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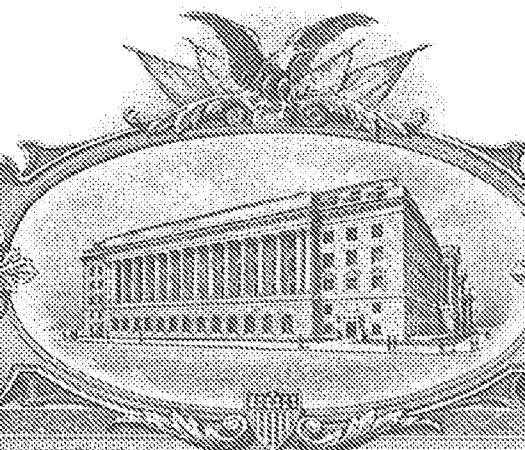
Application number: 63329939

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THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

April 13, 2023

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE UNDER 35 USC 111.

APPLICATION NUMBER: 63/329,939

FILING DATE: *April 12, 2022*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US63/329,939*



Certified by

Kathi

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	3602-2409US1
		Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor	1	Remove		
Legal Name				
Prefix	Given Name	Middle Name	Family Name	Suffix
	Ruoyang		YU	
Residence Information (Select One)				US Residency • Non US Residency Active US Military Service
City	Täby	Country of Residence ⁱ	SE	
Mailing Address of Inventor:				
Address 1		Attundagränd 2		
Address 2				
City	Täby	State/Province		
Postal Code	SE-183 39	Country ⁱ	SE	
Inventor	2	Remove		
Legal Name				
Prefix	Given Name	Middle Name	Family Name	Suffix
	Kenneth		ANDERSSON	
Residence Information (Select One)				US Residency ● Non US Residency Active US Military Service
City	Gävle	Country of Residence ⁱ	SE	
Mailing Address of Inventor:				
Address 1		Västra Trädgårdsvägen 52		
Address 2				
City	Gävle	State/Province		
Postal Code	SE-802 63	Country ⁱ	SE	
Inventor	3	Remove		
Legal Name				

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	3602-2409US1
	Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jacob		STRÖM	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				
City	Stockholm	Country of Residence ⁱ	SE	

Mailing Address of Inventor:

Address 1	Heleneborgsgatan 6c, 2 tr			
Address 2				
City	Stockholm	State/Province		
Postal Code	SE-117 32	Country ⁱ	SE	
Inventor	4	Remove		
Legal Name				

Prefix	Given Name	Middle Name	Family Name	Suffix
	Jack		ENHORN	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				
City	Kista	Country of Residence ⁱ	SE	

Mailing Address of Inventor:

Address 1	Langelandsgatan 18			
Address 2				
City	Kista	State/Province		
Postal Code	SE-164 43	Country ⁱ	SE	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. Add				

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
☐ An Address is being provided for the correspondence Information of this application.	
Customer Number	06449
Email Address	pto-pat-email@rfem.com Add Email Remove Email

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	3602-2409US1
		Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION		

Application Information:

Title of the Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION		
Attorney Docket Number	3602-2409US1	Small Entity Status Claimed	☐
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	23	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.			
Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	06449		

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	3602-2409US1
		Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status		Remove
Application Number	Continuity Type	Prior Application Number
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.		Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Remove
			Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	3602-2409US1
		Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	3602-2409US1
	Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
------------------	---	------------------------

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

[Clear](#)

☒ Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
---	--	----------------

Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest
---	--

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Telefonaktiebolaget LM Ericsson (publ)		
-------------------	--	--	--

Mailing Address Information For Applicant:

Address 1			
Address 2			
City	Stockholm	State/Province	
Country	SE	Postal Code	SE-164 83
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. [Add](#)

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	3602-2409US1
	Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION	

Assignee	1		
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.			
Remove			
If the Assignee or Non-Applicant Assignee is an Organization check here. ☒			
Organization Name	Telefonaktiebolaget LM Ericsson (publ)		
Mailing Address Information For Assignee including Non-Applicant Assignee:			
Address 1			
Address 2			
City	Stockholm	State/Province	
Country i	SE	Postal Code	SE-164 83
Phone Number		Fax Number	
Email Address			
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add			

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Michael V. Battaglia/		Date (YYYY-MM-DD)	2022-04-11	
First Name	Michael V.	Last Name	Battaglia	Registration Number	64,932
Additional Signature may be generated within this form by selecting the Add button. Add					

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	3602-2409US1
		Application Number	
Title of Invention	ENHANCED MULTI-HYPOTHESIS PREDICTION		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

