresponds to that before the scale-down procedure at the spatial decimator **101**, or to the spatial resolution of the enhancement layer which is one layer higher than the base layer.

[**0040**] It is preferable for the scale up procedure to the base-layer decoded video frame to compensate the lack of pixels in the spatial domain with those of the decoded frame using an interpolation function, such as, a sync function The spatial high-frequency components estimator and upscaler **105** applies a spatial high-frequency components estimation and scale-up procedure, in a specific direction in the spatial domain, to the base-layer decoded frame supplied by the base-layer decoder **103** (step S**105**). Moreover, based on the spatial high-frequency components estimation and scale-up procedure, the estimator and upscaler **105** generates a high-frequency components frame that carries estimated high-frequency components. The estimated high-frequency components correspond to a video frame that exhibits a spatial resolution before subjected to the scale-down procedure at the spatial decimator **101**.

[**0041**] The high-frequency components frame generated by the spatial high-frequency components estimator and upscaler **105** is then added to or mixed with the upscaled video frame generated by the spatial interpolator **104** (step S**106**), thus a composite base-layer high-frequency-components estimated video frame being generated. The composite base-layer high-frequency-components-estimated video frame is then supplied to the enhancement-layer encoder **106**. Or, the frames generated by the estimator and upscaler **105** and the interpolator **104** may be separately supplied to the encoder **106**.

[**0042**] The enhancement-layer encoder **106** receives: each enhancement-layer video frame carried by the input moving-picture video signal; and the composite base-layer high-frequency-components-estimated video frame (or, the high-frequency components frame and the upscaled video frame). The encoder **106** performs an enhancement-layer coding procedure based on correlation between the enhancement-layer video frame and the composite base-layer video frame (step S**107**), thus generating a bitstream which is then supplied to the multiplexer **107**.

[**0043**] In other words, the enhancement-layer encoder **106** performs: a prediction procedure between the enhancement-layer video frame (exhibiting a spatial resolution of the enhancement layer) and the composite base-layer high-frequency-components-estimated video frame (or, the upscaled video frame from the spatial interpolator **104** and the high-frequency components frame from the spatial high-frequency components estimator and upscaler **105**); and a encoding procedure to encode a predictive-error signal obtained by subtracting the composite video frame (or, the upscaled and high-frequency components frames) from the enhancement-layer video frame.

[**0044**] As disclosed above, the enhancement-layer encoding procedure in FIG. **1** has the following advantages: In known enhancement-layer encoding technology, a predictive-error signal to be coded is given by subtracting an upscaled video frame from an enhancement-layer video frame. On the contrary, in FIG. **1**, subtracted from the enhancement-layer video frame is not only the upscaled video frame but also the high-frequency components video frame generated by estimation and upscaling, as described above. This predictive encoding procedure gives smaller predictive errors to high-frequency components, and hence gives smaller amounts to bitstream thus encoded, compared to the known enhancement-layer encoding.

[**0045**] The enhancement-layer coding at the enhancement-layer encoder **106** may be any enhancement-layer coding technique based on correlation in both of the spatial and time domains and also between the layers. In other words, the encoder **106** may be equipped, at least, with circuitry for motion estimation, motion compensation, orthogonal transform, quantization, inverse orthogonal transform, dequantization, entropy coding, etc., under MPEG standards for example, based on frame correlation in the spatial and time domains and also between the layers. Accordingly, it is preferable for the encoder **106** to apply the motion estimation and motion compensation procedure to the enhancement-layer video frame using the composite base-layer high-frequency-components-estimated video frame as a reference frame, for higher coding efficiency.

[**0046**] The multiplexer **107** multiplexes the bistreams supplied by the base-layer encoder **102** and the enhancement-layer encoder **106** (S**108**), thus generating an embedded multiplexed bistream which is then output via the transfer cable or media **300**.

[**0047**] Disclosed above are the function of each unit of the layered coding apparatus **100** (FIG. **1**) and also the several steps in the layered coding procedure (FIG. **2**) performed by the apparatus **100**.

[**0048**] Disclosed next is the layered decoding apparatus **200** shown in FIG. **1**. The apparatus **200** is equipped with, at least, an extractor **201**, a base-layer decoder **202**, a spatial interpolator **203**, a spatial high-frequency components estimator and upscaler **204**, and an enhancement-layer decoder **205**.

[**0049**] The function of each unit of the layered decoding apparatus **200** will be described with reference to the block diagram shown in FIG.**1** and also a flowchart shown in FIG. **3**.

[**0050**] The extractor **201** receives the embedded multiplexed bistream output from the layered coding apparatus

100 via the transfer cable or media **300**. Not only from the apparatus **100**, the layered decoding apparatus **200** can receive bitstream from any source. The extractor **201** demultiplexes the embedded multiplexed bistream and extracts a base-layer bitstream and an enhancement-layer bitstream (step S**201**) which are then supplied to the base-layer decoder **202** and the enhancement-layer decoder **205**, respectively.

[**0051**] The base-layer decoder **202** decodes the base-layer bitstream supplied from the extractor **201** (step S**202**), thus generating a base-layer decoded video frame (a locally decoded signal). The base-layer decoded video frame is then supplied to the spatial interpolator **203** and the spatial high-frequency components estimator and upscaler **204**, and, if necessary, to a display apparatus (not shown).

[**0052**] As already mentioned, the base-layer coding at the base-layer encoder **102** of the layered coding apparatus **100** may be any base-layer coding technique based on correlation in both of the spatial and time domains. Thus, the base-layer decoding at the base-layer decoder **202** can be any base-layer decoding technique to accurately decode the bitstream generated by the encoder **102**.

[**0053**] In this regard, also already mentioned, the base-layer encoder **102** may be equipped, at least, with circuitry for motion estimation, motion compensation, orthogonal transform, quantization, inverse orthogonal transform, dequantization, entropy coding, etc., under MPEG standards for example, based on frame correlation in the spatial and time domains.

[**0054**] In order to be compatible with the base-layer encoder **102**, the base-layer decoder **202** may be equipped, at least, with circuitry for motion compensation, inverse orthogonal transform, dequantization, entropy decoding, etc., under MPEG standards for example, to accurately decode the base-layer bitstream.

[**0055**] The spatial interpolator **203** applies a spatial interpolation (scale up) procedure to the base-layer decoded video frame (locally decoded signal) supplied from the base-layer decoder **202**, thus generating an upscaled video frame (step S**203**) which is then supplied to the enhancement-layer decoder **205**. The upscaled video frame exhibits a spatial resolution corresponds to that before the scale-down procedure at the spatial decimator **101** of the layered coding apparatus **100**, or to the spatial resolution of the enhancement layer which is one layer higher than the base layer. It is preferable for the scale up procedure to the base-layer decoded video frame to compensate the lack of pixels in the spatial domain with those of the decoded frame using an interpolation function, such as, a sync function.

