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(54) Title: METHOD AND DEVICE FOR RECOVERING A LOST MACROBLOCK OF AN ENHANCEMENT LAYER FRAME OF A SPATIAL-SCALABLE VIDEO CODING SIGNAL

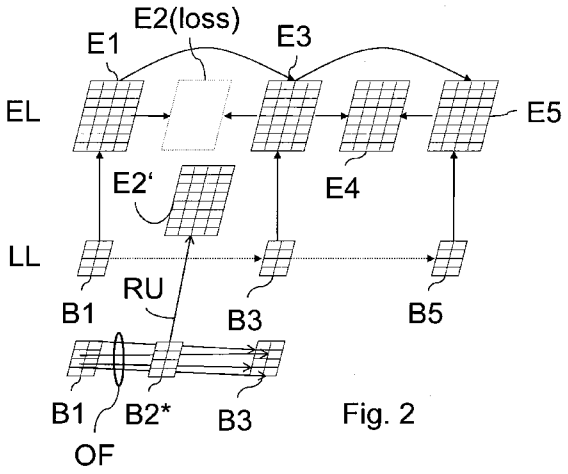

Fig. 2

(57) Abstract: The invention is made in the field of error concealment. In particular, the invention relates to recovering of a lost enhancement layer macro block of an enhancement layer frame (E2) encoded in a spatial-scalable video coding signal. An inter layer error concealment method known from prior art is Reconstruction Lower Layer Upsampling (RU). Precondition for prior art Reconstruction Lower Layer Upsampling (RU) is the availability of a lower layer frame corresponding to the enhancement layer frame (E2) from which a macroblock is lost. For removing this precondition, the invention proposes generating a lower layer macroblock using macroblocks comprised in lower layer frames (Bl, B3) non-coincident with said enhancement layer frame (E2). The generated lower layer macro block is then upsampled to enhanced layer resolution and used as concealment after upsampling.

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Method and device for recovering a lost macroblock of an enhancement layer frame of a spatial-scalable video coding signal

TECHNICAL FIELD

The invention is made in the field of error concealment. In particular, the invention relates to recovering of a lost enhancement layer macro block encoded in a spatial-scalable video coding signal.

BACKGROUND OF THE INVENTION

Scalable video coding (SVC) is an approach towards provision of same content in different qualities in a single video stream. The difference in quality may be related to temporal resolution, to spatial resolution or to signal-to-noise resolution.

In spatial scalable video coding, image frames of a video are encoded in a spatial lower layer and one or more enhanced spatial layers. While the lower layer provides a low resolution version of the video frames, the enhanced spatial layers carry higher resolution versions of the same content.

When the compressed video is transmitted over error-prone networks, channel errors, e.g. packet loss, are inevitable, and since compressed data are very vulnerable to channel errors, even a single bit error may corrupt a whole picture. In other cases, such as real-time communication, video is usually transmitted via unreliable UDP packets

without any possibility for retransmissions at the transport layer. Each UDP packet contains Cyclic Redundancy Check (CRC) allowing error detection. If a CRC fails, the whole UDP packet is discarded. A UDP packet represents a rather large part of the picture and its loss usually results in the discarding of the whole picture.

To tackle the frame loss problem in SVC, in Cheng Y., Xie K, Zhang F., Pandit P., Boyce J.: "Frame Loss Error Concealment for SVC" , Journal of Zhejiang University Science A, 2006 7(5): 677-683, the authors proposed four different picture-loss concealment methods: frame copy (FC) and temporal direct motion vector generation (TD) which are intra-layer concealment methods as well as residual upsampling (BLSkip), and reconstruction lower layer upsampling (RU) which are inter-layer concealment methods.

In the "frame copy" (FC) algorithm, each pixel value of the concealed frame is copied from the corresponding pixel of the first frame in Reference Picture List 0 (RefPicList0). This algorithm can be invoked for any layer.

In the "temporal direct motion vector generation" (TD) algorithm, the MVs and reference indices of each subblocks of the missing frame are calculated as if they were coded using the "temporal direct mode". This algorithm can be invoked for any layer.

Motion and Residual Upsampling (BLSkip) is an inter layer error concealment method wherein information from a lower layer which may be the lower layer are used for error concealment in an enhanced layer. In the "motion and residual upsampling" (BLSkip) algorithm, SVC tools are used

and the BLSkip mode is set in the enhancement layer. Residual upsampling is also used to upsample the residual of the lower layer for enhanced layer. However, the motion compensation is done at the enhanced layer using the upsampled motion fields. This algorithm can directly be used for the enhanced layer if there is no packet loss in the lower layer. If the lower layer is also lost, it needs to generate lower layer motion vectors using TD method in lower layer before BLSkip can use motion field upsampling.