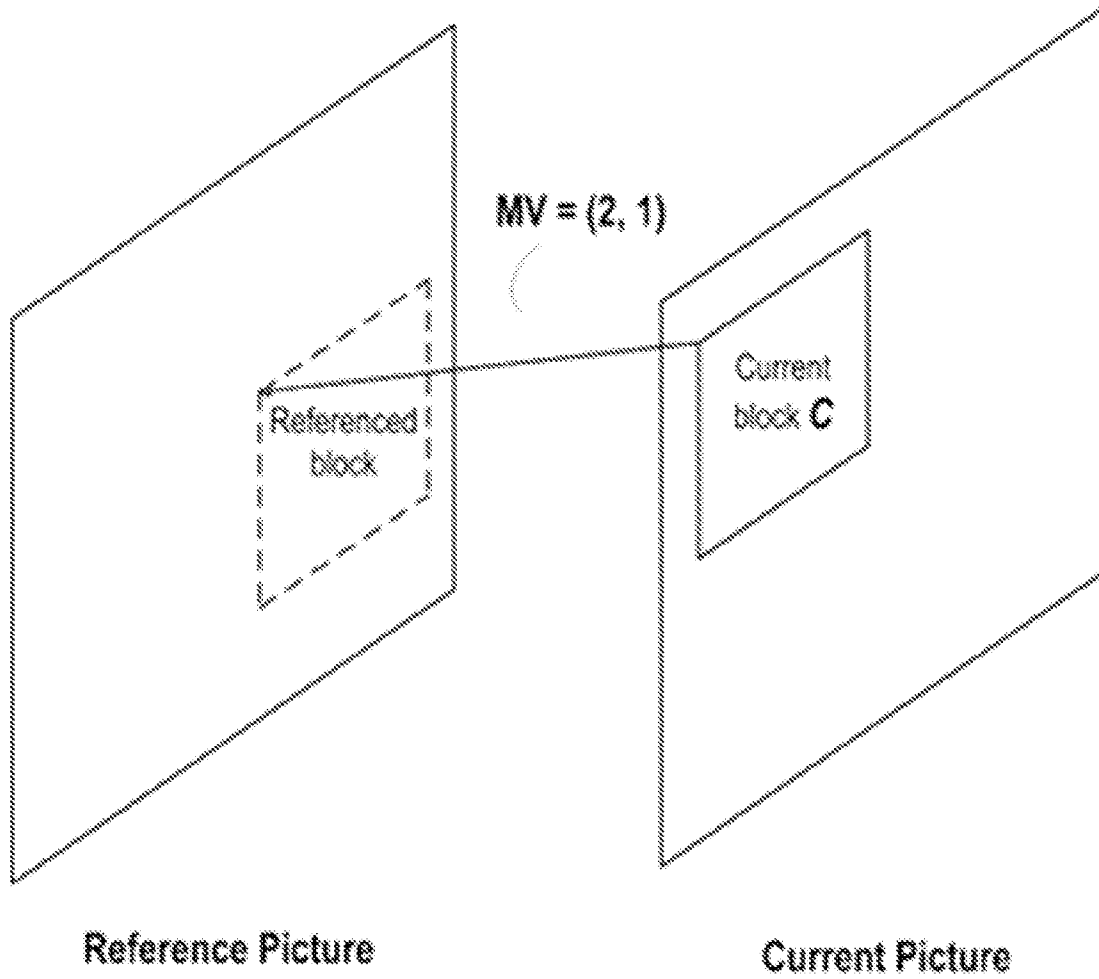


FIG. 1

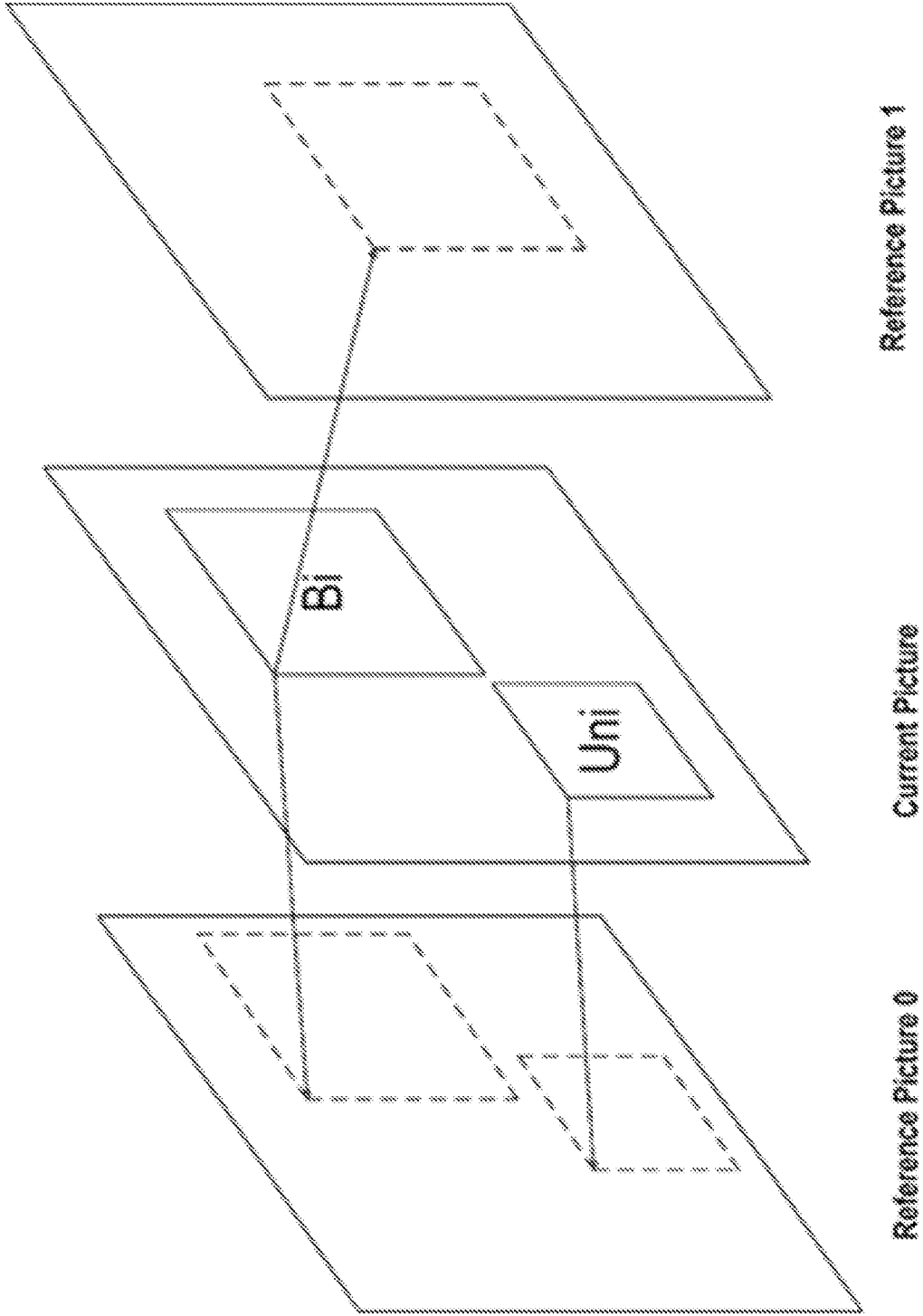


FIG. 2

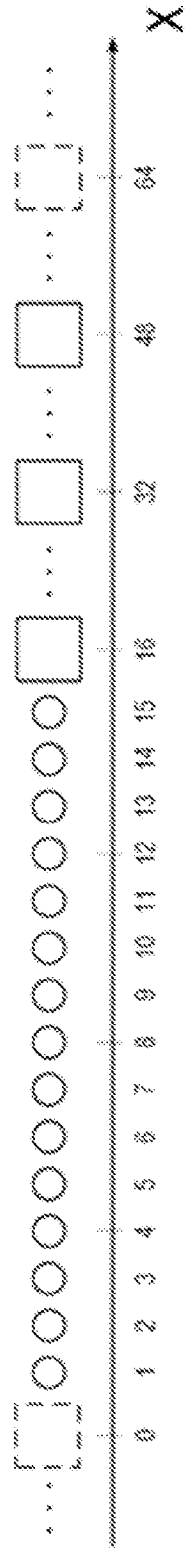


FIG. 3

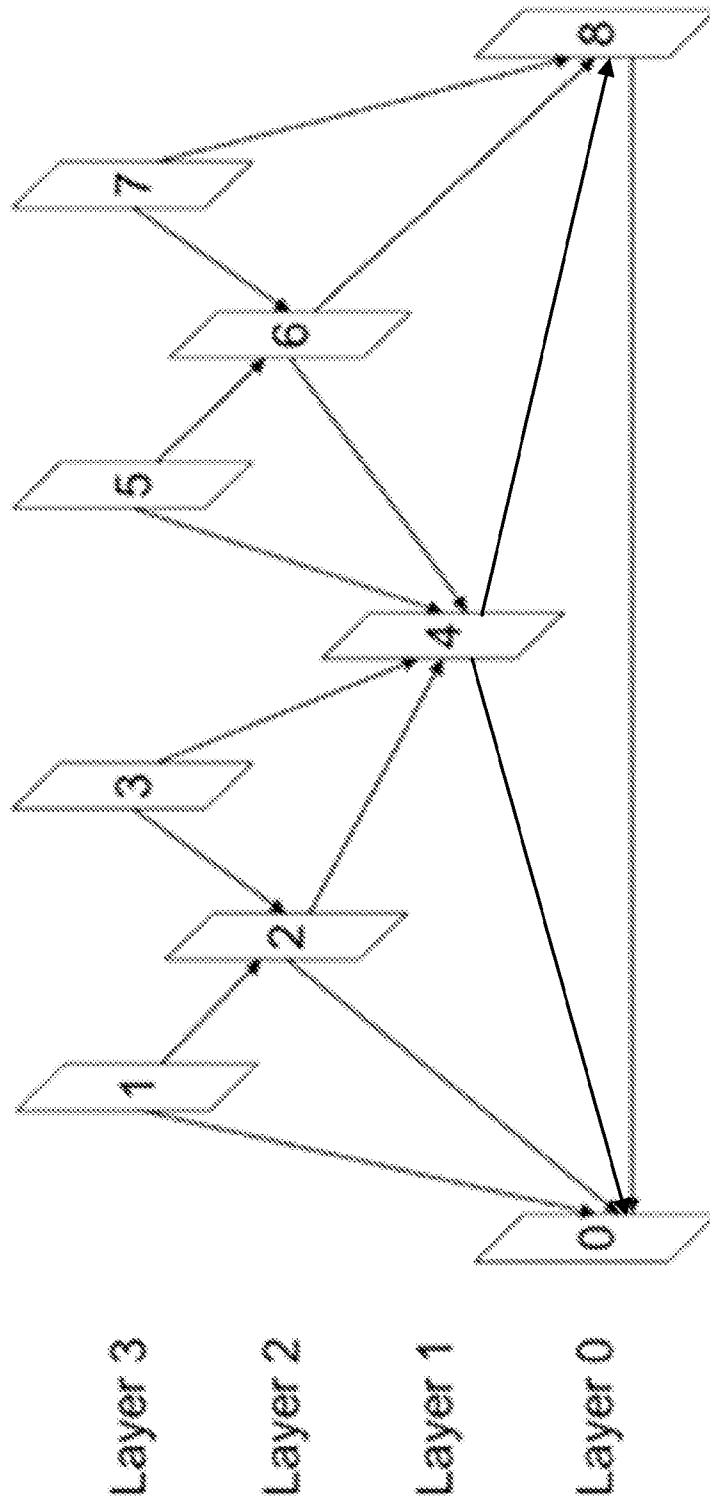


FIG. 4

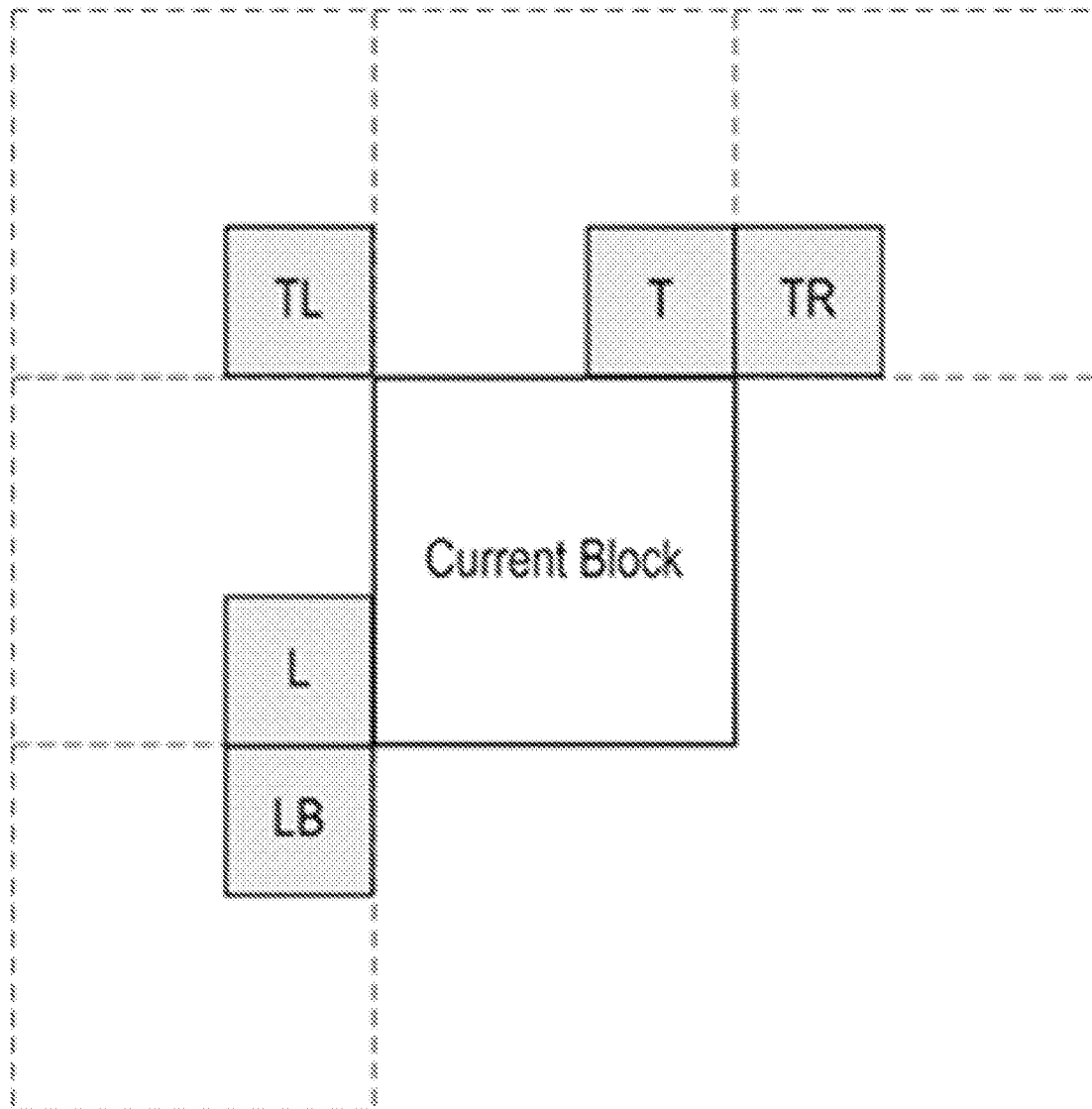


FIG. 5

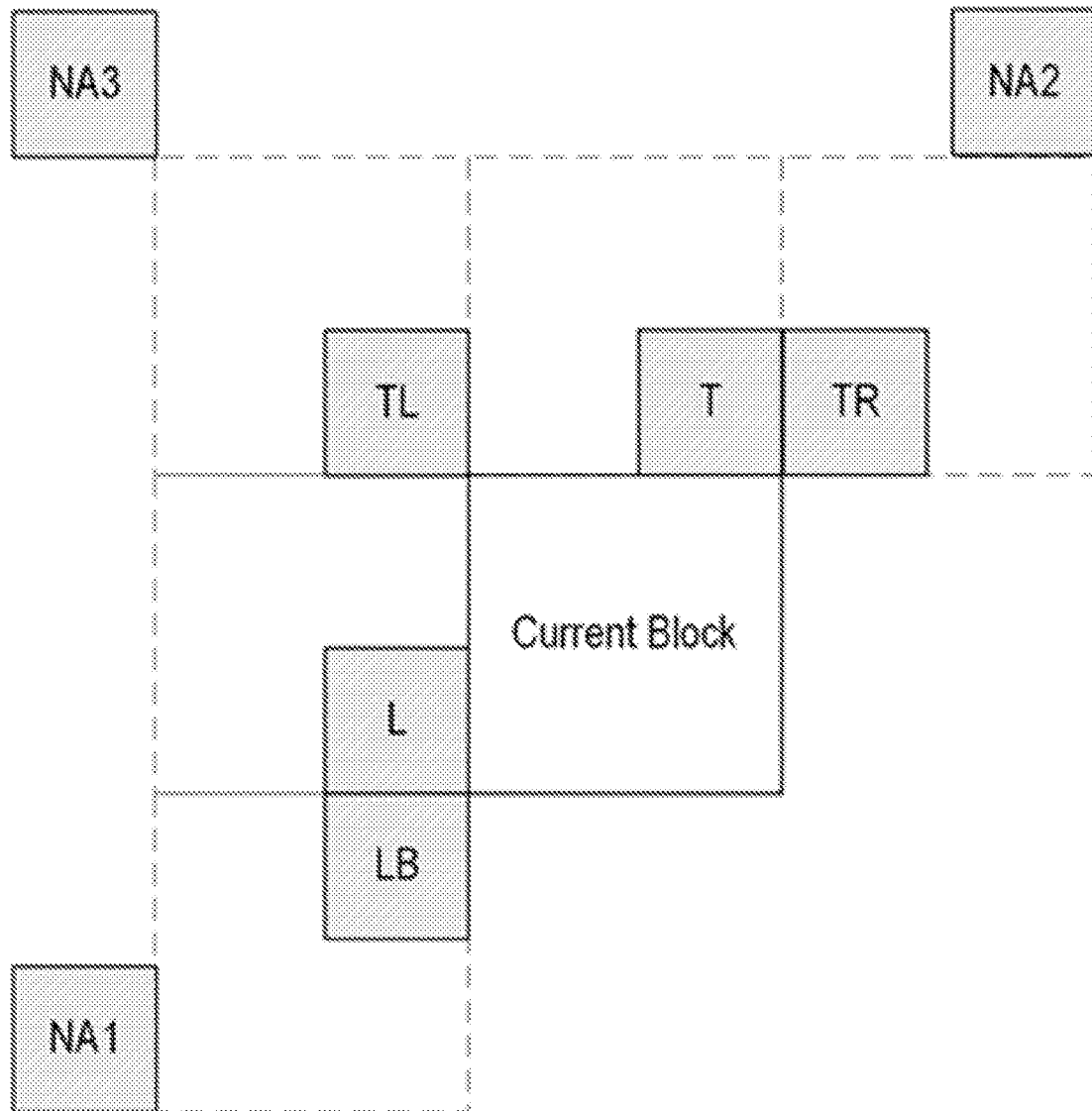


FIG. 6

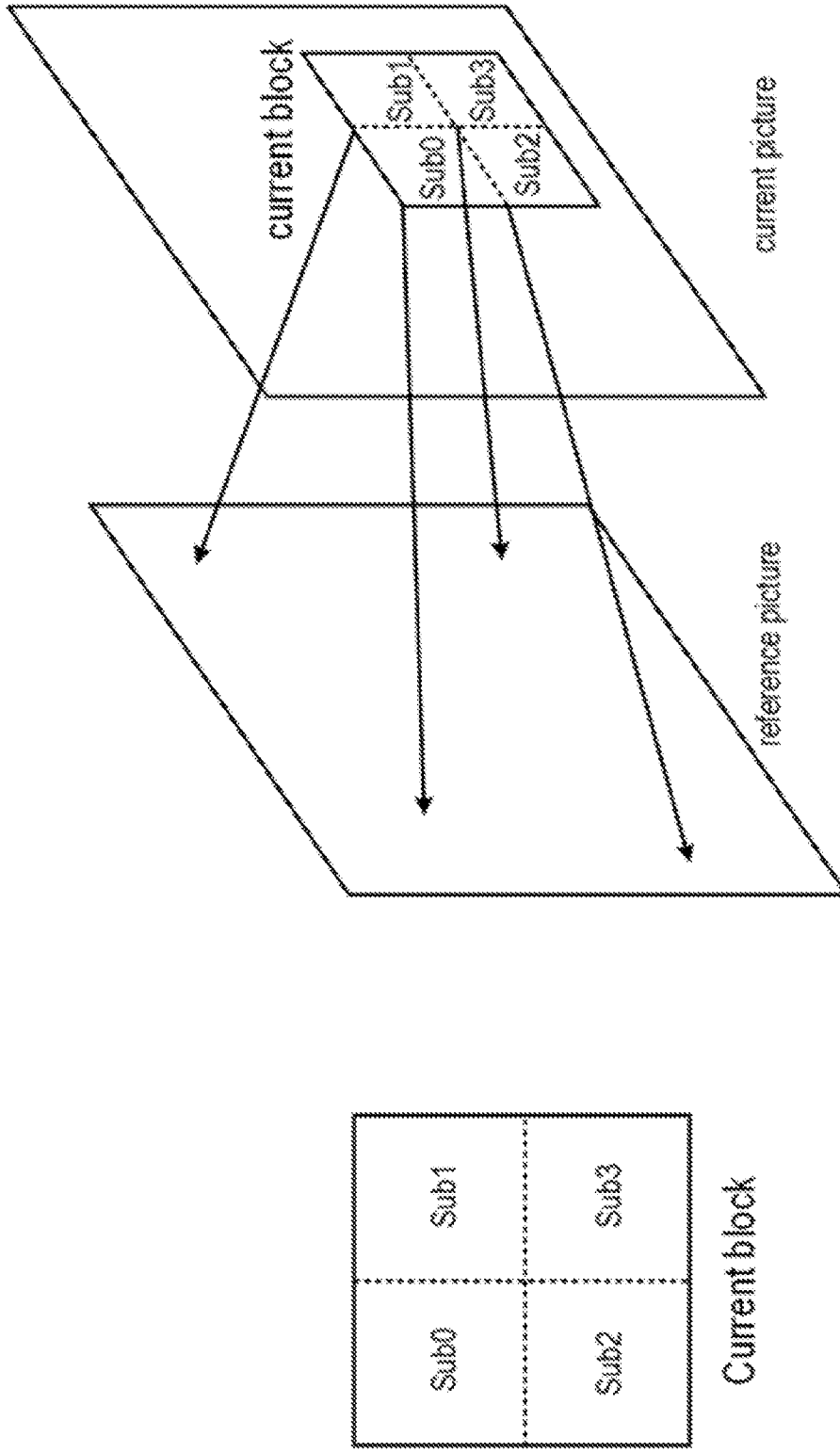


FIG. 7

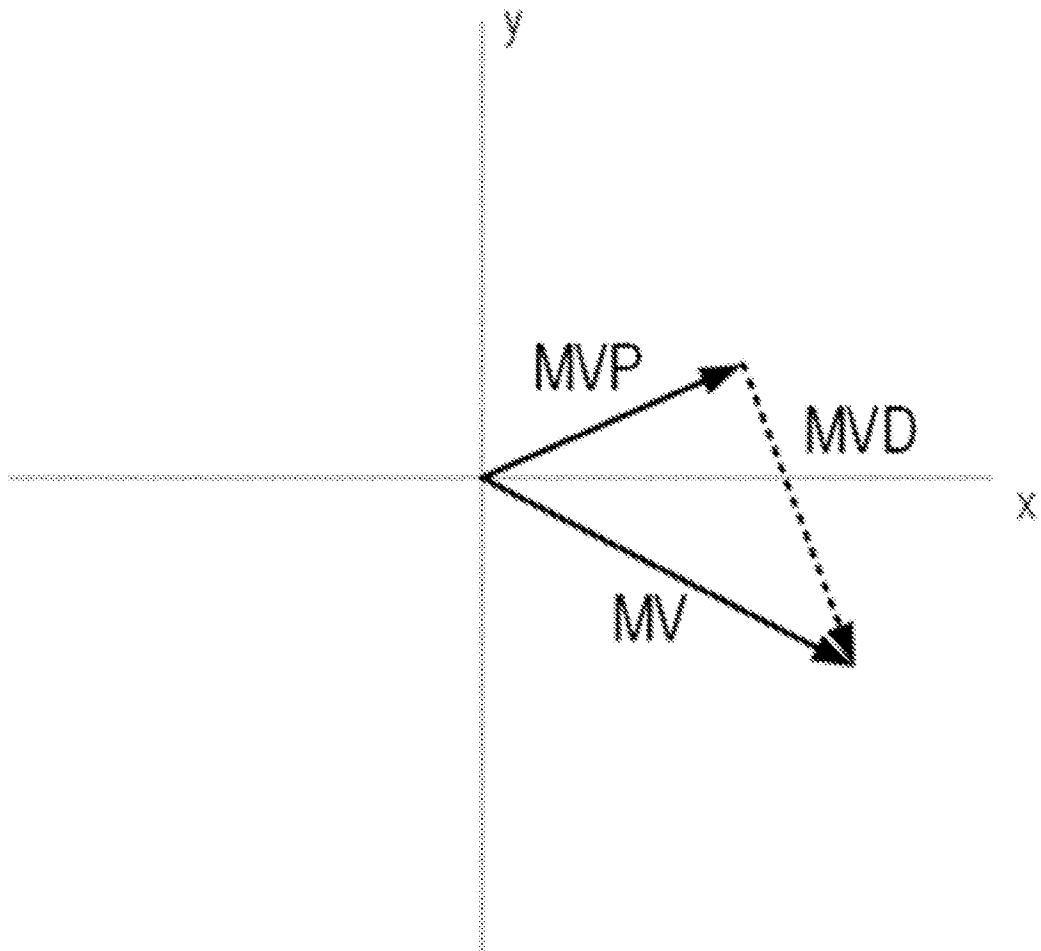


FIG. 8

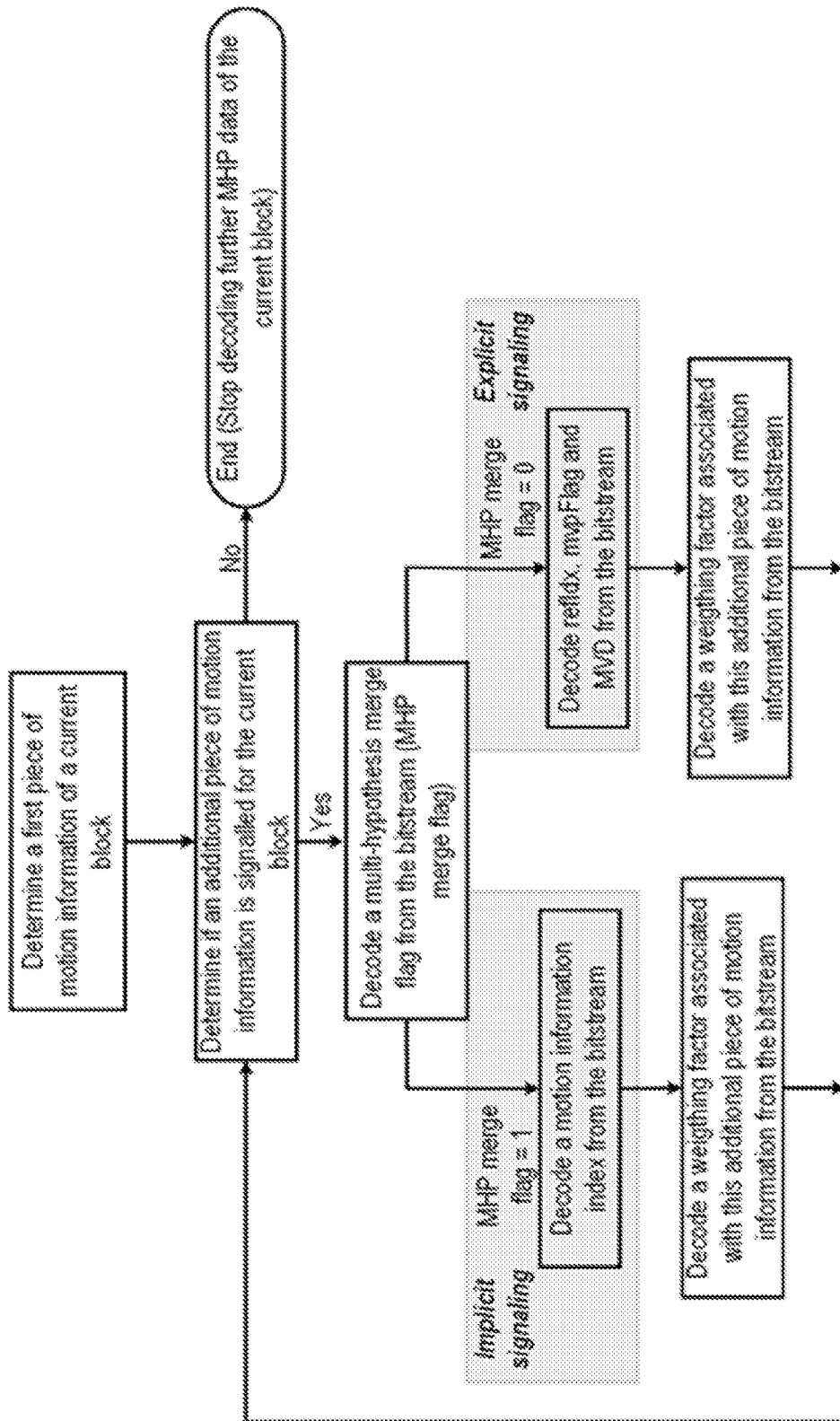


FIG. 9

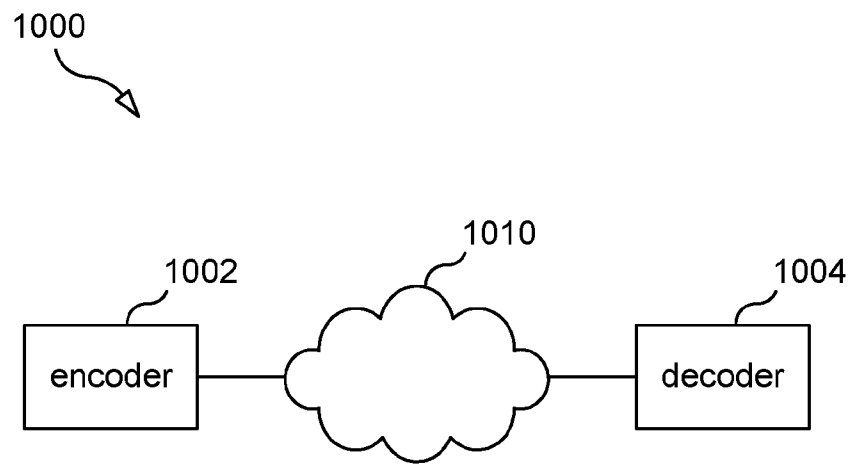