[**0056**] The spatial high-frequency components estimator and upscaler **204** applies high-frequency components estimation and scale-up procedure, in a specific direction in the spatial domain, to the base-layer decoded frame supplied by the base-layer decoder **202** (step S**204**). Moreover, based on the high-frequency components estimation and scale-up procedure, the estimator and upscaler **204** generates a high-frequency components frame that carries estimated high-frequency components. The estimated high-frequency components correspond to a video frame that exhibits a spatial resolution before subjected to the scale-down procedure at the spatial decimator **101** of the layered coding apparatus **100**.

[**0057**] The high-frequency components frame generated by the spatial high-frequency components estimator and upscaler **204** is then added to or mixed with the upscaled video frame generated by the spatial interpolator **203** (step S**205**), thus a composite base-layer high-frequency-components estimated video frame being generated. The composite base-layer high-frequency-components-estimated video frame is then supplied to the enhancement-layer decoder **205**. Or, the frames generated by the estimator and upscaler **204** and the interpolator **203** may be separately supplied to the decoder **205**.

[**0058**] The enhancement-layer decoder **205** receives: the enhancement-layer bitstream from the extractor **201**; and the composite base-layer high-frequency-components-estimated video frame (or, the high-frequency components frame and the upscaled video frame). The decoder **205** performs an enhancement-layer decoding procedure based on correlation between the enhancement-layer bitstream and the composite base-layer high-frequency-components-estimated video frame (step S**206**), thus generating an enhancement-layer decoded video frame (a decoded video signal).

[**0059**] As disclosed above, the multiplexed bitstream input to the layered decoding apparatus **200** includes the bitstream which is the encoded predictive-error signal given, in the layered coding apparatus **100**, by subtracting the composite base-layer high-frequency-components-estimated video frame (or, the upscaled video frame from the spatial interpolator **104** and the high-frequency components frame from the spatial high-frequency components estimator and upscaler **105**).

[**0060**] Therefore, the enhancement-layer decoder **205** in the layered decoding apparatus **200** performs the enhancement-layer decoding procedure to decode the enhancement-layer bitstream to gain a predictive-error signal and adds this signal and the composite base-layer high-frequency-components-estimated video frame (or, the high-frequency components frame from the spatial high-frequency components estimator and upscaler **204** and the upscaled video frame from the spatial interpolator **203**), thus generating an enhancement-layer decoded video frame.

[**0061**] Accordingly, the layered decoding apparatus **200** can accurately perform the decoding procedure even when the bitstream input thereto includes the bitstream which is the encoded predictive-error signal given, in the layered coding apparatus **100**, by subtracting the composite base-layer high-frequency-components-estimated video frame (or, the upscaled video frame from the spatial interpolator **104** and the high-frequency components frame from the spatial high-frequency components estimator and upscaler **105**).

[**0062**] The enhancement-layer decoded video frame generated by the enhancement-layer decoder **205** is supplied to a display apparatus (not shown). The base-layer decoded frame generated by the base-layer decoder **202** may be supplied to the display apparatus together with or instead of the enhancement-layer decoded video frame.

[**0063**] The enhancement-layer decoding procedure at the enhancement-layer decoder **205** is compatible with the enhancement-layer coding procedure at the enhancement-layer encoder **106** of the layered coding apparatus **100**.

[**0064**] Employed for the enhancement-layer decoding procedure at the enhancement-layer decoder **205** may be any

decoding technique that accurately decodes the enhancement-layer bitstream generated by the enhancement-layer encoder **106**.

[0065] In other words, the enhancement-layer decoder **205** may be equipped, at least, with circuitry for motion compensation, inverse orthogonal transform, dequantization, entropy decoding, etc., under MPEG standards for example, based on frame correlation in the spatial and time domains and also between the layers. Accordingly, it is preferable for the decoder **205** to be capable of applying the motion compensation procedure to the enhancement-layer video frame using the composite base-layer high-frequency-components-estimated video frame as a reference frame, for higher decoding efficiency.

[0066] Accordingly, the layered coding and decoding schemes according to the embodiment disclosed above focused on "a pyramidal structure of high-frequency components generated in a zone in a video frame, such as, a strong edge zone. Such high-frequency components are eliminated before the coding procedure, which can be estimated from a base layer of the video frame based on correlation between the base layer and an enhancement layer (one layer higher than the base layer) of the video frame. Elimination of the high-frequency components can be done with the subtraction procedure, as discussed in step S**107** of FIG. **2**.

[0067] Elimination of the high-frequency components results in suppression of a signal level of an interlayer predictive signal obtained from the difference between the enhancement and base layers. The interlayer predictive signal exhibits higher correlation with other interlayer predictive signals obtained in the vicinity of the signal in the time domain as the signal level is suppressed further, thus entropy being suppressed.

[0068] Therefore, coded data (bitstream) carry fewer bits under the higher efficient coding scheme according to the embodiment disclosed above. In addition, the suppressed interlayer predictive signal level diminishes adverse effects to decoding due to quantization errors, according to the above embodiment.

[0069] Disclosed next is the spatial high-frequency components estimator and upscaler **105** included in the layered coding apparatus **100**, whereas description is omitted for the spatial high-frequency components estimator and upscaler **204** included in the layered decoding apparatus **200** because the estimators and upscalers **105** and **204** are identical to each other.

[0070] FIG. **4** shows a block diagram of the spatial high-frequency components estimator and upscaler **105** included in the layered coding apparatus **100**.

[0071] The spatial high-frequency components estimator and upscaler **105** is equipped with, at least, a first high-pass filter **1051**, an interpolator **1052**, a level-limiter and constant-multiplier **1053**, and a second high-pass filter **1054**.

[0072] The function of each unit of the spatial high-frequency components estimator and upscaler **105** will be described with reference to the block diagram shown in FIG. **4** and also a flowchart shown in FIG. **5**.

[0073] The first high-pass filter **1051** receives the base-layer decoded frame supplied from the base-layer decoder **103** (FIG. **1**) and extracts specific high-frequency components from the base-layer decoded frame. The specific high-frequency components are those having a high correlation with high-frequency components carried by the enhancement-layer video frame to be coded (one layer higher than the base layer), hence suitable for use in estimation.

[0074] In this exemplary estimator and upscaler **105**, the first high-pass filter **1051** receives an input decoded frame **310** to be upscaled and extracts Laplacian components for high-frequency components suitable for use in estimation (step S **301**).

[0075] In the layered coding apparatus **100** that performs a coding procedure at two coding layers, the enhancement layer and the base layer, the input frame **310** is a base-layer decoded frame supplied from the base-layer decoder **103**. However, as disclosed later, the present invention is also applicable to multilayer coding and decoding schemes that handle a base coding layer and an N number of enhancement coding layers (N being a positive integer of one or more). Under the multilayer schemes, the input frame **310** is an (N−1)-th enhancement-layer decoded frame to be used for coding an N-th enhancement-layer frame at one layer higher than the (N−1)-th enhancement-layer.