Another inter layer error concealment method is Reconstruction Lower Layer Upsampling (RU). In the "reconstruction lower layer upsampling" (RU) algorithm, the lower layer picture is reconstructed and upsampled using the H.264/AVC 6-tap filter for the lost enhanced layer picture. If lower layer packet is also lost, the FC method is used for the enhancement layer, rather than using an upsampled concealed lower layer picture.

In "Analysis of Error Propagation in Hybrid Video Coding with application to Error Resilience", N. Farber, K. Stuhlmuller, B. Girod, Proc. ICIP: 550-554, October 1999, the authors introduce a selection-based EC strategy in which one of the four EC methods is adaptively selected to minimize the visual degradation of the concealed picture.

SUMMARY OF THE INVENTION

Precondition for error concealment using Reconstruction Lower Layer Upsampling (RU) as known from prior art is the availability of a lower layer frame corresponding to the enhancement layer frame for which a macroblock is lost or defect.

For overcoming this precondition and allowing for more flexible use of RU, a method and device for recovering a lost macroblock of an enhancement layer frame of a spatial-scalable video coding signal are proposed, the method comprising the features of claim 1 and the device being adapted fro performing said method.

Said method comprises using reconstruction lower layer upsampling for recovering said lost macroblock, wherein a generated lower layer macroblock is upsampled, said generated lower layer macroblock is generated using macroblocks comprised in lower layer frames non-coincident with said enhancement layer frame and said lost macroblock is recovered from the upsampled lower layer frame.

The features of further advantageous embodiments are specified in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are illustrated in the drawings and are explained in more detail in the following description. The exemplary embodiments are explained only for elucidating the invention, but not limiting the invention's disclosure, scope or spirit defined in the claims.

In the figures:

Fig. 1 exemplarily depicts SVC coding structure with two dependency layers with different frame rate and

Fig. 2 exemplarily depicts the proposed solution of temporal interpolation lowerd SVC error concealment.

EXEMPLARY EMBODIMENTS OF THE INVENTION

The invention can be realized on any electronic device comprising a processing device correspondingly adapted. For instance, the invention can be realized in a set-top-box, a television, a DVD- and/or BD-player, a mobile phone, a personal computer, a navigation system or a car video system.

An exemplary first SVC coding structure with error concealment is depicted in fig. 1. The figure shows an enhanced layer EL comprising the image frames E1, E2, E3, E4 and E5 and a lower layer LL which comprises the images frames B1, B3 and B5.

The enhanced layer EL is spatially as well as temporarily enhanced. That is, frames E1, E3 and E5 comprise the same content as frames B1, B3 and B5 but at a higher spatial resolution as indicated by the number of quadrangles comprised in the frames. Furthermore, the enhanced layer EL provides the same content with a higher temporal resolution as it comprises the frames E2 and E4 for which no corresponding lower layer frame is comprised in the lower layer LL.

Assumed that a macroblock from picture E5 is lost or damaged, as indicated by the dashed line, picture E5 may be replaced by an up-scaled version of picture B5.

But, if a macroblock of picture E2 or picture E4 is lost or damaged there is no corresponding lower layer frame from

which a collocated lower layer macroblock can be upsampled to enhancement layer resolution for concealing the lost macro block.

Still, RU can be the packet recovery method which promises the lowest overall visual degradation resulting from concealment error and error propagation.

Hence, the current invention proposes generating a corresponding lower layer macroblock, which can be upsampled for recovering the lost enhancement layer macroblock, if said corresponding collocated lower layer macroblock is not available. Unavailability of the corresponding lower layer macroblock can be due to the lower layer's lower frame rate or due to packet loss.

This is exemplarily depicted in Fig. 2 wherein the enhancement layer frame which suffered a macroblock loss is E2(loss). As a collocated lower layer macroblock does not exist, the corresponding lower layer macroblock is generated using frame interpolation technology. That is, a preceding lower layer frame B1 and a subsequent lower layer frame B3 are used for determining optical flow OF to get corresponding pixel motion directions between the preceding lower layer frame B1 and the subsequent lower layer frame B3. Then, the pixel motion directions are clustered. Finally, a least squares minimization method is used to get pixel values of said corresponding lower layer macroblock. In an embodiment, the clustered pixel motion is used for segmentation of the frame to-be-generated.

The corresponding lower layer macroblock is then upsampled to enhancement layer resolution and used as recovery of the lost enhancement layer block.

In an embodiment, the current invention proposes a temporal interpolation based method to conceal the transmission error of SVC bit stream to keep the continuity of the rendered video. It can be applied to SVC bit streams having different layers with different frame rate but is not restricted to such bit streams. The invention allows for reconstructing the signal of the higher spatial layer by a lower spatial layer signal. The invention can be applied to higher layer frames of any SVC signal of two or more layers. In an embodiment, the invention proposes adopting image processing methods to generate non-existing lower layer frames. In doing said image processing on lower layer frames, time cost of image processing can be controlled.