FIG. 10

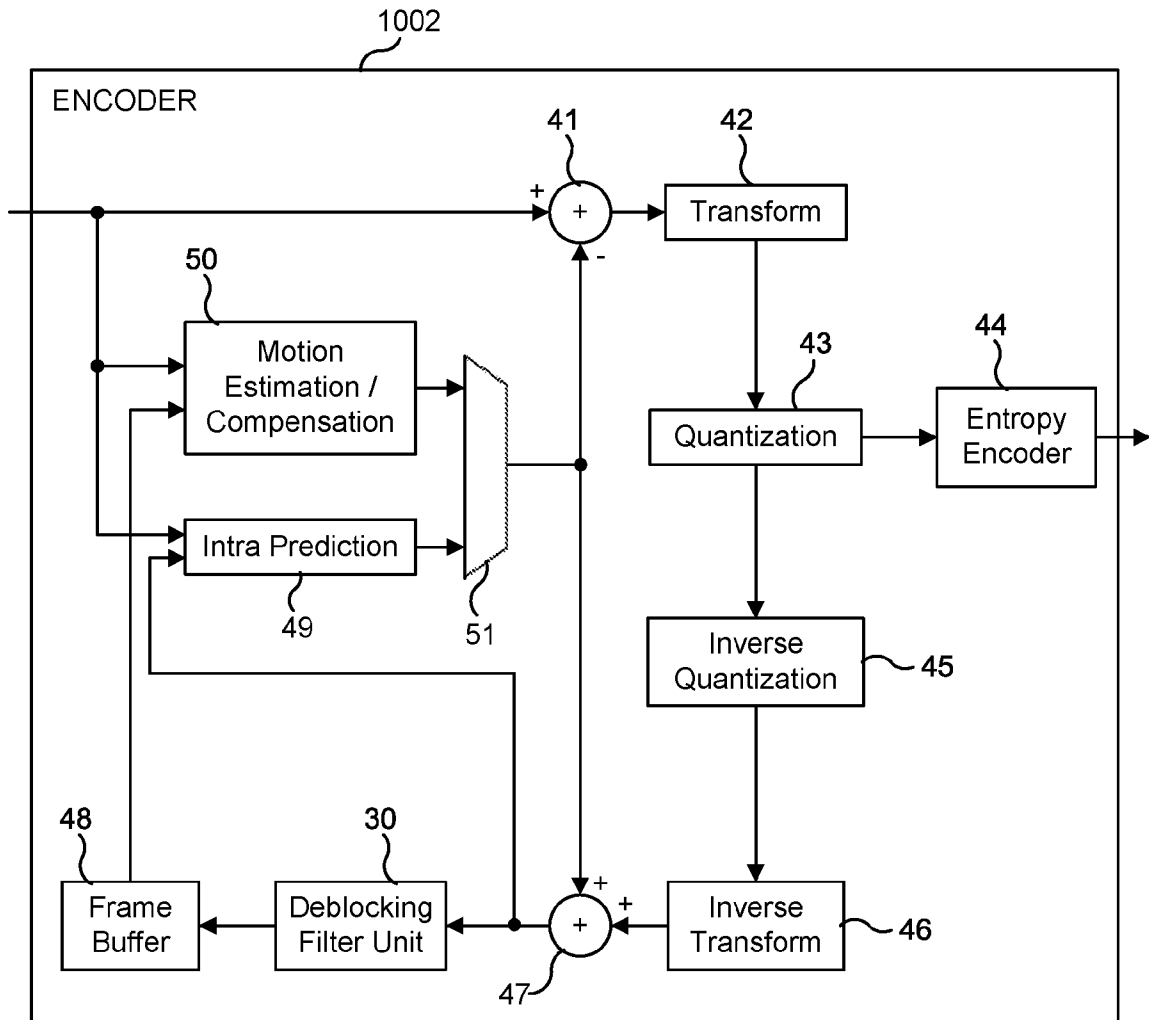


FIG. 11

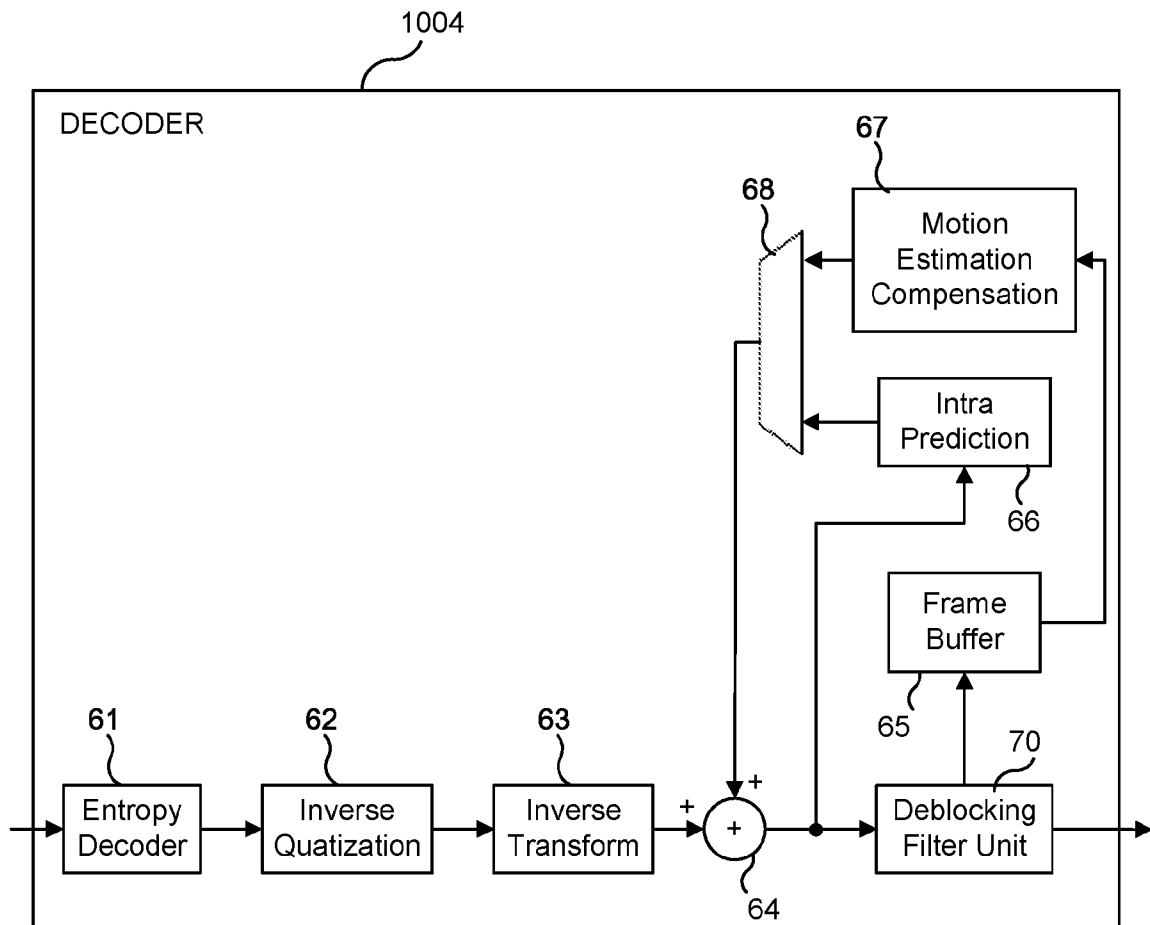


FIG. 12

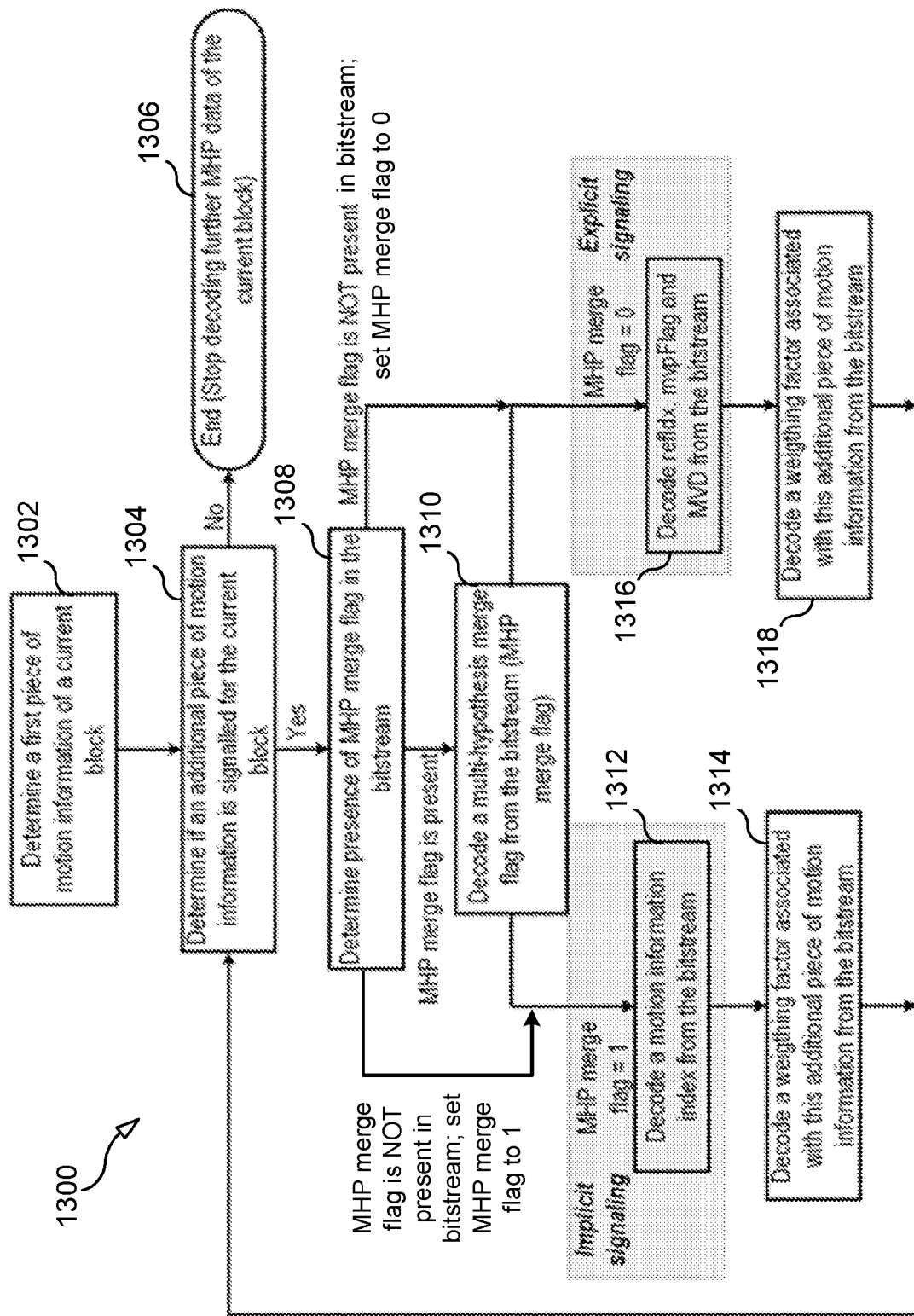


FIG. 13

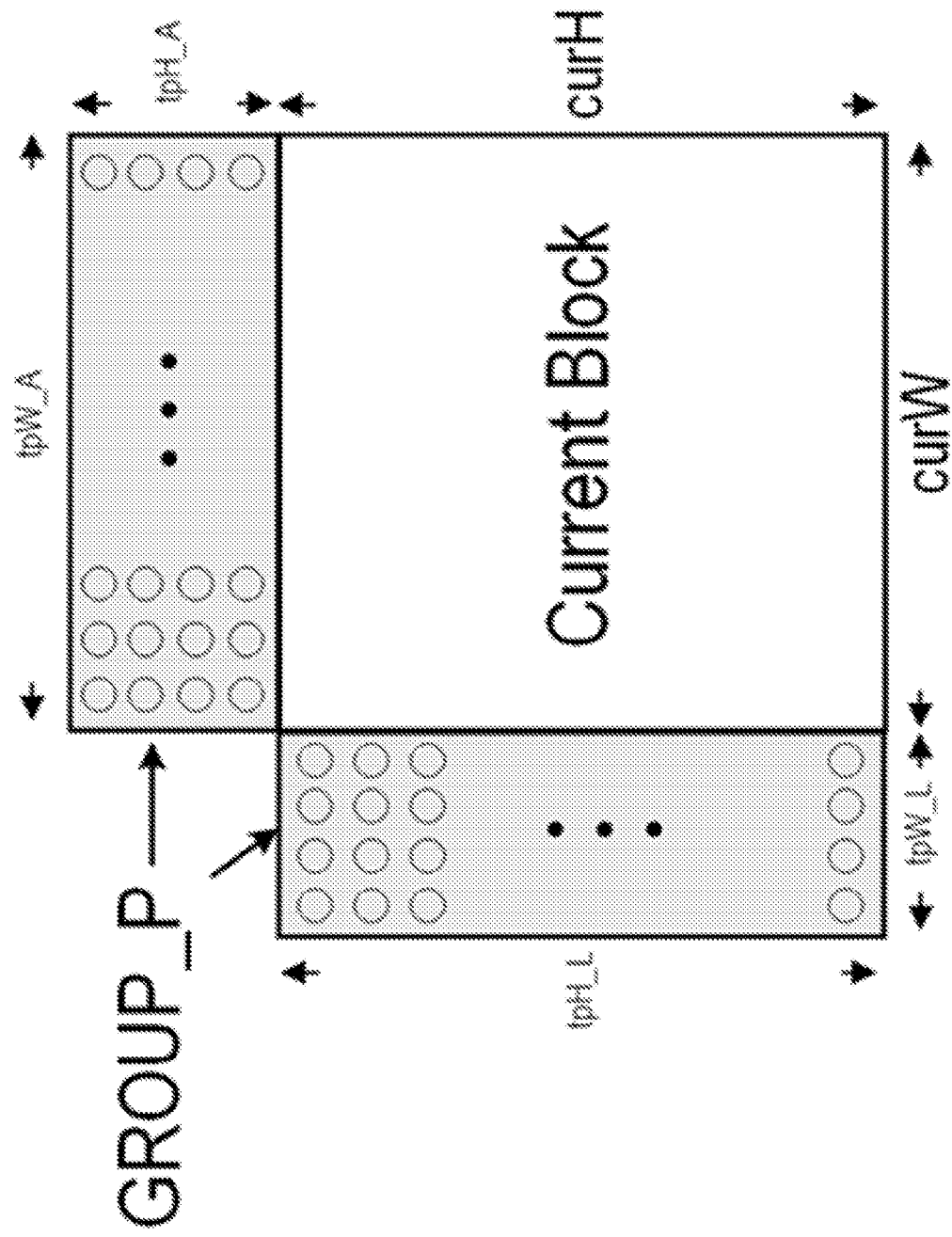


FIG. 14

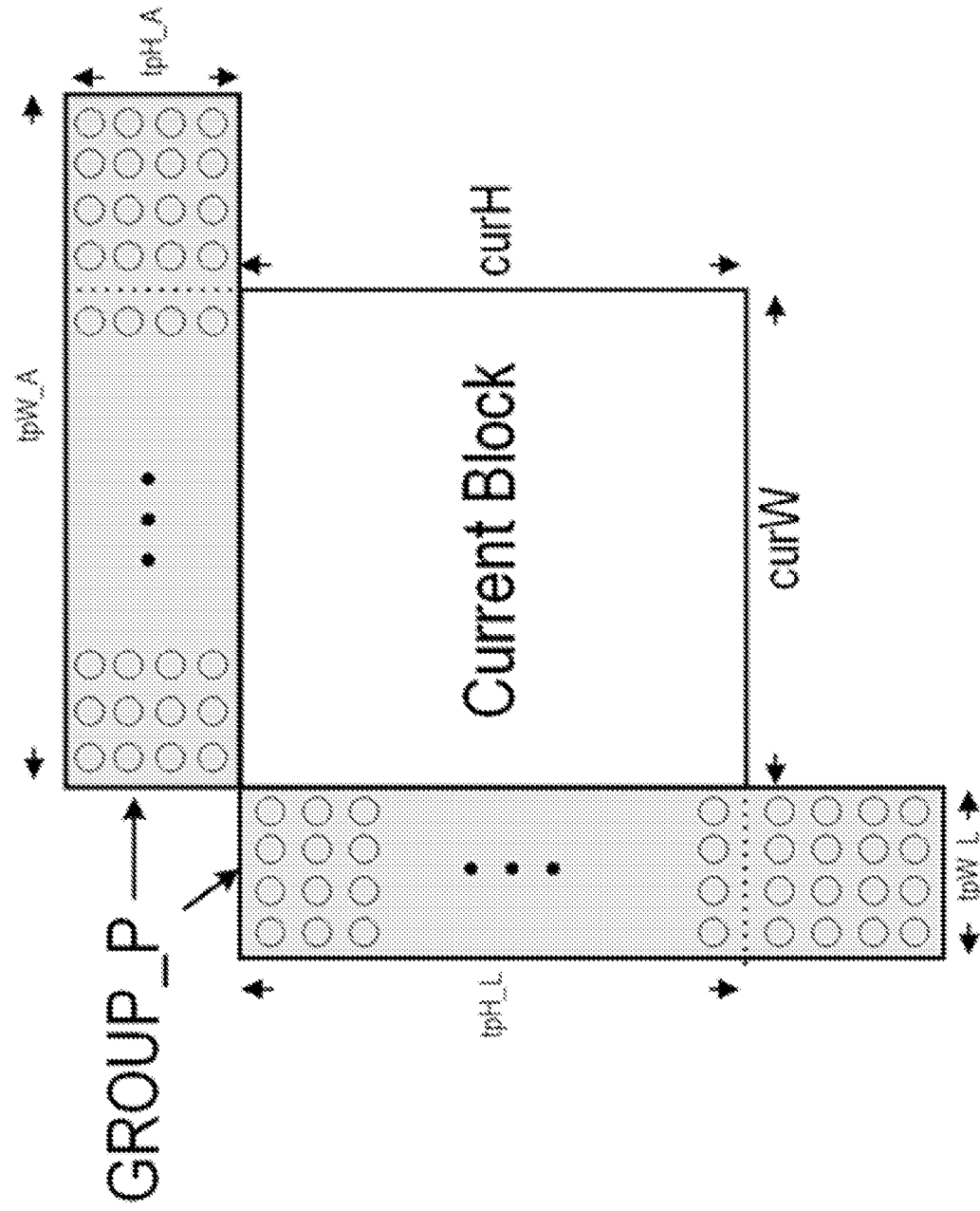


FIG. 15

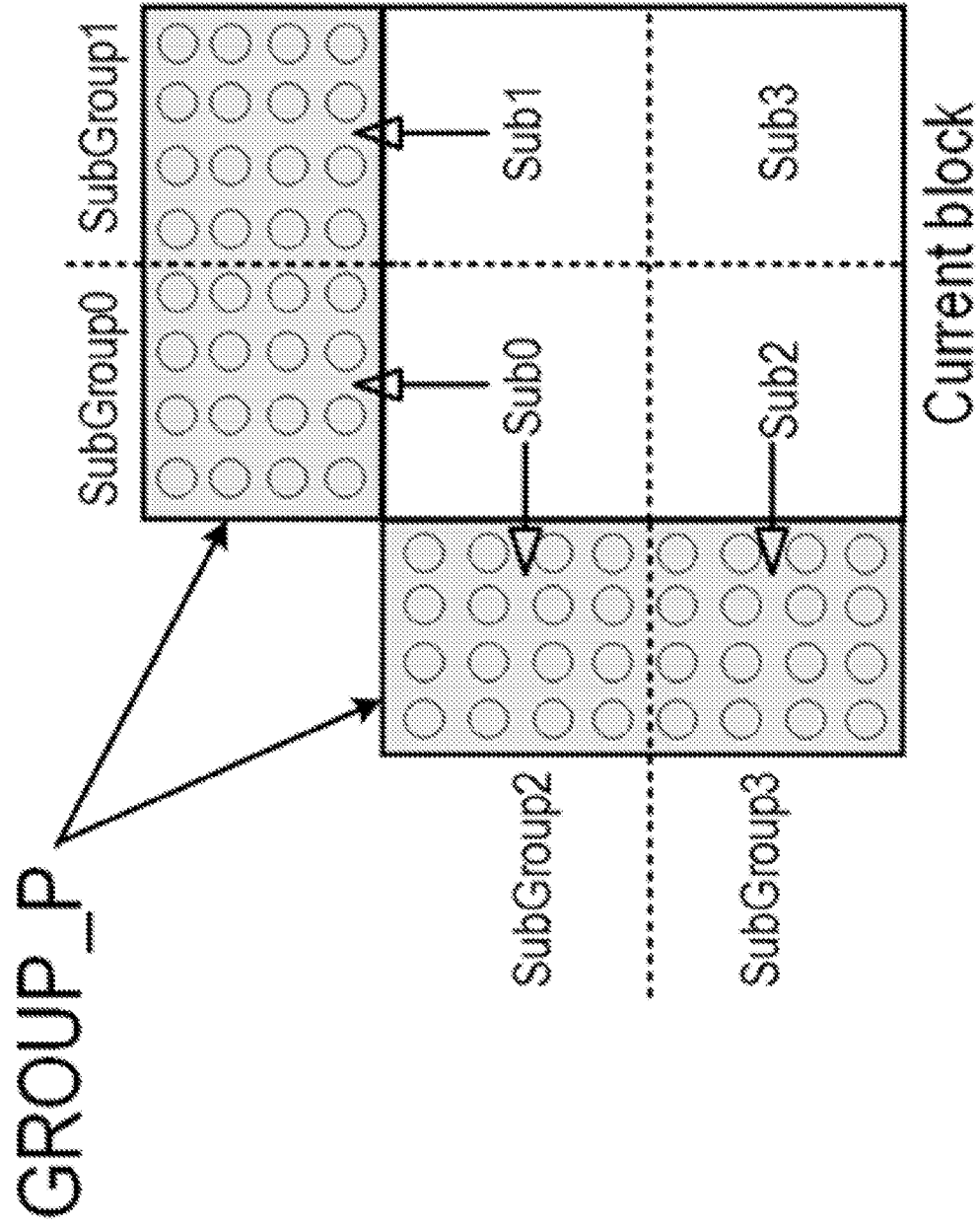


FIG. 16

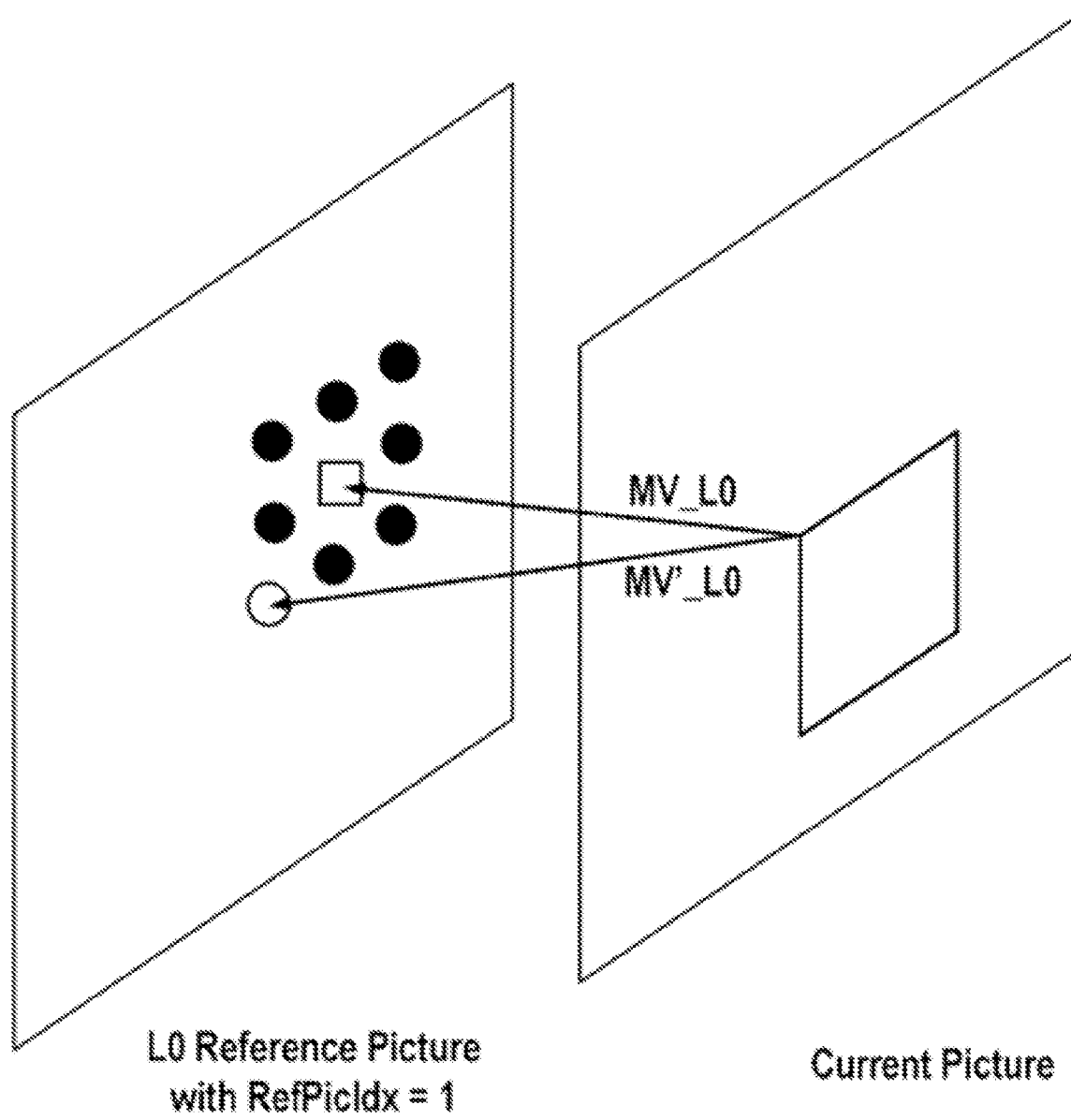


FIG. 17

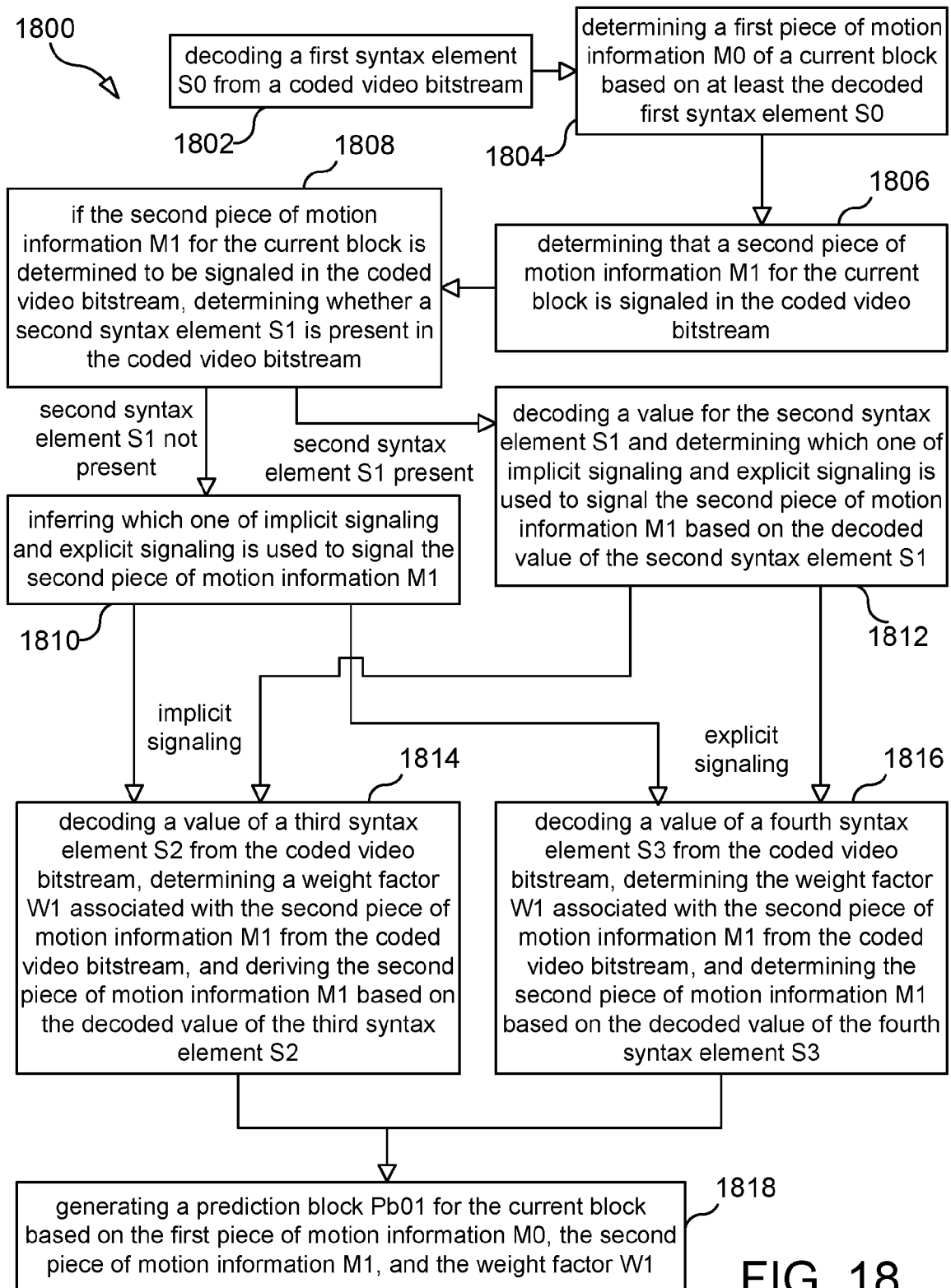


FIG. 18

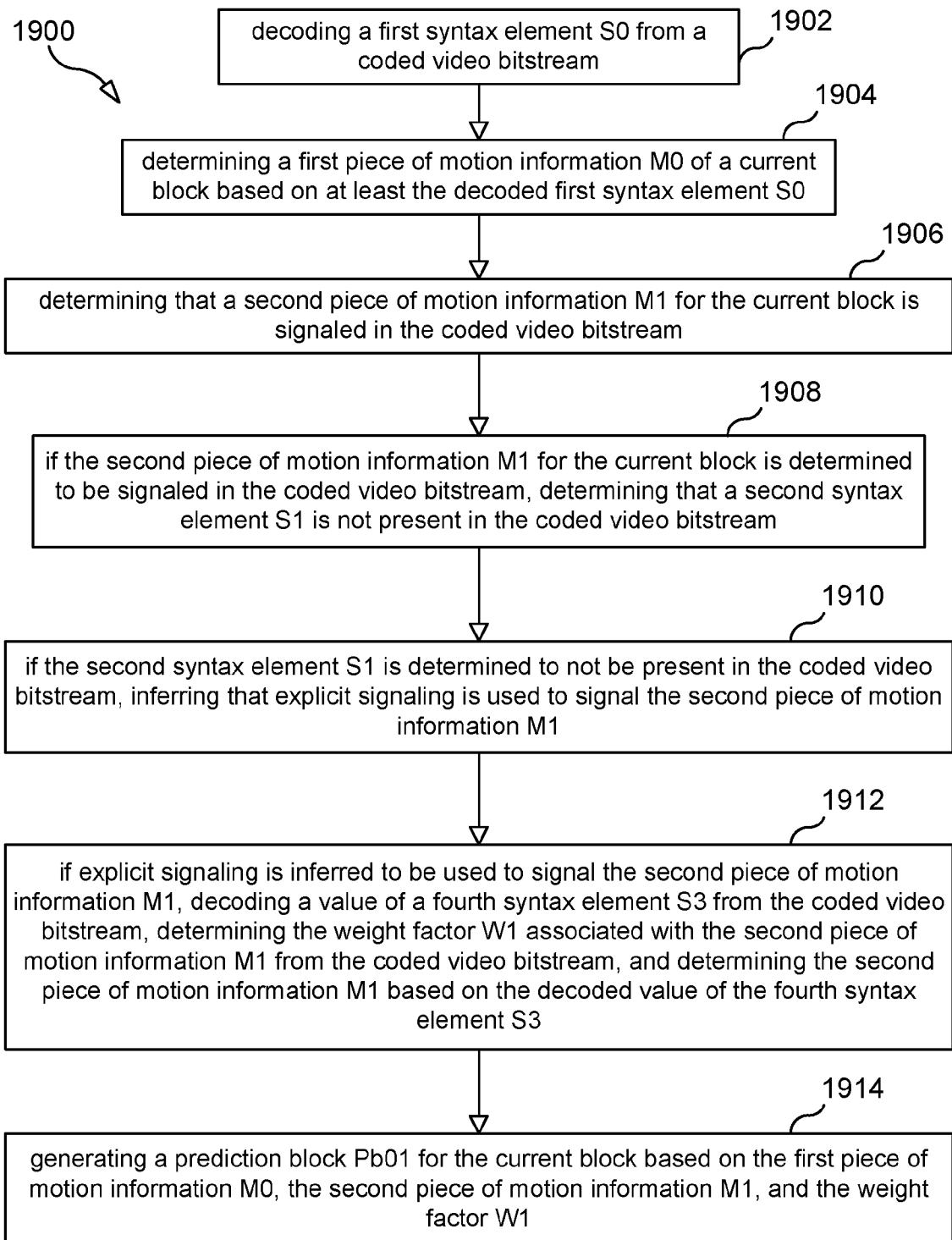


FIG. 19

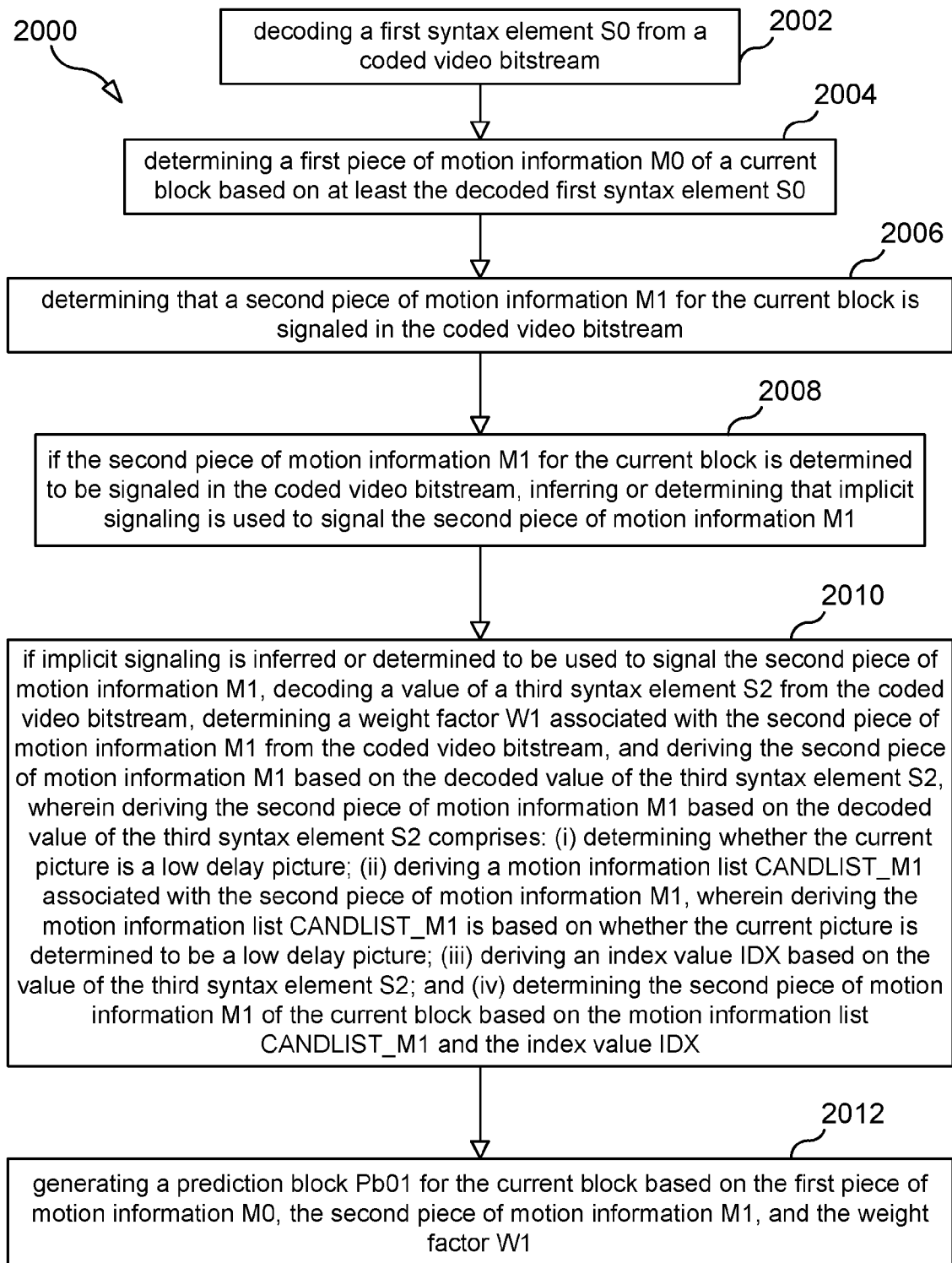