[0076] Laplacian components Lo(x) extracted from an input signal Go(x), as a one-dimensional signal model, can be expressed as follows:

$$L_o(x) = G_o(x) - \sum_{i=-l}^{l} W(i) \cdot G_o(x+i) \tag{1}$$

$$W(i) = \frac{1}{2\sqrt{\rho\pi}} e^{-\frac{i^2}{4\rho}} \tag{2}$$

[0077] The letters ""l" and "ρ" in the expressions (1) and (2) are the number of filter taps and a parameter for use in examining a bandwidth of a Gaussion filter, set to a value for halfband filtering, respectively.

[0078] The extracted high-frequency components suitable for use in estimation, in this case, Laplacian components Lo(x), are supplied to the interpolator **1052**.

[0079] The interpolator **1052** applies an interpolation procedure to the extracted high-frequency components, or Laplacian components Lo(x), at an enlargement scale (enhancement-layer spatial resolution/base-layer spatial resolution) for desired resolution (step S**302**).

[0080] The Interpolation procedure to the Laplacian components Lo(x) at an enlargement scale "r" (enhancement-layer spatial resolution/base-layer spatial resolution) can be expressed as follows:

$$(\text{EXPAND})_r L_o(x) = \sum_{i=-l}^{l} w_r(i) L_o\left(\text{int}\left(\frac{x}{2r}\right) + i\right) \tag{3}$$

$$W_r(i) = \frac{3}{4} e^{-\frac{9\pi}{16}(\Delta k + i)^2} \tag{4}$$

-continued

$$\Delta k = \mathrm{int}\left(\frac{x}{2^r}\right) - \frac{x}{2^r} \quad (5)$$

[0081] The letter "I" in the expression (3) is the number of filter taps. The sign "int(•)" in the expressions (3) and (5) indicates an integer extraction procedure.

[0082] An interpolated Laplacian-components signal $(\mathrm{EXPAND})_r\mathrm{Lo}(x)$ obtained through the interpolation procedure is then supplied to the level-limiter and constant-multiplier **1053**.

[0083] The level-limiter and constant-multiplier **1053** applies a level-limiting and constant-multiplying procedure to the interpolated Laplacian-components signal $(\mathrm{EXPAND})_r\mathrm{LO}(x)$ (step **S303**). This procedure is a first step of estimating unknown high-frequency components from the signal $(\mathrm{EXPAND})_r\mathrm{LO}(x)$, which can be expressed as follows:

$$\overline{L_r}(x) = \alpha_r \times \begin{cases} T & \text{if } T \leqq (\mathrm{EXPAND})_r L_o(x) \\ (\mathrm{EXPAND})_r L_o(x) & \text{if } -T < (\mathrm{EXPAND})_r L_o(x) < T \\ -T & \text{if } (\mathrm{EXPAND})_r L_o(x) \leqq -T \end{cases} \quad (6)$$

[0084] The first step of high-frequency components estimation at the level-limiter and constant-multiplier **1053** according to the expression (6) is performed as follows:

[0085] The level-limiter and constant-multiplier **1053** outputs: a signal which is a result of constant-multiplying procedure to the interpolated Laplacian-components signal $(\mathrm{EXPAND})_r\mathrm{Lo}(x)$ with "α_r" when the level of the signal $(\mathrm{EXPAND})_r\mathrm{LO}(x)$ lies between given levels T and −T; a signal having a level of "$\alpha_r \cdot (T)$" when the level of the signal $(\mathrm{EXPAND})_r\mathrm{Lo}(x)$ is at or higher than T; and a signal having a level of "$\alpha_r \cdot (-T)$" when at or lower than −T. The levels T and −T are used in level limitation.

[0086] The expressions (1) to (6) are taught from the description of the document "An Arbitrary Scale Image Enlargement Method with the Prediction of High-Frequency Components" published by the Institute of Electronics, Information and Communication Engineers, Vol. J84-A, No. 9, pp. 1192-1201, September 2001, the entire content of which is incorporated herein by reference.

[0087] Experimentally obtained values shown in the document can be used as the parameters T and α_r for the level limitation and constant multiplication, respectively. The parameter α_r depends on the enlargement scale.

[0088] The level-limited and constant-multiplied signal is supplied from the level-limiter and constant-multiplier **1053** to the second high-pass filter **1054**.

[0089] The second high-pass filter **1054** applies a second step of estimating unknown high-frequency components to the input level-limited and constant-multiplied signal. The second step is a high-pass filtering procedure to the input signal (subjected to the first step of estimating unknown high-frequency components) to remove unnecessary low-frequency components and extract essential high-frequency components (step **S304**).

[0090] The estimated high-frequency components output from the second high-pass filter **1054** can be expressed as follows:

$$\hat{L}_r(x) = \overline{L_r}(x) - \sum_{i=-I}^{I} W(i) \cdot \overline{L_r}(x+i) \quad (7)$$

[0091] The term W(i) in the expression (7) is given from the expression (2). The expression (7) is also taught from the teaching of the document mentioned above.

[0092] The estimated high-frequency components output from the second high-pass filter **1054** is supplied as a high-frequency components frame **311** (FIG. **4**) to the enhancement-layer encoder **106** (FIG. **1**).

[0093] Known layered coding and decoding schemes with per-block coding and decoding procedures with per-block Laplacian-components emphasis have difficulty in analysis, such as estimation, and emphasis on block borders.

[0094] In contrast, the layered coding and decoding schemes in the embodiment disclosed above include reproduction of a base-layer decoded frame and interpolation of the decoded frame to an enhancement-layer frame scale followed by estimation of high-frequency components with Laplacian-components emphasis. The schemes give an interlayer predictive signal higher correlation with other interlayer predictive signals obtained In the vicinity of the signal in the time domain as the signal level is suppressed further, thus entropy being suppressed. This results in that coded data (bitstream) can carry fewer bits for higher efficient coding.

[0095] The several functions of the layered coding and decoding apparatuses **100** and **200** disclosed above with reference to FIGS. **1** to **5** can be achieved with software programs under the present invention.

[0096] FIG. **6** shows a data processing system **400** with a software program installed therein that corresponds to the functions of the layered coding apparatus **100** (FIG. **1**).

[0097] The data processing system **400** is equipped with: an input unit **401** for entering several kinds of data; an output unit **402** for outputting several kinds of data; a central processing and controlling unit **403** with a layered coding program installed therein that corresponds to the functions of the layered coding apparatus **100**; an external memory unit **404**; a temporary memory unit **405** to be used, for example, as a working area in processing at the central processing and controlling unit **403**; and a communications unit **406** for external communications. The units are connected to one another via a bidirectional bus **407**.

[0098] Installed in the central processing and controlling unit **403** from a storage medium or via a communications network is a layered coding program that corresponds to the functions of the layered coding apparatus **100**.