CLAIMS:

1. Method for recovering a lost macroblock of an enhancement layer frame (E2) of a spatial-scalable video coding signal, said method comprises using reconstruction lower layer upsampling (RU) for recovering said lost macroblock, wherein a generated lower layer macroblock is upsampled, said generated lower layer macroblock is generated using lower layer frames (B1, B3) non-coincident with said enhancement layer frame (E2) and said lost macroblock is recovered from the upsampled lower layer frame.

2. Method of claim 1, wherein said non-coincident lower layer frames (B1, B3) comprise a preceding lower layer frame (B1) and a succeeding lower layer frame (B3), said method further comprising generating an interpolated frame (B2*) by interpolating between the preceding lower layer frame (B1) and a succeeding lower layer frame (B3) and selecting, from the interpolated frame (B2*) a base layer macroblock collocated with the lost enhancement layer macroblock.

3. Method of claim 2, wherein the interpolated frame (B2*) is generated by: determining optical flow (OF) to get pixel motion directions by determining corresponding pixels in said preceding lower layer frame (B1) and said succeeding lower layer frame (B3), clustering the pixel motion directions, using the clustered pixel motion directions for

determining pixel values of the generated lower layer macroblock using a least square minimizing method.

4. Device for performing the method of one of the preceding claims.

1 / 2

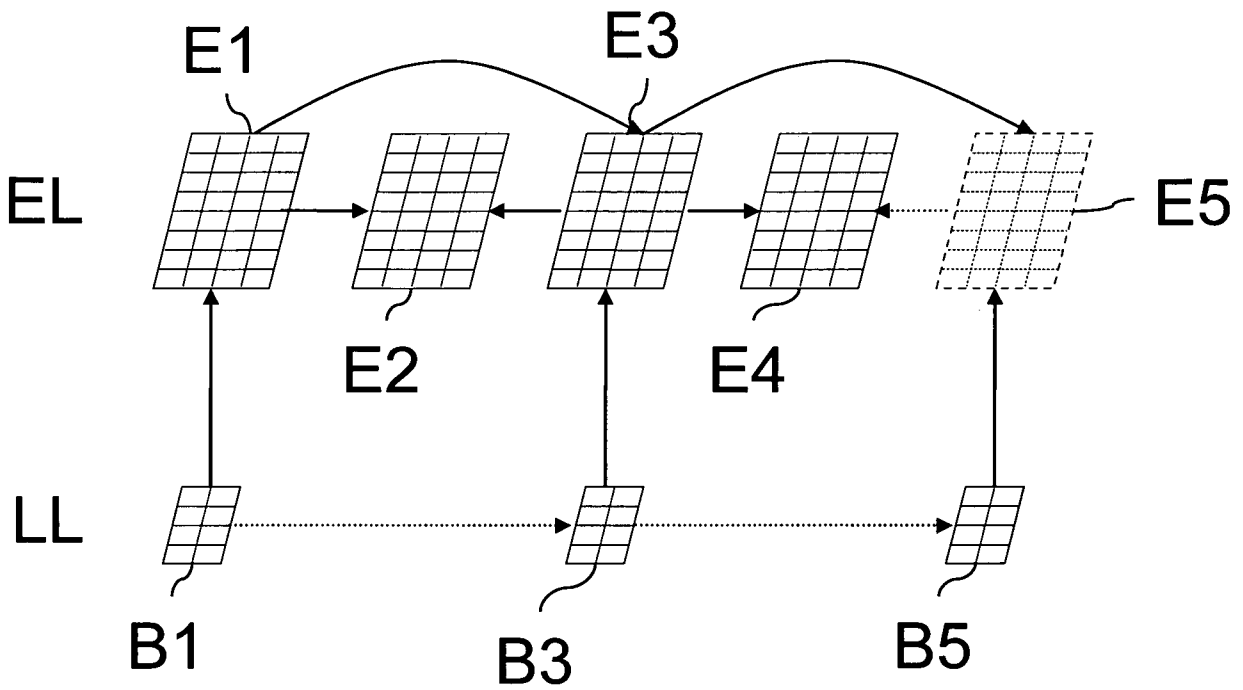

Fig. 1

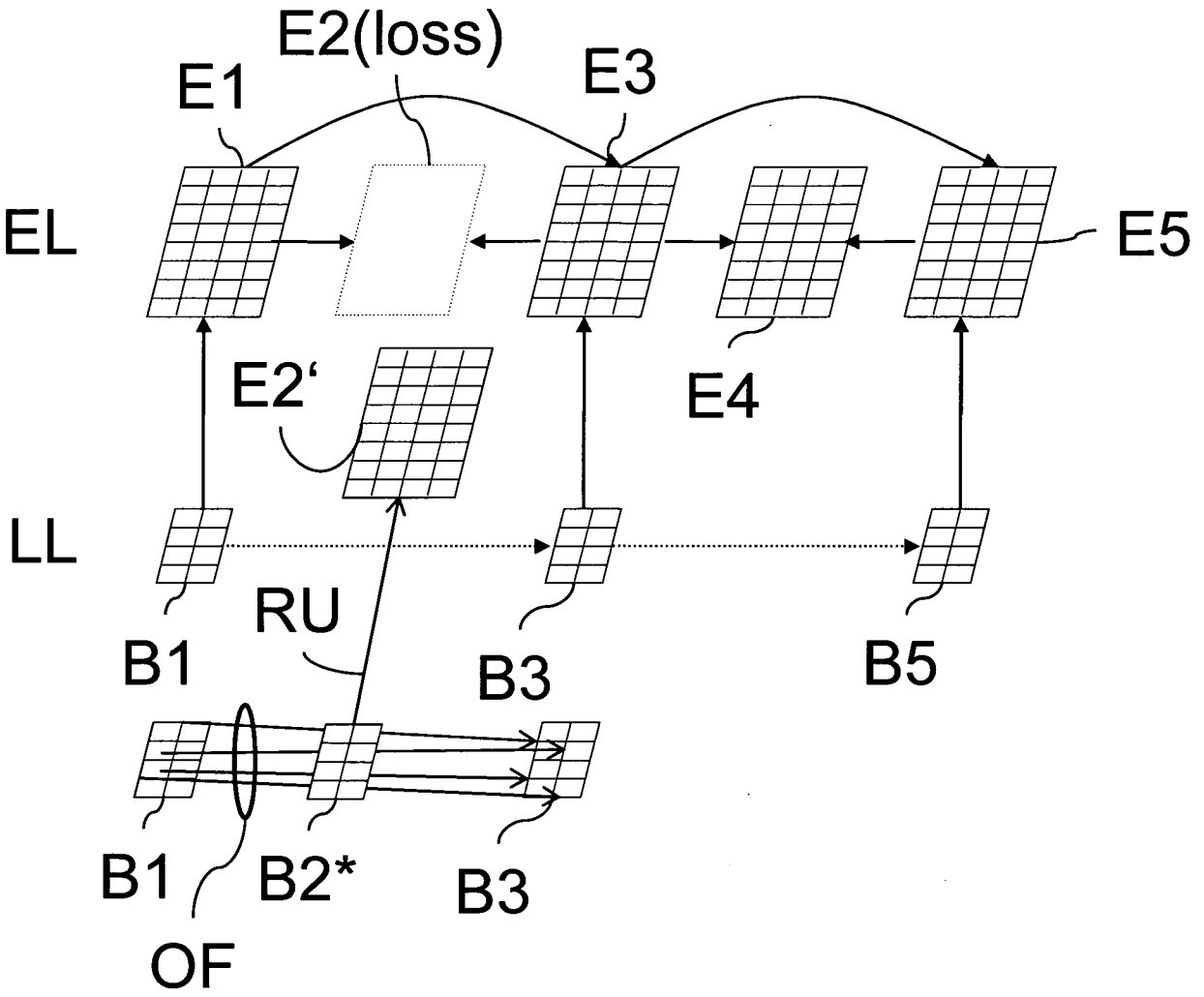

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2010/000501

A. CLASSIFICATION OF SUBJECT MATTER

H04N7/64 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04N/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, WPODOC, CNKI, CNPAT: macroblock, lost+, enhance+, enhancement, layer, lost+, upsampl+, base, interpolate+, pixel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO2007080408A2 (MITSUBISHI ELECTRIC CORP) 19 July 2007(19.07.2007) The description page 5 line 6- page 10 line 16	1-4
A	WO2007080480A2 (NOKIA CORP) 19 July 2007(19.07.2007) the whole document	1-4
A	CN101242540A (ANKAI GUANGZHOU SOFTWARE TECHN CO., LTD) 13 August 2008(13.08.2008) the whole document	1-4

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 December 2010(16.12.2010)	**27 Jan. 2011 (27.01.2011)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer LI, Jing Telephone No. (86-10)62411455

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO2007080408A2	19.07.2007	EP1809041A1	18.07.2007
		WO2007080408A3	25.10.2007
		EP1974547A2	01.10.2008
		CN101401432A	01.04.2009
		JP2009523345T	18.06.2009
		US2009220004A1	03.09.2009
WO2007080480A2	19.07.2007	US2007160137A1	12.07.2007
		WO2007080480A3	08.11.2007
		EP1977612A2	08.10.2008
		KR20080089633A	07.10.2008
		CN101401440A	01.04.2009
		TW200731812A	16.08.2007
		JP2009522972T	11.06.2009
CN101242540A	13.08.2008	CN101242540B	19.05.2010