FIG. 20

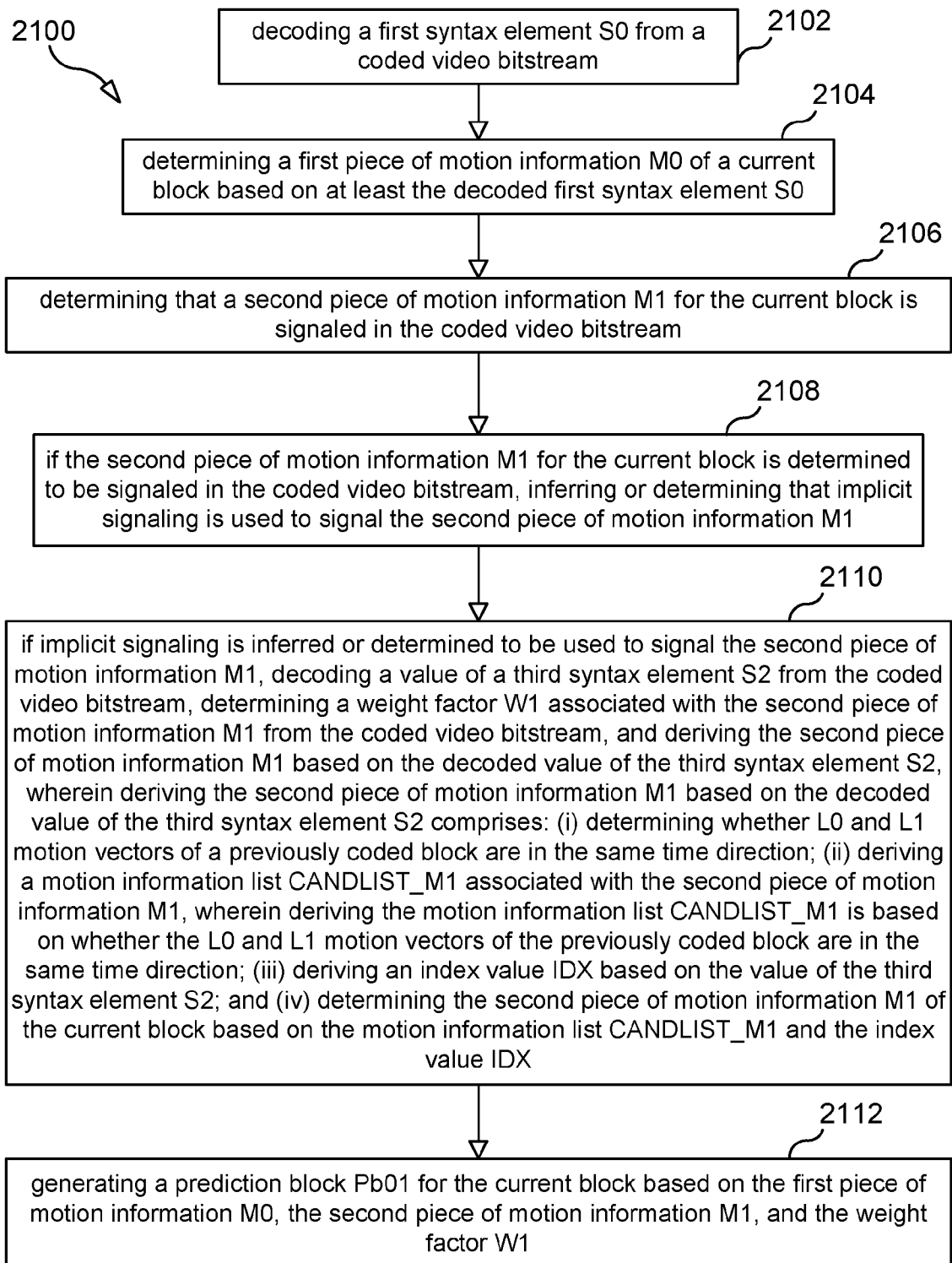


FIG. 21

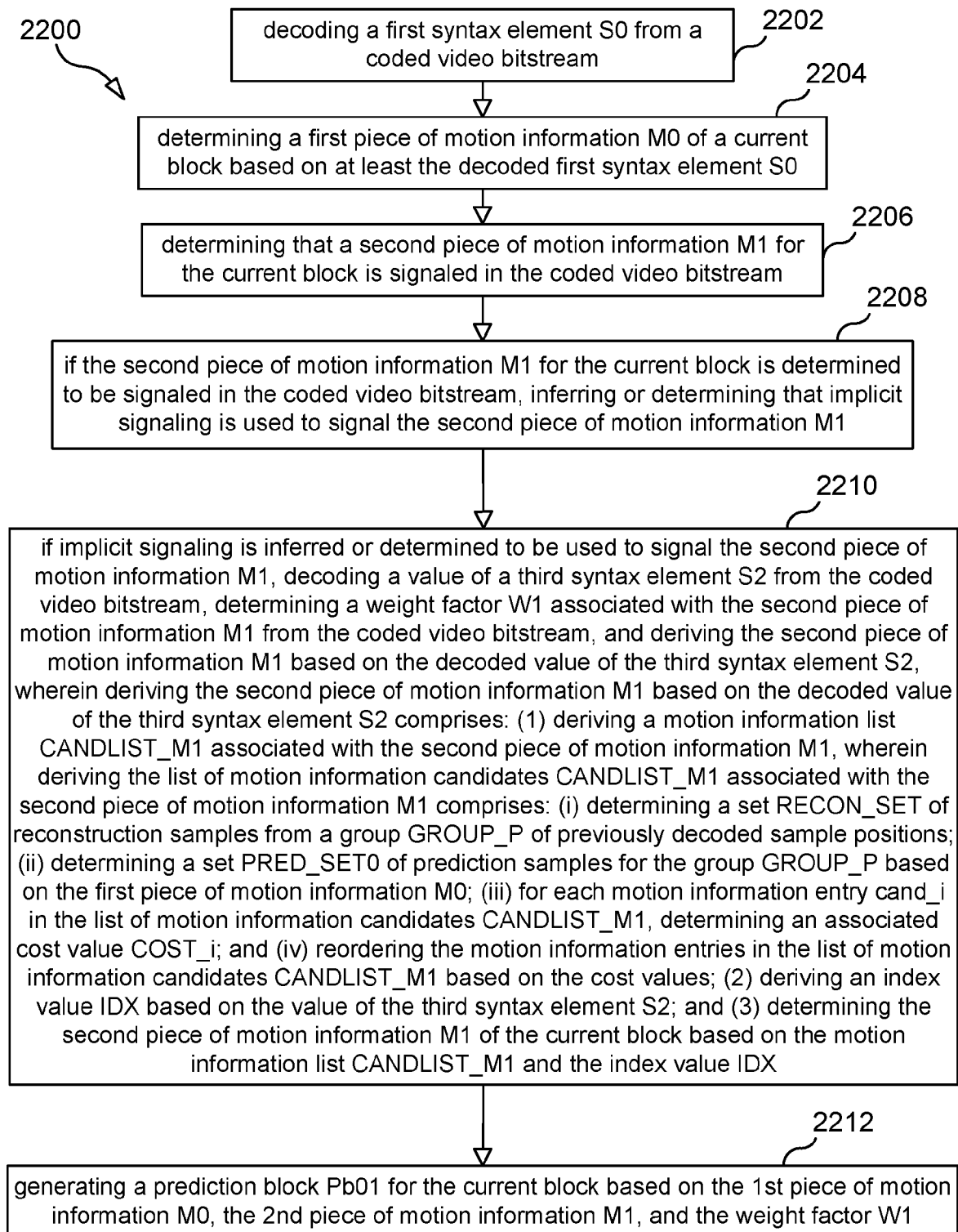


FIG. 22

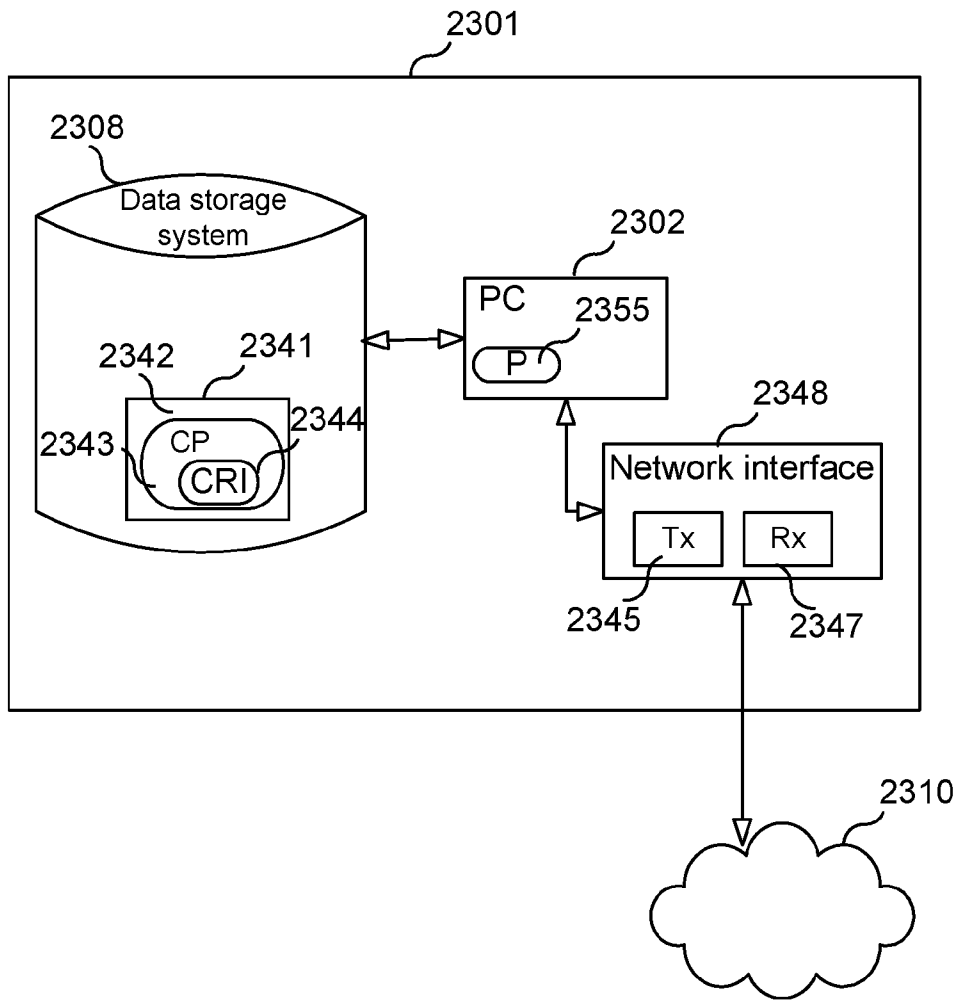


FIG. 23

Electronic Acknowledgement Receipt

EFS ID:	45450855
Application Number:	63329939
International Application Number:	
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Title of Invention:	ENHANCED MULTI-HYPOTHESIS PREDICTION
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RAM confirmation Number	E20224BA50473361
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			f2d7504a459856e65bfcc5d5f33732da9c65af7d		
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			8275bda9997729482208ef548e220a7c9e892c6e		
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4	Fee Worksheet (SB06)	fee-info.pdf	37597	no	2
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ENHANCED MULTI-HYPOTHESIS PREDICTION

TECHNICAL FIELD

[001] This disclosure relates to video encoding and/or decoding of a picture or a video sequence.