[0099] The layered coding program includes computer readable program codes, at least, a spatial decimation program code **411**, a base-layer encode program code **412**, a base-layer decode program code **413**, a spatial interpolation program code **414**, a spatial high-frequency components

estimate and upscale program code **415**, an enhancement-layer encode program code **416**, and a multiplex program code **417**.

[**0100**] The program codes **411**, **412**, **413**, **414**, **415**, **416** and **417** correspond to the functions of the spatial decimator **101**, the base-layer encoder **102**, the base-layer decoder **103**, the spatial interpolator **104**, the spatial high-frequency components estimator and upscaler **105**, the enhancement-layer encoder **106**, and the multiplexer **107**, respectively, shown in FIG. **1**.

[**0101**] The central processing and controlling unit **403** works like the layered coding apparatus **100** while the layered coding program with the computer readable program codes listed above is running thereon.

[**0102**] FIG. **7** shows a data processing system **500** with a software program installed therein that corresponds to the functions of the layered decoding apparatus **200** (FIG. **1**).

[**0103**] The data processing system **500** is equipped with; an input unit **501** for entering several kinds of data; an output unit **502** for outputting several kinds of data; a central processing and controlling unit **503** with a layered decoding program installed therein that corresponds to the functions of the layered decoding apparatus **200**; an external memory unit **504**; a temporary memory unit **505** to be used, for example, as a working area in processing at the central processing and controlling unit **503**; and a communications unit **506** for external communications. The units are connected to one another via a bidirectional bus **507**.

[**0104**] Installed in the central processing and controlling units **503** from a storage medium or via a communications network is a layered decoding program that corresponds to the functions of the layered decoding apparatus **200**.

[**0105**] The layered decoding program includes computer readable program codes, at least, an extraction program code **511**, a base-layer decode program code **512**, a spatial interpolation program code **513**, a spatial high-frequency components estimation and upscale program code **514**, and an enhancement-layer decode program code **515**.

[**0106**] The program codes **511**, **512**, **513**, **514**, and **515** correspond to the functions of the extractor **201**, the base-layer decoder **202**, the spatial interpolator **203**, the spatial high-frequency components estimator and upscaler **204**, and the enhancement-layer decoder **205**, respectively, shown in FIG. **1**.

[**0107**] The central processing and controlling unit **503** works like the layered decoding apparatus **200** while the layered decoding program with the computer readable program codes listed above is running thereon.

[**0108**] The data processing systems **400** and **500** are compatible with each other, so that data processed at the system **400** can be transferred to the system **500** via media, such as, a storage medium, a transfer cable, a communications network, etc.

[**0109**] Disclosed so far are layered coding and decoding schemes for two coding layers of video frames or fields: an base layer and an enhancement layer (one layer higher than the base layer). Not only the two layers, however, the present invention is applicable to multilayers of video frames or fields.

[**0110**] FIG. **8** shows a block diagram of a multilayer coding apparatus according to the present invention.

[**0111**] The same reference numerals are used for the components (FIGS. **8**) that are identical to those shown in FIG. **1**.

[**0112**] The multilayer coding apparatus shown in FIG. **8** is an extended version of the layered coding apparatus **100** shown in FIG. **1**. Provided in the apparatus of FIG. **8**, instead of the enhancement-layer encoder **106** of FIG. **1**, are: an N number of spatial decimators **101-1** to **101**-N; the first enhancement-layer encoder **106-1** to the (N+1)-th enhancement-layer encoder **106**-(N+1); the first enhancement-layer decoder **103-1** to the N-th enhancement-layer decoder **103**-N; an N number of spatial interpolators **104-1** to **104**-N; and an N number of spatial high-frequency components estimators and upscalers **105-1** to **105**-N, N being a positive integer of one or more.

[**0113**] The first enhancement layer is one layer higher than the base layer. The second enhancement layer is one layer higher than the first enhancement layer. The same is true for the third or upper enhancement layer, or the (N+1)-th enhancement layer is one layer higher than the N-th enhancement layer.

[**0114**] Supplied to a multiplexer **110** in the multilayer coding apparatus (FIG. **8**) are: a bitstream of a base-layer video frame coded at the base-layer encoder **102** after down-scaled at the spatial decimator **101**; and also the bitstream from the first enhancement-layer encoder **106-1** to the (N+1)-th enhancement-layer encoder **106**-(N+1).

[**0115**] The bitstream supplied from the first encoder **106-1** is an encoded predictive-error signal obtained based on correlation between; a first-enhancement-layer video frame signal gained by down scaling at the spatial decimator **101-1**; and an upscaled video frame signal from the spatial interpolator **104** of the base layer one layer lower than the first enhancement layer and a high-frequency components signal from the spatial high-frequency components estimators and upscaler **105** of the base layer. The predictive-error signal is obtained by subtracting the upscaled video frame signal and the high-frequency components signal (given based on the signals of the base layer one layer lower than the first enhancement layer) from the first-enhancement-layer video frame signal (of the first enhancement layer).

[**0116**] Likewise, the bitstream supplied from the second enhancement-layer encoder **106-2** to the (N+1)-th enhancement-layer encoder **106**-(N+1) are encoded predictive-error signals obtained based on correlation between: second to (N+1)-th enhancement-layer video frame signals; and upscaled video frame signals (from the spatial Interpolators **104-1** to **104**-N of one layer lower than the layer of the corresponding enhancement-layer video frame signal) and also high-frequency components signals (from the spatial high-frequency components estimators and upscalers **105-1** to **105**-N of one layer lower than the layer of the corresponding enhancement-layer video frame signal). Each predictive-error signal is obtained by subtracting the upscaled video frame signal and the high-frequency components signal (given based on the signals of the one-lower layer) from the corresponding enhancement-layer video frame signal.

[**0117**] Accordingly, the multiplexer **110** multiplexes the bitstream from the base-layer encoder **102** and an (N+1)

number of bitstream, thus outputting the multiplexed bitstream. Here, the (N+1) number of bitstream are the predictive-error signals each obtained by subtracting the upscaled video frame signal and the high-frequency components signal (given based on the signals of a specific enhancement layer from among the first to N-th enhancement layers) from the enhancement-layer video frame signal (of another specific enhancement layer that is one layer higher than the former specific enhancement layer).

[0118] FIG. **9** shows a block diagram of a multilayer decoding apparatus according to the present invention.

[0119] The same reference numerals are used for the components (FIG. **9**) that are identical to those shown in FIG. **1**.

[0120] The multilayer decoding apparatus shown in FIG. **9** is an extended version of the layered decoding apparatus **200** shown in FIG. **1**. Provided in the apparatus of FIG. **9**, instead of the enhancement-layer decoder **205** of FIG. **1**, are: an (N+1) number of enhancement-layer decoders **205-1** to **205**-(N+1); an N number of spatial interpolators **203-1** to **203**-N; and an N number of spatial high-frequency components estimators and upscalers **204-1** to **204**-N, N being a positive integer of one or more.