BACKGROUND

[002] Video and Picture

[003] A video sequence consists of a series of pictures (also referred to as “images” herein). In the Versatile Video Coding (VVC) standard, each picture is identified with a picture order count (POC) value. The POC value also represents a display order of the picture. A picture with a smaller POC value is displayed before another picture with a larger POC value.

[004] Components

[005] Each component can be described as a two-dimensional rectangular array of sample (also referred to as “pixel” herein) values. It is common that each picture consists of three components: one luma component Y where the sample values are luma values and two chroma components Cb and Cr where the sample values are chroma values.

[006] It is also common that the dimensions of the chroma components are smaller than the luma components by a factor of two in each dimension. For example, the size of the luma component of an HD picture would be 1920x1080 and the chroma components would each have the dimension of 960x540. Components are sometimes referred to as color components.

[007] Coding Unit and Coding Block

[008] A block is one two-dimensional array of samples. In video coding, each component is split into blocks, and the coded video bitstream consists of a series of coded blocks. It is common in video coding that pictures are split into units that cover a specific area of the picture.

[009] Each unit consists of all blocks from all components that make up that specific area and each block belongs fully to one unit. The coding unit (CU) in VVC is an example of units.

In VVC, the CUs may be split recursively to smaller CUs. The CU at the top level is referred to as the coding tree unit (CTU).

[0010] A CU usually contains three coding blocks, e.g., one coding block for luma and two coding blocks for chroma. The size of luma coding block is the same as the CU.

[0011] In the current VVC (i.e., version 1), the CUs can have size of 4x4 up to 128x128.

[0012] Parameter Sets, Slice Headers, and Picture Headers

[0013] VVC specifies three types of parameter sets: the picture parameter set (PPS), the sequence parameter set (SPS), and the video parameter set (VPS). The PPS contains data that is common for a whole picture, the SPS contains data that is common for a coded layer video sequence (CLVS), and the VPS contains data that is common for multiple CLVSs (e.g., data for multiple layers in the bitstream).

[0014] The concept of slices divides the picture into independently coded slices, where decoding of one slice in a picture is independent of other slices of the same picture. Each slice has a slice header comprising syntax elements. Decoded slice header values from these syntax elements are used when decoding the slice.

[0015] In VVC, a coded picture contains a picture header. The picture header contains parameters that are common for all slices of the coded picture.

[0016] Intra Prediction

[0017] In intra prediction, also known as spatial prediction, a block is predicted using the previous decoded blocks within the same picture. The samples from the previously decoded blocks within the same picture are used to predict the samples inside the current block.

[0018] A picture consisting of only intra-predicted blocks is referred to as an intra picture.

[0019] Inter Prediction

[0020] In inter prediction, also known as temporal prediction, blocks of the current picture are predicted using blocks from previously decoded pictures. The samples from blocks in the previously decoded pictures are used to predict the samples of the current block.

[0021] A picture that allows inter-predicted block is referred to as an inter picture. The previous decoded pictures used for inter prediction are referred to as reference pictures.

[0022] The location of the referenced block inside the reference picture is indicated using a motion vector (MV). Each MV consists of x and y components, which represent the displacements between current block and the referenced block in x or y dimension. The value of a component may have a resolution finer than an integer position. When that is the case, a filtering (typically interpolation) is done to calculate values used for prediction. FIG. 1 shows an example of a MV for the current block C. In the example, the $MV = (2,1)$ indicates that the referenced block can be found two steps to the right and one step down compared to the position of the current block.

[0023] An inter picture may use several reference pictures. The reference pictures are usually put into two reference picture lists, L0 and L1. The reference pictures that are output before the current picture are typically the first pictures in L0. The reference pictures that are output after the current picture are typically the first pictures in L1.

[0024] Inter predicted blocks can use one of two prediction types, uni- and bi-prediction. Uni-predicted block predicts from one reference picture, either using L0 or L1. Bi-prediction predicts from two reference pictures, one from L0 and the other from L1. FIG. 2 shows an example of the prediction types.

[0025] Low Delay Picture and Non-Low Delay Picture

[0026] A low delay picture is a picture that has all its reference pictures displayed before the picture. In other words, for a low delay picture, all its reference pictures have smaller POC values than the current POC value.

[0027] A non-low delay picture is a picture that has at least one of its reference pictures displayed after the picture. In other words, a non-low delay picture has at least one reference picture with a larger POC value than the current POC.

[0028] Fractional MVs, Interpolation Filter, and MV Rounding

[0029] The value of the MV's x or y component may correspond to a sample position that has a finer granularity than an integer (sample) position. Those positions are also referred to as fractional (sample) positions.

[0030] In VVC, the MV can be at 1/16 sample position. FIG. 3 depicts several fractional positions in the horizontal (x-) dimension. The solid-square blocks represent integer positions. The circles represent 1/16-position. For example, $MV = (4, 10)$ means the x component is at 4/16 position, the y component is at 10/16 position.

[0031] In video coding, a MV rounding process is sometimes used to convert a MV at one position to another target position. One example of rounding is to round a fractional MV position to the nearest integer position.

[0032] When a MV is at a fractional position, filtering (typically interpolation) is done to calculate the sample values at those positions. In VVC, the length (number of filter taps) of the interpolation filter for luma component is 8, as shown in Table 1 below.

Fractional sample position p	interpolation filter coefficients							
	fr.[p][0]	fr.[p][1]	fr.[p][2]	fr.[p][3]	fr.[p][4]	fr.[p][5]	fr.[p][6]	fr.[p][7]
1	0	1	-3	63	4	-2	1	0
2	-1	2	-5	62	8	-3	1	0
3	-1	3	-8	60	13	-4	1	0
4	-1	4	-10	58	17	-5	1	0
5	-1	4	-11	52	26	-8	3	-1
6	-1	3	-9	47	31	-10	4	-1
7	-1	4	-11	45	34	-10	4	-1
8	-1	4	-11	40	40	-11	4	-1
9	-1	4	-10	34	45	-11	4	-1
10	-1	4	-10	31	47	-9	3	-1
11	1	3	8	26	52	11	4	1
12	0	1	-5	17	58	-10	4	-1
13	0	1	-4	13	60	-8	3	-1
14	0	1	-3	8	62	-5	2	-1
15	0	1	-2	4	63	-3	1	0

Table 1

[0033] Residual, Transform, and Quantization

[0034] The difference between samples of a source block (which contains original samples) and samples of the prediction block, is often called ‘residual block’. This residual block is typically transformed by a spatial transform, such as a discrete sine transform (DST) or a discrete cosine transform (DCT), to remove further redundancy. The transform coefficients are then quantized by a quantization parameter (QP) to control the fidelity of the residual block and thus also the bitrate required to compress the block. A coded block flag (CBF) is used to indicate if there are any non-zero quantized transform coefficients. All coding parameters are then entropy coded at the encoder and decoded at the decoder. If the coded block flag is one, a reconstructed block can then be derived by inverse quantization and inverse transformation of the quantized transform coefficients and then adding that to the prediction block. If the coded block flag is zero, the reconstructed block is identical to the prediction block.

[0035] Hierarchical Picture Coding Structure

[0036] In a random access configuration, intra coded pictures (or intra pictures for short) are typically positioned with a fixed interval (e.g., every second). Pictures between the intra pictures are typically coded with a bi-directional group of pictures (B-GOP) structure as shown in FIG. 4. In the example shown in FIG. 4, picture 0 is coded first and then picture 8 is coded using picture 0 as its reference picture. Then, picture 8 and picture 0 are used as reference pictures to code picture 4. Then, similarly, picture 2 and picture 6 are coded. Finally, pictures 1, 3, 5, and 7 are coded.

[0037] Pictures 1, 3, 5, and 7 are referred to as belonging to the highest hierarchical layer, pictures 2 and 6 are referred to as belonging to the second-highest hierarchical layer, picture 4 is referred to as belonging to the second-lowest layer, and pictures 0 and 8 are referred to as belonging to the lowest layer. Typically, pictures 1, 3, 5, and 7 are not used as reference pictures for any other pictures. They are called non-reference pictures.

[0038] The assigned slice QP for each picture are usually different and are set according to the hierarchy level. Higher slice QPs are assigned to pictures that belong to higher hierarchy layers.

[0039] Inter Prediction / Motion Information

[0040] For an inter block in an inter picture in VVC, the inter prediction information of the inter block consists of the following three elements: (1) a reference picture list flag (RefPicListFlag), (2) a reference picture index (RefPicIdx) per reference picture list used, and (3) a motion vector (MV) per reference picture used. A reference picture list flag (RefPicListFlag) signals which reference picture list is used. When the value of RefPicListFlag is equal to 0, L0 is used. When the value of RefPicListFlag is equal to 1, L1 is used. When the value of RefPicListFlag is equal to 2, both L0 and L1 are used. The reference picture index (RefPicIdx) signals which reference picture inside the reference list is to be used for predicting the current block. The motion vector (MV) signals the position inside the reference picture that is used for predicting the current block.

[0041] The inter prediction information is also referred to as motion information. The decoder stores the motion information for each inter block. In other words, an inter block maintains its own motion information.

[0042] Encoder Decision and Rate Distortion (RD) Cost

[0043] In practice, for an encoder to decide the best prediction mode for a current block, the encoder will evaluate many or all of the possible prediction modes for the current block and select the prediction mode that yields the smallest Rate-Distortion (RD) cost.

[0044] The RD cost is calculated as $D + \lambda * R$. The D (Distortion) measures the difference between the reconstructed block and the corresponding source block. One commonly used metric for calculating D is the sum of squared errors $SSE = \sum_{x,y} (P_A(x,y) - P_B(x,y))^2$, where the P_A and P_B are the sample values in the two blocks A and B respectively. The R (Rate) is usually an estimation of the number of bits to be spent on encoding the mode. The λ is a trade-off parameter between R and D.

[0045] Motion Information Signaling

[0046] VVC includes several methods for implicit signaling of motion information for each block, including the merge method and the subblock merge method. A common motivation behind the implicit methods is to inherit motion information from neighboring coded blocks.

This often works in practice due to spatial correlation of close-by blocks (e.g., because nearby blocks often behave similarly).

[0047] Merge (Block Merge) Method and Merge Mode

[0048] The merge method is similar to the one in the High Efficiency Video Coding (HEVC) standard. The method is sometimes referred to as the block merge method because the derived motion information is used for generating the samples of the entire block.

[0049] The method first generates a list of motion information candidates. This list is also referred to as the merge list. The candidates are derived from previously coded blocks. These previously coded blocks can be spatially adjacent neighboring blocks or temporally collocated blocks relative to the current block. FIG. 5 shows the spatial neighboring blocks: left (L), top(T), top-right(TR), left-bottom (LB), and top-left (TL).

[0050] The merge list construction process usually checks the previously coded blocks in a predefined order (e.g., T – L – TR – LB – TL). For each previously coded block being checked, if this previously coded block is inter coded and its motion information has no duplicates in the list, then the motion information of this previously coded block is added to the merge list.

[0051] After the merge list is generated, one of the candidates inside the list is used to derive the motion information of the current block. The candidate selection process is done on the encoder side. An encoder would select a best candidate from the list and encode an index (merge_index) in the bitstream to signal to a decoder. The decoder receives the index, follows the same merge list derivation process as the encoder, and uses the index to retrieve the correct candidate.

[0052] The blocks that use the block merge method are sometimes referred to as blocks in merge mode.

[0053] In the current development of ECM (an enhanced compression model studied in JVET with compression capabilities beyond VVC), non-adjacent spatial blocks are also considered as sources of motion information during the merge list construction. FIG. 6 shows some of the non-adjacent spatial blocks (marked with NA1, NA2 and NA3) considered as sources of motion information during the merge list construction.

[0054] Subblock Merge Method and Subblock Motion Refinement

[0055] VVC also includes a subblock merge method and also a method of subblock-based motion refinement. VVC splits a current block into a number of subblocks and allows each subblock to have its own motion information. FIG. 7 shows an example of a current block and its subblocks. Each subblock maintains its own motion information.

[0056] Explicit Motion Information Signaling

[0057] VVC also includes an explicit motion information signaling method, such as alternative motion vector prediction (AMVP). For a current inter block that is coded with AMVP, the number of reference pictures, reference picture indices, and motion vectors for the current inter block are explicitly signaled and encoded into the bitstream.

[0058] The explicit motion information signaling is usually chosen by an encoder when directly inheriting or reusing motion information from previously coded inter blocks do not fit well for a current block. For example, when the previously coded blocks and the current block belong to different objects, it is likely that the motion of the previously coded blocks and that of the current block do not correlate well.

[0059] When an encoder decides to use explicit signaling for the current block's MV, the process usually involves deriving of a motion vector predictor (MVP). The MVP is derived from MVs of previously coded blocks. After the MVP is derived, a motion vector difference (MVD) between the MVP and the current MV is calculated as $MVD = MV - MVP$. FIG. 8 shows an example of the MVD derivation.

[0060] As shown in FIG. 8, the MVD also has two components: an x-component and a y-component. Each component has information of two types: magnitude and sign. Both the magnitude and sign information (if the magnitude is non-zero) of the x- and y-components are signaled in a bitstream. For example, if the current block's MV is (+10, -5), and the derived MVP is (+7, +3), then the MVD would be (+3, -8), where $3 = 10 - 7$ and $-8 = -5 - 3$. The magnitudes 3 and 8, as well as the signs + and -, are all signaled in the bitstream.

[0061] For a decoder to reconstruct the MV of the current block, the decoder decodes the magnitude and sign information of both the x- and the y-component of the MVD from the

bitstream. Then, the decoder follows the same predictor derivation process as the encoder to derive the MVP from MVs of previously coded blocks, and the MV is reconstructed by using the MVP and MVD. Using the example above, the decoder decodes the magnitudes 3 and 8 as well as the signs + and – from the bitstream to get the MVD (+3, -8). The decoder then uses the same predictor derivation process to get MVP which is (+7, +3). The decoder then derives the MV as (+10, -5), where $10 = 3 + 7$ and $-5 = -8 + 3$.

[0062] Multi-Hypothesis Prediction (MHP)

[0063] Multi-hypothesis prediction (MHP) is a tool included in ECM. MHP allows the signaling of additional motion information in addition to conventional bi-predictive motion information when AMVP is used for a current block. MHP also allows the signaling of additional motion information when the current block is in merge mode. Each type of motion information constitutes a prediction hypothesis for the samples of the current block.

[0064] In the current ECM common test configuration (an encoding configuration that is suggested to be used for testing), up to two pieces of additional motion information can be signaled for a current block. It is possible to allow the signaling of more than two pieces of additional motion information for the current block by changing the encoding configuration.

[0065] In a first example, let's assume that one piece of additional motion information is signaled in addition to the conventional bi-predictive motion information. P_{bi} denotes the prediction block generated using the conventional bi-predictive motion information, P_{h0} denotes the prediction block generated using the additional motion information. The final prediction block P_{f0} would be a weighted combination of the P_{bi} and P_{h0} :

$$P_{f0} = (1 - \alpha_0) * P_{bi} + \alpha_0 * P_{h0}$$

where the α_0 is a weighting factor and has a value of 1/4 or -1/8 in the existing ECM.

[0066] When there is more than one piece of additional motion information signaled, the final prediction block is derived by iteratively accumulating each prediction block that is generated using the additional motion information. For example, assuming there are two pieces of additional motion information signaled, using the same notation as above, P_{f0} is generated first based on the conventional motion information and the first piece of additional motion

information. Ph1 denotes the prediction block generated using the second piece of additional motion information. The final prediction block Pf1 would be a weighted combination of the Pf0 and Ph1:

$$Pf0 = (1 - \alpha0) * Pbi + \alpha0 * Ph0$$

$$Pf1 = (1 - \alpha1) * Pf0 + \alpha1 * Ph1$$

where each piece of additional motion information is associated with a weighting factor. The first piece of additional motion information is associated with a weighting factor $\alpha0$. The second piece of additional motion information is associated with another weighting factor $\alpha1$.

[0067] FIG. 9 gives a general illustration of the parsing steps of the existing MHP design in ECM. As can be seen in FIG. 9, the weighting factor that is associated with each additional piece of motion information is explicitly signaled and present in the bitstream. The associated weighting factor with each additional motion information indicates how to combine the prediction samples from this additional motion information with the existing prediction samples from the already decoded motion information of the current block.

[0068] Each additional piece of motion information (which contains a reference picture list flag, a reference picture index per reference picture list, and motion vector information per reference picture list), can either be explicitly or implicitly signaled. In the existing MHP design, a multi-hypothesis merge flag (also referred to as MHP merge flag in the text below) is always signaled for each additional motion information to indicate whether explicit or implicit signaling is used.

[0069] When the implicit signaling is used, a motion information index is signaled. In this case, a construction of a motion information list based on the motion information from previously coded blocks is done first. The decoder then uses the decoded index to fetch the corresponding motion information from the list. The motion information list construction process is similar to the merge list construction process. A number of previously decoded blocks are selected as candidates for having their motion information being included in the motion information list. The construction process checks those previously decoded blocks in a predefined order and derives whether the motion information should be added (to the list) based on the motion information from the previously decoded blocks.

[0070] The motion information list used in the existing MHP design is a list of uni-motion pieces of information (where each motion information entry only uses L0 or L1). Table 2 below shows an example of a motion information list with uni-motion information entries, where BLK_A, BLK_B, and BLK_C are some of the previously decoded blocks.

Index	Motion information	
0 (Derived from the L0 of BLK_A)	RefPicListFlag = 1 (only L0 is used)	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-1, 2)	MV L1: -
1 (Derived from the L1 of BLK_B)	RefPicListFlag = 2 (only L1 is used)	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (0, 0)
2 (Derived from the L0 of BLK_C)	RefPicListFlag = 1 (only L0 is used)	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (3, 1)	MV L1: -

Table 2

[0071] When the explicit signaling is used, a reference picture index, a motion vector predictor flag, and a motion vector difference are signaled. In other words, the additional motion information is explicitly signaled in the bitstream.

SUMMARY

[0072] There are several drawbacks with the existing multi-hypothesis prediction (MHP) design. One drawback is that, for each additional signaled motion information, an MHP merge flag is always signaled. It would be beneficial to make the presence of the flag conditioned under a certain criterion. For example, the MHP merge flag may not be present when it is desired to have all the additional pieces of motion information being signaled using implicit signaling method (e.g., to achieve better prediction accuracy). For another example, the MHP merge flag may not be present when the motion information list has zero entries (e.g., when there

is no motion information that can be directly reused). In both examples, the MHP merge flag would be a constant, and there is no need to have the flag signaled and present in the bitstream. In other words, the MHP merge flag is redundantly signaled in the bitstream in these examples, and bits are wastefully spent.

[0073] Another drawback is that the construction of the motion information list (when implicit signaling is used) only considers one of the L0 or L1 motion vectors from the motion information of a first previously decoded block before checking the L0 or L1 motion vectors from a second previously decoded block. This is inefficient because both the L0 and L1 motion vectors from the motion information of the first previously decoded block may provide better fits than the motion vector from the second block. For example, when the second block has larger spatial distance to the current block than the first block, both L0 and L1 motion vectors of the first block may be more relevant than any of the motion vectors of the second block.

[0074] Still another drawback is that the construction of the motion information list only considers motion information from previously coded blocks, which may be inefficient, especially when the current block has different motion characteristics than the previously coded blocks.

[0075] Aspects of the invention may overcome one or more of the drawbacks of the existing MHP design by using (1) conditional signaling of the MHP merge flag to avoid redundancy and/or (2) a better motion information list construction process. Aspects of the invention may include one or more modifications to the existing MHP.

[0076] In some aspects, the existing MHP may be modified by adding a motion information list length check when parsing the MHP merge flag. The motion information list length check may be performed because, when the motion information list length is 0, the MHP merge flag does not need to be signaled and be present in a bitstream. A corresponding decoder can directly infer or derive the MHP merge flag to be 0.

[0077] In some aspects, the existing MHP may additionally or alternatively be modified by, when constructing the motion information list, considering both the L0 motion vector and the L1 motion vector (if they are present) from a first previously decoded block before moving on to check the motion vectors from a second previously decoded block. For example, if a first previously decoded block is BLK_A and a second previously decoded block is BLK_B, the

checking order in the existing MHP solution is BLK_A_L0 then BLK_B_L1. In some aspects, the checking order may be modified as BLK_A_L0, then BLK_A_L1, then BLK_B_L1. Similarly, if there is a third previously decoded block BLK_C, the checking order would be BLK_A_L0, BLK_A_L1, then BLK_B_L1, BLK_B_L0, and then BLK_C_L0 (instead of BLK_A_L0, BLK_B_L1, BLK_C_L0).

[0078] In some aspects, the checking both the L0 and L1 motion vectors of a previously encoded block may only be activated or enabled when the current picture is a non-low delay picture. When the current picture is a non-low delay picture, both L0 and L1 motion vectors may give equally useful prediction information (because they are more likely referring to different directions), and both L0 and L1 motion vectors should be considered. When the current picture is a low delay picture, L0 and L1 motion vectors may give similar prediction information, therefore it is enough to consider only one of them.

[0079] In some alternative aspects, the decoder may check the time direction of each motion vector of the first block (i.e., whether the motion vector points to a block forward or backward in time). In some aspects, the time direction of the L0 motion vector of the first block may, for example, be determined by comparing the picture order count (POC) of the L0 picture with the POC of the current picture. In some aspects, if $L0_POC - POC < 0$, the time direction is negative (e.g., the L0 motion vector may be referring to a block in an earlier picture in display order). In some aspects, if $L0_POC - POC > 0$, the time direction is positive. In some aspects, the time direction for L1 may be determined to positive or negative in a similar fashion. In some aspects, if the time directions are different, then both L0 and L1 of the first block may be considered before any motion vector of the second block, which would equate to the order BLK_A_L0, BLK_A_L1, and then BLK_B_L1 in the example above. In some aspects, if the time directions are the same, then the order from the existing MHP solution (i.e., BLK_A_L0 then BLK_B_L1) may be used.

[0080] In some aspects, the existing MHP may additionally or alternatively be modified by, when constructing the motion information list for predicting an additional piece of motion information of a current block, considering the already signaled or decoded motion information of the current block. Using already signaled motion information of the current block may provide a better fit compared to the motion information from previously decoded blocks.

[0081] In some aspects, the existing MHP may additionally or alternatively be modified by introducing a refinement process after the derivation of the motion information list. The entries in the motion information list may be further refined and/or reordered. The motion information entries may be adjusted or refined in the list to achieve a better prediction of a corresponding additional piece of motion information.

[0082] Aspects of the modified/enhanced MHP may provide the advantage of improved compression efficiency. For example, Table 3 below shows the objective performance of the modified/enhanced MHP compared to ECM-4.0, which is the current ECM software, under the ECM random access common test configuration. The numbers in Table 3 show the relative bit-cost for the proposed method to achieve equivalent objective video quality (measured in peak signal-to-noise (PSNR)) as ECM-4.0. The Bjontegaard rate (BD-rate) number -0.X% means the proposed solution requires 0.X% less bits than ECM-4.0 for the same quality for different sequence classes.

	Y	U	V
Class A1			
Class A2			
Class B			
Class C			
Class E			
Overall			
Class D	-0.08%	-0.11%	0.02%

Table 3

[0083] One aspect of the invention may provide a method for processing (e.g., decoding) a current block within a current picture. The method may include decoding a first syntax element S0 from a coded video bitstream. The method may include determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The method may include determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The method may include, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video

bitstream, determining whether a second syntax element S1 is present in the coded video bitstream. The method may include, if the second syntax element S1 is determined to not be present in the coded video bitstream, inferring which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1. The method may include, if the second syntax element S1 is determined to be present in the coded video bitstream, decoding a value for the second syntax element S1 and determining which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1 based on the decoded value of the second syntax element S1. The method may include, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2. The method may include, if explicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a fourth syntax element S3 from the coded video bitstream, determining the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determining the second piece of motion information M1 based on the decoded value of the fourth syntax element S3. The method may include generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[0084] In some aspects, the second syntax element S1 may be a multi-hypothesis prediction (MHP) merge flag. In some aspects, the third syntax element S2 may be a motion information index.

[0085] In some aspects, determining whether the second syntax element S1 is present in the coded video bitstream may include determining a value V1 based on a fifth syntax element S4 in a parameter set P and comparing the value V1 to a constant value C0 (e.g., 0, 1, or 2). In some aspects, the parameter set P may be a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header. In some aspects, the second syntax element S1 may be determined to be present in the coded video bitstream if the value V1 is greater than the constant value C0, and the second syntax element S1 may be determined to be not present in the coded

video bitstream if the value V1 is not greater than the constant value C0. In some aspects, the value V1 may indicate a maximum length of a motion information list CANDLIST_M1 associated with the second piece of motion information M1. In some aspects, if the value V1 indicates a maximum length of 0 for the motion information list CANDLIST_M1 associated with the second piece of motion information M1, the second syntax element S1 may be determined to not be present in the coded video bitstream, and explicit signaling may be inferred to be used to signal the second piece of motion information M1 associated with the second piece of motion information M1.

[0086] In some aspects, determining the second piece of motion information M1 based on the value of the fourth syntax element S3 may include determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

[0087] In some aspects, deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include: deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, deriving an index value IDX based on the value of the third syntax element S2, and determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. In some aspects, at least one motion information entry in the motion information list CANDLIST_M1 associated with the second piece of motion information M1 may be derived based on the first piece of motion information M0 of the current block.

[0088] In some aspects, the method may further include determining whether the current picture is a low delay picture, and deriving the motion information list CANDLIST_M1 may be based on whether the current picture is determined to be a low delay picture. In some aspects, the motion information list CANDLIST_M1 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the current picture is determined to be a low delay picture, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an

entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the current picture is determined to not be a low delay picture.

[0089] In some aspects, the method may further include determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction, and deriving the motion information list CANDLIST_M1 may be based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction. In some aspects, the motion information list CANDLIST_M1 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the previously coded block BLK_A are determined to be in the same time direction, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to not be in the same time direction. In some aspects, determining whether the L0 and L1 motion vectors of the previously coded block are in the same time direction may include: determining the time direction of the L0 motion vector of the previously coded block, determining the time direction of the L1 motion vector of the previously coded block, and determining whether the time directions of the L0 and L1 motion vectors of the previously coded block are the same. In some aspects, determining the time direction of the L0 motion vector of the previously coded block may include comparing a picture order count (POC) value of an L0 picture of the previously coded block with a POC value of the current picture, and determining the time direction of the L1 motion vector of the previously coded block may include comparing a POC value of an L1 picture of the previously coded block with the POC value of the current picture.

[0090] In some aspects, deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 may include: (i) determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions; (ii) determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0; (iii) for each motion information entry cand_i

in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and (iv) reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values. In some aspects, determining the associated cost value COST_i for the motion information entry cand_i may include: (i) determining a set CANDPRED_i of prediction samples for the group GROUP_P based on the motion information cand_i; (ii) determining a set COMBI_i of prediction samples including prediction sample values that are a combination of the prediction sample set PRED_SET0 and the prediction sample set CANDPRED_i based on the weight W1; (iii) comparing the reconstruction set RECON_SET and the prediction sample set COMBI_i; and (iv) determining the cost value COST_i based on a comparison of the reconstruction set RECON_SET and the prediction set COMBI_i. In some aspects, reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values may include reordering the motion information entries in the list of motion information candidates CANDLIST_M1 to have ascending cost values.

[0091] In some aspects, the group GROUP_P of previously decoded sample positions may be sample positions in the current picture and/or one or more previously decoded pictures. In some aspects, the GROUP_P of previously decoded sample positions may be sample positions that are spatially neighboring to the current block. In some aspects, the GROUP_P of previously decoded sample positions may be sample positions that are above the current block and/or to the left of the current block. In some aspects, a width tpW_A of the sample positions of the GROUP_P of previously decoded sample positions that are above the current block in a horizontal direction may equal or be greater than a width curW of the current block, and a height tpH_L of the sample positions of the GROUP_P of previously decoded sample positions that are to the left of the current block in a vertical direction may equal or be greater than a height curH of the current block.

[0092] In some aspects, determining the set PRED_SET0 of prediction samples for the group GROUP_P may include: (i) determining motion information of boundary subblocks of the current block based on the first piece of motion information M0; (ii) dividing the sample position group GROUP_P into subgroups that are each associated with motion information of a boundary subblock; and (iii) for each subgroup in GROUP_P, generating corresponding prediction samples

for the subgroup based on the associated motion information of the boundary subblock. In some aspects, the determined set PRED_SET0 may include the prediction samples from all the subgroups.

[0093] In some aspects, determining an associated cost value COST_i for a motion information entry cand_i in the list of motion information candidates CANDLIST_M1 may include: (i) determining a set of alternative motion information ALTERMI_SET based on the entry cand_i; (ii) determining a cost value ALTERCOST_j for each alternative motion information AMI_j in the set ALTERMI_SET; (iii) determining the motion information entry cand_i to be the alternative motion information that has the smallest cost value within the alternative motion information set ALTERMI_SET; and (iv) determining the associated cost value COST_i of the entry cand_i as the smallest cost value within the set ALTERMI_SET. In some aspects, determining the cost value ALTERCOST_j for an alternative motion information AMI_j in the set ALTERMI_SET may include: (i) determining a set ALTERPRED_j of prediction samples for the sample position group GROUP_P based on the alternative motion information AMI_j; (ii) determining a set ALTERCOMBI_j of prediction samples that is a combination of the prediction sample set PRED_SET0 and ALTERPRED_j based on the weight W1; and (iii) determining the cost value ALTERCOST_j based on comparing the reconstruction set RECON_SET and the prediction set ALTERCOMBI_j.

[0094] In some aspects, determining the associated cost value COST_i for the motion information entry cand_i may include: (i) for each sample position in the group GROUP_P, determining a cost value C_i for the sample position and a cost weighting factor cW_i for the sample position; and (ii) determining the cost value COST_i as a sum of C_i * cW_i for the sample positions in the group GROUP_P. In some aspects, a cost weighting factor (e.g., cW_i = 2) determined for sample positions that are closer to a boundary of the current block may be higher than a cost weighting factor (e.g., cW_i = 1) determined for sample positions that are further away from a boundary of the current block.

[0095] In some aspects, generating the prediction block Pb01 for the current block may include: (i) generating a first prediction block P0 for the current block based on the first piece of motion information M0; (ii) generating a second prediction block P1 for the current block based on the second piece of motion information M1; and (iii) generating the prediction block Pb01 as

a weighted combination of the first and second prediction blocks P0 and P1 based on the weight factor W1. In some aspects, generating the second prediction block P1 for the current block based on the second piece of motion information M1 may include: (i) refining the second piece of motion information M1 based on motion estimation such that the refined second piece of motion information M1 generates a prediction block for the current block that minimizes a difference with the first prediction block P0 for the current block; and (ii) using the refined second piece of motion information M1 to generate the second prediction block P1 for the current block.

[0096] In some aspects, deriving the motion information list CANDLIST_M1 associated with the second piece of motion information M1 may include: (i) for each motion information entry cand_i in the motion information list CANDLIST_M1, finding a refined motion information refinedCand_i based on motion estimation that generates a prediction block that minimizes a difference with the first prediction block P0 for the current block; and (ii) determining the motion information entry cand_i to be the refined motion information refinedCand_i.

[0097] Another aspect of the invention may provide a decoder. The decoder may be configured to decode a first syntax element S0 of a current block within a current picture from a coded video bitstream. The decoder may be configured to determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The decoder may be configured to determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The decoder may be configured to, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determine whether a second syntax element S1 is present in the coded video bitstream. The decoder may be configured to, if the second syntax element S1 is determined to not be present in the coded video bitstream, infer which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1. The decoder may be configured to, if the second syntax element S1 is determined to be present in the coded video bitstream, decode a value for the second syntax element S1 and determine which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1 based on the decoded value of the second syntax element S1. The decoder may be

configured to, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2. The decoder may be configured to, if explicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a fourth syntax element S3 from the coded video bitstream, determine the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determine the second piece of motion information M1 based on the decoded value of the fourth syntax element S3. The decoder may be configured to generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[0098] Still another aspect of the invention may provide a method for processing (e.g., decoding) a current block within a current picture. The method may include decoding a first syntax element S0 from a coded video bitstream. The method may include determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The method may include determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The method may include, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determining that a second syntax element S1 is not present in the coded video bitstream. The method may include, if the second syntax element S1 is determined to not be present in the coded video bitstream, inferring that explicit signaling is used to signal the second piece of motion information M1. The method may include, if explicit signaling is inferred to be used to signal the second piece of motion information M1, decoding a value of a fourth syntax element S3 from the coded video bitstream, determining the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determining the second piece of motion information M1 based on the decoded value of the fourth syntax element S3. The method may include generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[0099] In some aspects, the second syntax element S1 may be a multi-hypothesis prediction (MHP) merge flag. In some aspects, determining that the second syntax element S1 is not present in the coded video bitstream may include: determining a value V1 based on a fifth syntax element S4 in a parameter set P and comparing the value V1 to a constant value C0 (e.g., 0, 1, or 2). In some aspects, the parameter set P may be a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header. In some aspects, the second syntax element S1 may be determined to be not present in the coded video bitstream if the value V1 is not greater than the constant value C0. In some aspects, the value V1 may indicate a maximum length of a motion information list CANDLIST_M1 associated with the second piece of motion information M1. In some aspects, the value V1 may indicate a maximum length of 0 for the motion information list CANDLIST_M1 associated with the second piece of motion information M1. In some aspects, determining the second piece of motion information M1 based on the value of the fourth syntax element S3 may include determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

[00100] Yet another aspect of the invention may provide a decoder. The decoder may be configured to decode a first syntax element S0 of a current block within a current picture from a coded video bitstream. The decoder may be configured to determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The decoder may be configured to determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The decoder may be configured to, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determine that a second syntax element S1 is not present in the coded video bitstream. The decoder may be configured to, if the second syntax element S1 is determined to not be present in the coded video bitstream, infer that explicit signaling is used to signal the second piece of motion information M1. The decoder may be configured to, if explicit signaling is inferred to be used to signal the second piece of motion information M1, decode a value of a fourth syntax element S3 from the coded video bitstream, determine the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determine the second piece of motion information M1 based on the decoded value of the

fourth syntax element S3. The decoder may be configured to generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00101] Still another aspect of the invention may provide a method for processing (e.g., decoding) a current block within a current picture. The method may include decoding a first syntax element S0 from a coded video bitstream. The method may include determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The method may include determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The method may include, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, inferring or determining that implicit signaling is used to signal the second piece of motion information M1. The method may include, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2. Deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include: (i) determining whether the current picture is a low delay picture, (ii) deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1; (iii) deriving an index value IDX based on the value of the third syntax element S2; and (iv) determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. Deriving the motion information list CANDLIST_M1 may be based on whether the current picture is determined to be a low delay picture. The method may include generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00102] In some aspects, the motion information list CANDLIST_M1 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the current picture is determined to be a low delay picture, and the motion information list CANDLIST_M1

may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the current picture is determined to not be a low delay picture.