[0121] A multiplexed bitstream supplied, for example, from the multilayer coding apparatus (FIG. **8**) is input to an extractor **201** in FIG. **9**. The extractor **201** extracts a base-layer bitstream and the first to (N+1)-th enhancement-layer bitstream from the multiplexed bitstream.

[0122] The base-layer bitstream is decoded into a base-layer decoded output video signal at a base-layer decoder **202**, like described with reference to FIG. **1**.

[0123] The first to (N+1)-th enhancement-layer bitstream are supplied to the first to (N+1)-th enhancement-layer decoders **205-1** to **205**-(N+1), respectively. Also supplied to the decoders **205-1** to **205**-(N+1) are upscaled video frame signals gained by interpolation at the spatial interpolators **203** to **203**-N, respectively, and high-frequency components signals gained by spatial high-frequency components estimation and upscaling at the spatial high-frequency components estimators and upscalers **204** to **204**-N, respectively.

[0124] The first to (N+1)-th enhancement-layer decoders **205-1** to **205**-(N+1) perform the reverse procedure of the encoding procedure at the first to (N+1)-th enhancement-layer encoders **106-1** to **106**-(N+1) shown in FIG. **8**. In detail, the decoders **205-1** to **205**-(N+1) decode the bitstream at the first to (N+1)-th enhancement decoding layers, respectively, to gain predictive-error signals. The decoder **205-1** to **205**-(N+1) add the respective upscaled video frame signals and high-frequency components signals to the corresponding predictive-error signals, thus reproducing video signals exhibiting the spatial resolution of the respective enhancement layers from among the first to (N+1)-th enhancement layers.

[0125] Accordingly, the base-layer decoder **202** and the first to (N+1)-th enhancement-layer decoders **205-1** to **205**-(N+1) output video signals exhibiting the spatial resolution of the respective layers.

[0126] The number of layers is thus not limited to any particular number and easily extended as disclosed with respect to FIGS. **8** and **9**, according to the present invention.

[0127] Moreover, in FIGS. **8** and **9**, Laplacian components extracted from the base-layer decoded frame or the N-th enhancement-layer decoded frame in high-frequency components estimation promote elimination of high-frequency components with the subtraction procedure discussed in step **S107** of FIG. **2**, resulting in suppression of a signal level of an interlayer predictive signal for higher efficient coding.

[0128] In each embodiment disclosed above, the spatial high-frequency components estimator and upscaler performs level-limitation and constant-multiplication using a predetermined estimation and upscaling parameter at a given enhancement layer.

[0129] On the contrary, in each embodiment described below, an enhancement-layer encoder instructs a spatial high-frequency components estimator and upscaler to change estimation and upscaling parameters for use in estimation and upscaling and perform a spatial high-frequency components estimation and upscaling procedure with the changed parameters so that the encoder can generate the least amount of bitstream.

[0130] Shown in FIG. **10** are block diagrams of a layered coding apparatus **700** and a layered decoding apparatus **750** according to the present invention. The units identical or analogous to those shown in FIG. **1** are given the same reference numerals, with the explanation thereof being omitted.

[0131] In FIG. **10**, an enhancement-layer encoder **106***a* calculates a code amount when encoding a predictive-error signal at a spatial resolution of an enhancement layer. Like the counterpart **106** in FIG. **1**, the encoder **106***a* obtains the predictive-error signal by subtracting an upscaled video (frame or field) signal from a spatial interpolator **104** and a high-frequency components (frame or field) signal from a spatial high-frequency components estimator and upscaler **105***a* from an input enhancement-layer video (frame or field) signal.

[0132] Although not shown in FIG. **10**, the enhancement-layer encoder **106***a* includes an orthogonal transformer, a quantizater, an entropy encoder, etc. Therefore, the code amount to be calculated by the encoder **106***a* may be a code amount generated after the predictive-error signal mentioned above is subjected to orthogonal transformation and quantization or a code amount generated after the predictive-error signal is subjected to orthogonal transformation and quantization, and also entropy encoding. The latter code amount is closer to the code amount of the output bitstream of the encoder **106***a* than the former code amount is. Nevertheless, the latter requires more calculation than the former.

[0133] The enhancement-layer encoder **106***a* sends a reprocessing command, based on the code amount discussed above, to the spatial high-frequency components estimator and upscaler **105***a* to change the estimation and upscaling parameters and perform again the spatial high-frequency components estimation and upscaling procedure. The reprocessing command may be generated for the spatial high-frequency components estimation and upscaling procedure to be performed several times, such as, three or four times. It may also be generated when a currently calculated code amount is smaller than a preset value or a code amount calculated just before the current code amount.

[0134] With the high-frequency components signals generated again or several times from the spatial high-frequency components estimator and upscaler **105** and an upscaled video signal from the spatial interpolator **104**, the enhancement-layer encoder **106***a* calculates code amounts of predictive-error signals coded in accordance with the high-frequency components signals generated again or several times and supplies a bitstream of the least code amount to a multiplexer **107***a*.

[0135] FIG. **11** shows an exemplary block diagram of the spatial high-frequency components estimator and upscaler **105***a*. The units identical or analogous to those shown in FIG. **4** are given the same reference numerals, with the explanation thereof being omitted.

[0136] In FIG. **11**, when the reprocessing command is sent from the enhancement-layer encoder **106***a*, a level-limiter and constant-multiplier **1053***a* changes the estimation and upscaling parameters and performs again or several times the spatial high-frequency components estimation and upscaling procedure.

[0137] In detail, in response to the reprocessing command, the level-limiter and constant-multiplier **1053***a* changes the parameter T for estimation and upscaling and the parameter α_r for constant-multiplication, both shown in the expression (6). These two parameters are referred to as the estimation and upscaling parameters mentioned above. Then, the level-limiter and constant-multiplier **1053***a* performs again or several times a level-limitation and constant-multiplication procedure with the changed parameters, the output being sent to a second high-pass filter **1054**.

[0138] The level-limiter and constant-multiplier **1053***a* may prestore several sets of the parameter T for estimation and upscaling and the parameter or for constant-multiplication, shown in the expression (6), or may change these parameters by a given value in response to the reprocessing command.

[0139] When the level-limiter and constant-multiplier **1053***a* has changed the estimation and upscaling parameters and performed the level-limitation and constant-multiplication procedure again, the enhancement-layer encoder **106***a* performs the encoding procedure and calculates code amounts, in accordance with the number of the level-limitation and constant-multiplication procedure performed, to find out the least code amount. The encoder **106***a* sends a command regarding the least coded amount to the spatial high-frequency components estimator and upscaler **105***a*. In respond to the command, the estimator and upscaler **105***a* sends the estimation and upscaling parameters for the least code amount to the multiplexer **107***a*. The parameters may be sent to the multiplexer **107***a* after subjected to entropy coding or the like.

[0140] The multiplexer **107***a* receives the bitstream of the least code amount from the enhancement-layer encoder **106***a* and the estimation and upscaling parameters for the least code amount from the spatial high-frequency components estimator and upscaler **105***a*. Then the multiplexer **107***a* multiplexes the bitstream and parameters into a multiplexed bitstream which can be supplied to the layered decoding apparatus **750** via a transfer cable or other media **300**.

[0141] As disclosed above, according to the layered coding apparatus **700** shown in FIG. **10**, the enhancement-layer encoder **106***a* generates a bitstream of a smaller code amount and hence the multiplexer **107***a* outputs a multiplexed bitstream at a higher transfer rate.

[0142] Then, in FIG. **10**, the layered decoding apparatus **750** receives the multiplexed bitstream via the transfer cable or **25**, other media **300**. Nevertheless, the apparatus **750** can receive bitstream not only from the layered coding apparatus **700** but also from any source.

[0143] An extractor **201***a* receives the multiplexed bistream and demultiplexes it into the base-layer bitstream, the enhancement-layer bitstream, and the estimation and upscaling parameters, which are supplied to a base-layer decoder **202**, an enhancement-layer decoder **205**, and a spatial high-frequency components estimator and upscaler **204***a*, respectively. The estimation and upscaling parameters are decoded if encoded by entropy coding or the like.

[0144] FIG. **12** shows an exemplary block diagram of the spatial high-frequency components estimator and upscaler **204***a*. The units identical or analogous to those shown in FIG. **4** are given the same reference numerals, with the explanation thereof being omitted.

[0145] In FIG. **12**, the estimation and upscaling parameters are sent to a level-limiter and constant-multiplier **1053***b* from the extractor **201***a*.

[0146] The label "ESTIMATION AND UPSCALING PARAMETER" in FIG. **12** indicates both of the parameter T for estimation and upscaling and the parameter α_r for constant-multiplication, shown in the expression (6).

[0147] The level-limiter and constant-multiplier **1053***b* performs a spatial high-frequency components estimation and upscaling procedure, with estimation and upscaling parameters, to a base-layer decoded video (frame or field) signal, or a locally decoded signal supplied from the base-layer decoder **202**, thus generating a high-frequency components (frame or filed) signal which is supplied to the enhancement-layer decoder **205**.

[0148] The enhancement-layer decoder **205** decodes an enhancement-layer bitstream supplied from the extractor **201***a* to gain a predictive-error signal. Then, the decoder **205** adds the predictive-error signal, and an upscaled video (frame or field) signal from a spatial interpolator **203** and the high-frequency components (frame or filed) signal from the high-frequency components estimator and upscaler **204***a*, thus reproducing an enhancement-layer video signal.

[0149] As disclosed above, when an input enhancement-layer bitstream is multiplexed with the estimation and upscaling parameters, in the layered decoding apparatus **750**, the enhancement-layer decoder **205** decodes the input enhancement-layer bitstream through the high-frequency components estimation and upscaling procedure at the high-frequency components estimator and upscaler **204***a* to a signal decoded at the base-layer decoder **202**, using the estimation and upscaling parameters. Thus, the layered decoding apparatus **750** accurately decodes a bitstream supplied from the layered decoding apparatus **700**.

[0150] In the embodiment shown in FIG. **10**, the multiplexer **107***a* multiplexes the enhancement-layer bitstream from the enhancement-layer encoder **106***a* with the estimation and upscaling parameters from the spatial high-fre-

quency components estimator and upscaler **105***a*, thus generating the multiplexed bitstream.

[**0151**] Not only that, the enhancement-layer encoder **106***a* may supply the estimation and upscaling parameters to the spatial high-frequency components estimator and upscaler **105***a* and also multiplex the enhancement-layer bitstream with the parameters into the output multiplexed bitstream.

[**0152**] As disclosed above, the embodiment in FIG. **10** includes the layered coding apparatus **700** and the layered decoding apparatus **750** which ate two-layer apparatuses (the enhancement layer and the base layer), for encoding and decoding using the estimation and upscaling parameters for the least code amount of bitstream.

[**0153**] Disclosed below are multilayer coding and decoding apparatuses for encoding and decoding using the estimation and upscaling parameters for the least coded amount of bitstream.

[**0154**] FIG. **13** shows a block diagram of a multilayer coding apparatus **800** according to the present invention. The units identical or analogous to those shown in FIG. **8** are given the same reference numerals, with the explanation thereof being omitted.

[**0155**] Like the enhancement-layer encoder **106***a* in FIG. **10**, first- to (N+1)-th enhancement-layer encoders **106***a*-**1** to **106***a*-(N+1) calculate code amounts and send reprocessing commands to spatial high-frequency components estimators and upscalers **105***a* to **105***a*-N, respectively.

[**0156**] In response to the reprocessing commands, the spatial high-frequency components estimators and upscalers **105***a* to **105***a*-N change the estimation and upscaling parameters and perform the spatial high-frequency components estimation and upscaling procedure again or several times to generate high-frequency components signals which are supplied to the enhancement-layer encoders **106***a*-**1** to **106***a*-(N+1), respectively.

[**0157**] Each of the spatial high-frequency components estimator and upscaler **105***a* to **105***a*-N has the same structure as shown in FIG. **11**.

[**0158**] Each of the first- to (N+1)-th enhancement-layer encoders **106***a*-i to **106***a*-(N+1) supplies the bitstream of the least code amount to a multiplexer **110***a*, through plural times of the high-frequency components estimation and upscaling procedure. Each of the spatial high-frequency components estimator and upscaler **105***a* to **105***a*-N supplies the estimation and upscaling parameters for the least code amount to the multiplexer **110***a*. The multiplexer **110***a* multiplexes first- to (N+1)-th enhancement-layer bitstream with the corresponding parameters, thus generating an output multiplexed bitstream. The parameters may be sent to the multiplexer **110***a* after subjected to entropy coding or the like.

[**0159**] FIG. **14** shows a block diagram of a multilayer decoding apparatus **850** according to the present invention. The units identical or analogous to those shown in FIG. **9** are given the same reference numerals, with the explanation thereof being omitted.

[**0160**] The layered decoding apparatus **850** receives the multiplexed bitstream supplied from the layered coding apparatus **800**. Nevertheless, the apparatus **850** can receive bitstream not only from the layered coding apparatus **800** but also from any source.

[**0161**] An extractor **201***a* receives the multiplexed bistream and demultiplexes it into the base-layer bitstream, the first- to (N+1)-th enhancement-layer bitstream, and the estimation and upscaling parameters, which are supplied to a base-layer decoder **202**, first- to N-th enhancement-layer decoders **205-1** to **205**-N, and spatial high-frequency components estimators and upscalers **204***a* to **204***a*-N, respectively. The estimation and upscaling parameters are decoded if encoded by entropy coding or the like.

[**0162**] The spatial high-frequency components estimators and upscalers **204***a* to **204***a*-N perform a high-frequency components estimation and upscaling procedure to decoded video (frame or field) signals, or locally decoded signals, supplied from a base-layer decoder **202**, and first to N-the enhancement-layer decoders **205-1** to **20-5**N, respectively, thus generating high-frequency components (frame or filed) signals. The generated high-frequency components (frame or filed) signals are supplied to the enhancement-layer decoders **205-1** to **205**-N.

[**0163**] Each of the spatial high-frequency components estimators and upscalers **204***a* to **204***a*-N has the same structure as shown in FIG. **12**.

[**0164**] The first to (N+1)-th enhancement-layer decoders **205-1** to **205**-(N+1) decode first to (N+1)-th enhancement-layer bitstream, respectively, supplied from the extractor **201***b*, to gain predictive-error signals. Then, the decoders **205-1** to **205**-(N+1) add the predictive-error signals, and upscaled video (frame or field) signals from spatial interpolators **203** to **203**-N and the high-frequency components (frame or filed) signals from the high-frequency components estimators and upscalers **204***a* to **204***a*-N, thus reproducing first to (N+1)-th enhancement-layer video signals, respectively.

[**0165**] As disclosed above, according to the multilayer coding apparatus **800** shown in FIG. **13**, the enhancement-layer encoders **106***a*-**1** to **106***a*-(N+1) generate bitstream of a smaller coded amount and hence the multiplexer **110***a* outputs a multiplexed bitstream at a higher transfer rate. And, the multilayer decoding apparatus **850** shown in FIG. **14** can accurately decode such a multiplexed bitstream.

[**0166**] According to the several embodiments disclosed above, the encoding procedure is performed at one enhancement layer or all of a plurality of enhancement layers, besides the base layer that is the lowest layer with the lowest spatial resolution.

[**0167**] In detail, the encoding procedure is performed to a predictive-error signal obtained by subtracting an upscaled decoded video signal and a high-frequency components signal from an input video signal exhibiting a spatial resolution of the one enhancement layer or each of the enhancement layers mentioned above.

[**0168**] Here, the upscaled decoded video signal is obtained by scaling up a decoded signal of one layer lower than the one enhancement layer or each of the enhancement layers, as exhibiting the spatial resolution of the one enhancement layer or each of the enhancement layers. The high-frequency components signal is obtained by estimation

and scaling up high-frequency components at the spatial resolution of the one enhancement layer or each of the enhancement layers.

[0169] Not only that, according to the present invention, the encoding procedure can be performed at any enhancement layer of a plurality of enhancement layers. In addition, the decoded signal to be subjected to the upscaling procedure is not only a signal decoded at one layer lower than the one enhancement layer or each of the enhancement layers but also decoded at two or more layers lower than the one enhancement layer or each of the enhancement layers.

[0170] The several embodiments disclosed above employ a moving-picture signal as a signal to be encoded. Not only that, however, a still-picture signal may also be employed as a signal to be encoded, which is compressed with spatial correlation.

[0171] As disclosed above in detail, according to the layered coding and decoding schemes according to the present invention, high-frequency components generated, mostly, in a zone in a video frame, such as, a strong edge zone, are eliminated before the coding procedure. Such high-frequency components can be estimated from a base layer based on correlation between the base layer and an enhancement layer (one layer higher than the base layer) of a video frame or field. Or, they can be estimated from an (N−1)-th enhancement layer based on correlation between the (N−1)-th enhancement layer and an N-th enhancement layer (one layer higher than the (N−1)-th layer) of a video frame or field.

[0172] Elimination of the high-frequency components results in suppression of a signal level of or data amount carried by an interlayer predictive signal. The interlayer predictive signal exhibits higher correlation with other interlayer predictive signals obtained in the vicinity of the signal in the time domain as the signal level is suppressed further. Therefore, entropy is suppressed, and hence, coded data carry fewer bits. In addition, the suppressed interlayer predictive signal level diminishes adverse effects to decoding due to quantization errors.

What is claimed is:

1. A layered coding apparatus for encoding an input video signal at a plurality of coding layers exhibiting different spatial resolutions comprising:

a decoder to decode a given signal coded at a lower coding layer lower than a specific coding layer among the plurality of coding layers, thus generating a decoded signal of the lower coding layer;

a spatial interpolator to apply spatial interpolation to the decoded signal of the lower coding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upscating procedure to upscale the decoded signal of the lower coding layer into a spatial resolution of the specific coding layer;

a spatial high-frequency components estimator and upscaler to apply a spatial high-frequency components estimation and scale up procedure to the decoded signal of the lower coding layer, thus generating a high-frequency components signal; and

an encoder to subtract the upscaled decoded video signal and the high-frequency components signal from the input video signal exhibiting a spatial resolution of the specific coding layer to produce a predictive-error signal, and encode the predictive-error signal at the specific coding layer, thus generating an output bitstream,

wherein the decoder, the spatial interpolator, the spatial high-frequency components estimator and upscaler, and the encoder function at, at least, the specific coding layer among the plurality of coding layers except the lowest coding layer exhibiting the lowest spatial resolution thereamong.

2. The layered coding apparatus according to claim 1, wherein the encoder calculates a code amount of the predictive-error signal thus encoded at the specific coding layer and makes the spatial high-frequency components estimator and upscaler, based on the code amount, change estimation and upscaling parameters for use in estimation and upscaling, and perform, at least once again, the spatial high-frequency components estimation and upscaling procedure, and based on the spatial high-frequency components estimation and upscaling procedure performed at least once again, the encoder calculates the code amount at least once again and generates an output bitstream having the least code amount among code amounts thus calculated, and the spatial high-frequency components estimator and upscaler outputs estimation and upscaling parameters for the least code amount,

wherein the layered coding apparatus further comprises a multiplexer to multiplex the bitstream having the least code amount and the estimation and upscaling parameters for the least code amount.

3. The layered coding apparatus according to claim 1, wherein the coding layers are two coding layers, the specific coding layer being an enhancement layer, and the lower coding layer being a base layer lower than the enhancement layer and exhibiting a spatial resolution lower than the spatial resolution of the enhancement layer.

4. The layered coding apparatus according to claim 1, wherein the coding layers are at least three coding layers, the specific coding layer including at least two enhancement layers exhibiting different spatial resolutions, and the lower coding layer being a base layer lower than the two enhancement layers and exhibiting a spatial resolution lower than the spatial resolutions of the two enhancement layers.

5. A layered decoding apparatus for decoding an input bitstream comprising:

a spatial interpolator to apply spatial interpolation to a given signal decoded at a lower decoding layer lower than a specific decoding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upscaling procedure to upscale the given decoded signal into a spatial resolution of the specific decoding layer;

a spatial high-frequency components estimator and upscaler to apply a spatial high-frequency components estimation and scale up procedure to the given decoded signal at the lower decoding layer, thus generating a high-frequency components signal; and

a decoder to decode the input bitstream to obtain a predictive error-signal and add the upscaled decoded video signal and the high-frequency components signal to the predictive-error signal, thus generating a reproduced video signal,

wherein the spatial interpolator, the spatial high-frequency components estimator and upscaler, and the decoder function at the specific decoding layer that corresponds to at least one specific coding layer among a plurality of coding layers exhibiting different spatial resolutions except the lowest coding layer exhibiting the lowest spatial resolution thereamong, wherein the input bitstream has been obtained by encoding a predictive-error signal at, at least, the specific coding layer, the predictive-error signal being obtained by subtracting an upsealed decoded video signal and a high-frequency components signal from a video signal exhibiting a spatial resolution of the specific coding layer, the upscaled decoded video signal having been obtained by applying spatial interpolation to a signal decoded at a lower coding layer lower than the specific coding layer, the spatial interpolation being an upsealing procedure to upscale the signal decoded at the lower coding layer into a spatial resolution of the specific coding layer, and the high-frequency components signal having been obtained by applying a spatial high-frequency components estimation and scale up procedure to the signal decoded at the lower coding layer.

6. The layered decoding apparatus according to claim 5 further comprising an extractor to demultiple" the input bitstream per decoding layer and extract estimation and upscaling parameters for use in estimation and upscaling from the input bitstream, wherein the spatial high-frequency components estimator and upsealer applies the spatial high-frequency components estimation and scale up procedure to the given decoded signal at the lower decoding layer, based on the estimation and upscaling parameters, thus generating the high-frequency components signal.

7. A layered coding method of encoding an input video signal at a plurality of coding layers exhibiting different spatial resolutions comprising the steps of:

a decoding step of decoding a given signal coded at a lower coding layer lower than a specific coding layer among the plurality of coding layers, thus generating a decoded signal of the lower coding layer;

a spatial interpolating step of applying spatial interpolation to me decoded signal of the lower coding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upscaling procedure to upscale the decoded signal of the lower coding layer into a spatial resolution of the specific coding layer;

a spatial high-frequency components estimating and upscaling step of applying a spatial high-frequency components estimation and scale up procedure to the decoded signal of the lower coding layer, thus generating a high-frequency components signal; and

an encoding step of subtracting the upscaled decoded video signal and the high-frequency components signal from the input video signal exhibiting a spatial resolution of the specific coding layer to produce a predictive-error signal, and encoding the predictive-error signal at the specific coding layer, thus generating an output bitstream,

wherein the decoding step, the spatial interpolating step, the spatial high-frequency components estimating and upscaling step, and the encoding step are executed at, at least, the specific coding layer among the plurality of coding layers except the lowest coding layer exhibiting the lowest spatial resolution thereamong.

8. A layered decoding method of decoding an input bistream comprising the steps of:

a spatial interpolating step of applying spatial interpolation to a given signal decoded at a lower decoding layer lower than a specific decoding layer, thus generating an upscaled decoded video signal, me spatial interpolation being an upscaling procedure to upscale the given decoded signal into a spatial resolution of the specific decoding layer;

a spatial high-frequency components estimating and upscaling step of applying a spatial high-frequency components estimation and scale up procedure to the given decoded signal at the lower decoding layer, thus generating a high-frequency components signal; and

a decoding step of decoding the input bitstream to obtain a predictive error-signal and adding the upscaled decoded video signal and the high-frequency components signal to the predictive-error signal, thus generating a reproduced video signal,

wherein the spatial interpolating step, the spatial high-frequency components estimating and upscaling step, and the decoding step are executed at the specific decoding layer that corresponds to at least one specific coding layer among a plurality of coding layers exhibiting different spatial resolutions except the lowest coding layer exhibiting the lowest spatial resolution thereamong, wherein the input bitstream has been obtained by encoding a predictive-error signal at, at least, the specific coding layer, the predictive-error signal being obtained by subtracting an upscaled decoded video signal and a high-frequency components signal from a video signal exhibiting a spatial resolution of the specific coding layer, the upscaled decoded video signal having been obtained by applying spatial interpolation to a signal decoded at a lower coding layer lower than the specific coding layer, the spatial interpolation being an upscaling procedure to upscale the signal decoded at the lower coding layer into a spatial resolution of the specific coding layer, and the high-frequency components signal having been obtained by applying a spatial high-frequency components estimation and scale up procedure to the signal decoded at the lower coding layer.

9. A layered coding program in a computer readable medium for encoding an input video signal at a plurality of coding layers exhibiting different spatial resolutions, comprising:

a decoding program code to decode a given signal coded at a lower coding layer lower than a specific coding layer among the plurality of coding layers, thus generating a decoded signal of the lower coding layer;

a spatial interpolating program code to apply spatial interpolation to the decoded signal of the lower coding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upscaling procedure to upscale the decoded signal of the lower coding layer into a spatial resolution of the specific coding layer;

a spatial high-frequency components estimating and upsealing program code to apply a spatial high-frequency components estimation and scale up procedure to the decoded signal of the lower coding layer, thus generating a high-frequency components signal; and

an encoding program code to subtract the upscaled decoded video signal and the high-frequency components signal from the input video signal exhibiting a spatial resolution of the specific coding layer to produce a predictive-error signal, and encode the predictive-error signal at the specific coding layer, thus generating an output bitstream,

wherein the decoding program code, the spatial interpolating program code, the spatial high-frequency components estimating and upscaling program code, and the encoding program code are executed at, at least, the specific coding layer among the plurality of coding layers except the lowest coding layer exhibiting the lowest spatial resolution thereamong.

10. A layered decoding program in a computer readable medium for decoding an input bitstream comprising:

a spatial interpolating program code to apply spatial Interpolation to a given signal decoded at a lower decoding layer lower than a specific decoding layer, thus generating an upscaled decoded video signal, the spatial interpolation being an upscaling procedure to upscale the given decoded signal into a spatial resolution of the specific decoding layer;

a spatial high-frequency components estimating and upscaling program code to apply a spatial high-frequency components estimation and scale up procedure to the given decoded signal at the lower decoding layer, thus generating a high-frequency components signal; and

a decoding program code to decode the input bitstream to obtain a predictive error-signal and adding the upscaled decoded video signal and the high-frequency components signal to the predictive-error signal, thus generating a reproduced video signal,

wherein the spatial interpolating program code, the spatial high-frequency components estimating and upscaling program code, and the decoding program code are executed at the specific decoding layer that corresponds to at least one specific coding layer among a plurality of coding layers exhibiting different spatial resolutions except the lowest coding layer exhibiting the lowest spatial resolution thereamong, wherein the input bitstream has been obtained by encoding a predictive-error signal at, at least, the specific coding layer, the predictive-error signal being obtained by subtracting an upscaled decoded video signal and a high-frequency components signal from a video signal exhibiting a spatial resolution of the specific coding layer, the upscaled decoded video signal having been obtained by applying spatial interpolation to a signal decoded at a lower coding layer lower than the specific coding layer, the spatial interpolation being an upscaling procedure to upscale the signal decoded at the lower coding layer into a spatial resolution of the specific coding layer, and the high-frequency components signal having been obtained by applying a spatial high-frequency components estimation and scale up procedure to the signal decoded at the lower coding layer.

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