[00103] Yet another aspect of the invention may provide a decoder. The decoder may be configured to decode a first syntax element S0 of a current block within a current picture from a coded video bitstream. The decoder may be configured to determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The decoder may be configured to determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The decoder may be configured to, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infer or determine that implicit signaling is used to signal the second piece of motion information M1. The decoder may be configured to, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2. Deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include (i) determine whether the current picture is a low delay picture; (ii) deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1; (iii) deriving an index value IDX based on the value of the third syntax element S2; and (iv) determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. Deriving the motion information list CANDLIST_M1 may be based on whether the current picture is determined to be a low delay picture. The decoder may be configured to generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00104] Still another aspect of the invention may provide a method for processing (e.g., decoding) a current block within a current picture. The method may include decoding a first syntax element S0 from a coded video bitstream. The method may include determining a first

piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The method may include determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The method may include, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, inferring or determining that implicit signaling is used to signal the second piece of motion information M1. The method may include, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2. Deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include: (i) determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction; (ii) deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1; (iii) deriving an index value IDX based on the value of the third syntax element S2; and (iv) determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. Deriving the motion information list CANDLIST_M1 may be based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction. The method may include generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00105] In some aspects, the motion information list CANDLIST_M1 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to be in the same time direction, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the L0

and L1 motion vectors of the first previously coded block BLK_A are determined to not be in the same time direction.

[00106] In some aspects, determining whether the L0 and L1 motion vectors of the previously coded block are in the same time direction may include: (i) determining the time direction of the L0 motion vector of the previously coded block; (ii) determining the time direction of the L1 motion vector of the previously coded block; and (iii) determining whether the time directions of the L0 and L1 motion vectors of the previously coded block are the same. In some aspects, determining the time direction of the L0 motion vector of the previously coded block may include comparing a picture order count (POC) value of an L0 picture of the previously coded block with a POC value of the current picture, and determining the time direction of the L1 motion vector of the previously coded block may include comparing a POC value of an L1 picture of the previously coded block with the POC value of the current picture.

[00107] Yet another aspect of the invention may provide a decoder. The decoder may be configured to decode a first syntax element S0 of a current block within a current picture from a coded video bitstream. The decoder may be configured to determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The decoder may be configured to determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The decoder may be configured to, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infer or determine that implicit signaling is used to signal the second piece of motion information M1. The decoder may be configured to, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2. Deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include: (i) determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction; (ii) deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1; (iii) deriving an index value IDX based on the value of the third syntax element S2; and (iv) determining the

second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. Deriving the motion information list CANDLIST_M1 may be based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction. The decoder may be configured to generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00108] Still another aspect of the invention may provide a method for processing (e.g., decoding) a current block within a current picture. The method may include decoding a first syntax element S0 from a coded video bitstream. The method may include determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The method may include determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The method may include, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, inferring or determining that implicit signaling is used to signal the second piece of motion information M1. The method may include, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2. Deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1. Deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 may include: (i) determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions; (ii) determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0; (iii) for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and (iv) reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values. Deriving the second piece of motion information M1 based on the decoded value of

the third syntax element S2 may further include deriving an index value IDX based on the value of the third syntax element S2 and determining the second piece of motion information $M1$ of the current block based on the motion information list $CANDLIST_M1$ and the index value IDX . The method may include generating a prediction block $Pb01$ for the current block based on the first piece of motion information $M0$, the second piece of motion information $M1$, and the weight factor $W1$.

[00109] In some aspects, determining the associated cost value $COST_i$ for the motion information entry $cand_i$ may include: (i) determining a set $CANDPRED_i$ of prediction samples for the group $GROUP_P$ based on the motion information $cand_i$; (ii) determining a set $COMBI_i$ of prediction samples including prediction sample values that are a combination of the prediction sample set $PRED_SET0$ and the prediction sample set $CANDPRED_i$ based on the weight $W1$; (iii) comparing the reconstruction set $RECON_SET$ and the prediction sample set $COMBI_i$; and (iv) determining the cost value $COST_i$ based on a comparison of the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$. In some aspects, reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ based on the cost values may include reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ to have ascending cost values.

[00110] In some aspects, the group $GROUP_P$ of previously decoded sample positions may be sample positions in the current picture and/or one or more previously decoded pictures. In some aspects, the $GROUP_P$ of previously decoded sample positions may be sample positions that are spatially neighboring to the current block. In some aspects, the $GROUP_P$ of previously decoded sample positions may be sample positions that are above the current block and/or to the left of the current block. In some aspects, a width tpW_A of the sample positions of the $GROUP_P$ of previously decoded sample positions that are above the current block in a horizontal direction may equal or be greater than a width $curW$ of the current block, and a height tpH_L of the sample positions of the $GROUP_P$ of previously decoded sample positions that are to the left of the current block in a vertical direction may equal or be greater than a height $curH$ of the current block.

[00111] In some aspects, determining the set $PRED_SET0$ of prediction samples for the group $GROUP_P$ may include: (i) determining motion information of boundary subblocks of the

current block based on the first piece of motion information M0; (ii) dividing the sample position group GROUP_P into subgroups that are each associated with motion information of a boundary subblock; and (iii) for each subgroup in GROUP_P, generating corresponding prediction samples for the subgroup based on the associated motion information of the boundary subblock. The determined set PRED_SET0 may include the prediction samples from all the subgroups.

[00112] In some aspects, determining an associated cost value COST_i for a motion information entry cand_i in the list of motion information candidates CANDLIST_M1 may include: (i) determining a set of alternative motion information ALTERMI_SET based on the entry cand_i; (ii) determining a cost value ALTERCOST_j for each alternative motion information AMI_j in the set ALTERMI_SET; (iii) determining the motion information entry cand_i to be the alternative motion information that has the smallest cost value within the alternative motion information set ALTERMI_SET; and (iv) determining the associated cost value COST_i of the entry cand_i as the smallest cost value within the set ALTERMI_SET. In some aspects, determining the cost value ALTERCOST_j for an alternative motion information AMI_j in the set ALTERMI_SET may include: (i) determining a set ALTERPRED_j of prediction samples for the sample position group GROUP_P based on the alternative motion information AMI_j; (ii) determining a set ALTERCOMBI_j of prediction samples that is a combination of the prediction sample set PRED_SET0 and ALTERPRED_j based on the weight W1; and (iii) determining the cost value ALTERCOST_j based on comparing the reconstruction set RECON_SET and the prediction set ALTERCOMBI_j.

[00113] In some aspects, determining the associated cost value COST_i for the motion information entry cand_i may include: (i) for each sample position in the group GROUP_P, determining a cost value C_i for the sample position and a cost weighting factor cW_i for the sample position; and (ii) determining the cost value COST_i as a sum of C_i * cW_i for the sample positions in the group GROUP_P. In some aspects, a cost weighting factor (e.g., cW_i = 2) determined for sample positions that are closer to a boundary of the current block may be higher than a cost weighting factor (e.g., cW_i = 1) determined for sample positions that are further away from a boundary of the current block.

[00114] Yet another aspect of the invention may provide a decoder. The decoder may be configured to decode a first syntax element S0 of a current block within a current picture from a

coded video bitstream. The decoder may be configured to determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0. The decoder may be configured to determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream. The decoder may be configured to, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infer or determine that implicit signaling is used to signal the second piece of motion information M1. The decoder may be configured to, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2. In some aspects, deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1. Deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 may include: (i) determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions; (ii) determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0; (iii) for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and (iv) reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values. In some aspects, deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include deriving an index value IDX based on the value of the third syntax element S2 and determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. The decoder may be configured to generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00115] Yet another aspect of the invention may provide a computer program including instructions for adapting an apparatus to perform any of the above methods. Still another aspect

of the invention may provide a carrier containing the computer program, and the carrier may be one of an electronic signal, optical signal, radio signal, or compute readable storage medium.

[00116] Yet another aspect of the invention may provide an apparatus. The apparatus may include processing circuitry and a memory. The memory may contain instructions executable by said processing circuitry, and the apparatus may be operative to perform any of the above methods.

[00117] Still another aspect of the invention may provide an apparatus adapted to perform any of the above methods.

[00118] Yet another aspect of the invention may provide any combination of the aspects set forth above.

BRIEF DESCRIPTION OF THE DRAWINGS

[00119] The accompanying drawings, which are incorporated herein and form part of the specification, illustrate various embodiments.

[00120] FIG. 1 shows an example of a motion vector (MV) for a current block C.

[00121] FIG. 2 shows an example of Uni- and Bi- inter prediction.

[00122] FIG. 3 shows motion vector sample positions in the horizontal (x) dimension.

[00123] FIG. 4 shows an example of a four-layer bi-directional group of pictures (B-GOP) structure using two reference pictures per picture.

[00124] FIG. 5 shows possible spatial blocks for fetching neighboring motion information.

[00125] FIG. 6 shows possible adjacent spatial blocks and non-adjacent spatial blocks for fetching motion information.

[00126] FIG. 7 shows an example of subblocks and their corresponding motion.

[00127] FIG. 8 shows an example of motion vector difference (MVD) derivation.

[00128] FIG. 9 shows a general illustration of the parsing steps of the existing multi-hypothesis prediction (MHP) in Enhanced Compression Model (ECM).

[00129] FIG. 10 illustrates a system comprising an encoder and a decoder according to some aspects.

[00130] FIG. 11 illustrates an example encoder according to some aspects.

[00131] FIG. 12 illustrates an example decoder according to some aspects.

[00132] FIG. 13 illustrates the parsing steps of an enhanced multi-hypothesis prediction (MHP) according to some aspects.

[00133] FIG. 14 illustrates an example of a group of previously decoded sample positions for use in determining a set of reconstruction samples in the derivation of a list of motion information candidates according to some aspects.

[00134] FIG. 15 illustrates an example of a group of previously decoded sample positions for use in determining a set of reconstruction samples in the derivation of a list of motion information candidates according to some aspects.

[00135] FIG. 16 shows an example of subblocks of a current block and subgroups of the group of previously decoded sample positions for determining a set of prediction samples in the derivation of a list of motion information candidates according to some aspects.

[00136] FIG. 17 shows an alternative motion information having a smallest cost value according to some aspects.

[00137] FIG. 18 is a flow chart illustrating a process according to some aspects.

[00138] FIG. 19 is a flow chart illustrating a process according to some aspects.

[00139] FIG. 20 is a flow chart illustrating a process according to some aspects.

[00140] FIG. 21 is a flow chart illustrating a process according to some aspects.

[00141] FIG. 22 is a flow chart illustrating a process according to some aspects.

[00142] FIG. 23 is a block diagram of an apparatus according to some aspects.

DETAILED DESCRIPTION

[00143] FIG. 10 illustrates a system 1000 according to some aspects. System 1000 includes an encoder 1002 and a decoder 1004. In the example shown, decoder 1004 receives, via a network 1010 (e.g., the Internet or other network), encoded images produced by encoder 1002.

[00144] FIG. 11 is a schematic block diagram of the encoder 1002 according to some aspects. In some aspects, the encoder 1002 may be for encoding a block of pixel values in a video frame (e.g., picture) of a video sequence according to some embodiments. In some aspects, as shown in FIG. 11, the encoder 1002 may include a motion estimator 50 that predicts a current block by performing a motion estimation from an already provided block in the same frame or in a previous frame. The result of the motion estimation may be a motion or displacement vector associated with the reference block, in the case of inter prediction. In some aspects, the motion compensator 50 may utilize the motion vector for outputting an inter prediction of the block. In some aspects, the encoder 1002 may include an intra predictor 49 that computes an intra prediction of the current block. In some aspects, the encoder 1002 may include a selector 51 that receives outputs from the motion estimator/compensator 50 and the intra predictor 49 as inputs and either selects intra prediction or inter prediction for the current block. In some aspects, the output from the selector 51 may be input to an error calculator in the form of an adder 41 that also receives the pixel values of the current block. In some aspects, the adder 41 may calculate and output a residual error as the difference in pixel values between the block and its prediction. In some aspects, the encoder 1002 may include a transformer 42 that transforms the error, such as by a discrete cosine transform. In some aspects, the encoder 1002 may include a quantizer 43 that quantizes the transformed error. In some aspects, the encoder 1002 may include an encoder 44, such as an entropy encoder, that codes the quantized error. In inter coding, the estimated motion vector may also be brought to the encoder 44 for generating the coded representation of the current block. In some aspects, the encoder 1002 may include an inverse quantizer 45 and an inverse transformer 46 that receive the transformed and quantized residual error for the current block and retrieve the original residual error. In some aspects, the encoder may include an adder 47 that adds the original residual error to the block prediction output from the motion compensator 50 or the intra predictor 49 to create a reference block that can be used in the prediction and coding of a next block. In some aspects, the encoder 1002 may include a

deblocking filter unit 30 that processes the new reference block in order to perform deblocking filtering to combat any blocking artifact. In some aspects, the encoder 1002 may include a frame buffer 48 that temporarily stores the processed new reference block, and it may be available to the intra predictor 49 and/or the motion estimator/compensator 50.

[00145] FIG. 12 is a schematic block diagram of the decoder 1004 according to some aspects. In some aspects, as shown in FIG. 12, the decoder 1004 may include a decoder 61, such as an entropy decoder, for decoding an encoded representation of a block to get a set of quantized and transformed residual errors. In some aspects, the decoder 1004 may include an inverse quantizer 62 that dequantizes the residual errors and an inverse transformer 63 and inverse transforms the residual errors to get a set of residual errors. In some aspects, the decoder 1004 may include an adder 64 that adds the residual errors to the pixel values of a reference block. In some aspects, the decoder 1004 may include a motion estimator/compensator 67 and intra predictor 66 that each determine a reference block, and a selector 48 selects one of the reference blocks depending on whether inter or intra prediction is performed. In some aspects, the selector 68 may be interconnected to the adder 64, the motion estimator/compensator 67, and the intra predictor 66. In some aspects, the resulting decoded block output from the adder 64 may be input to a deblocking filter unit 70 in order to deblocking filter any blocking artifacts. In some aspects, the filtered block may be output from the decoder 1004 and may be provided to a frame buffer 65 for temporary storage so that the filtered block may be used as a reference block for a subsequent block to be decoded. In some aspects, the frame buffer 65 may be connected to the motion estimator/compensator 67 to make the stored blocks of pixels available to the motion estimator/compensator 67. In some aspects, the output from the adder 64 may preferably be also input to the intra predictor 66 to be used as an unfiltered reference block.

[00146] In some aspects, the motion information of aspects of the invention may contain a reference picture list flag, a reference picture index, and/or a motion vector.

[00147] Aspects of the invention relate to an enhanced method for multi-hypothesis prediction (MHP). In some aspects, the enhanced MHP method may include one or more modifications to the existing MHP method. In some aspects, the enhanced MHP method may include: (1) adding a motion information list length check when parsing the MHP merge flag, (2) when constructing the motion information list, considering both the L0 motion vector and the L1 motion vector (if

they are present) from a first previously decoded block before moving on to check motion vectors from a second previously decoded block, (3) when constructing the motion information list for predicting an additional piece of motion information of a current block, considering the already signaled or decoded motion information of the current block, and/or (4) introducing a refinement process after the derivation of the motion information list in which the entries in the motion information list are further refined and/or reordered.

[00148] In some aspects, checking the motion information list length may enable the encoder 1002 to not signal the MHP merge flag such that the MHP merge flag is not present in the bitstream when the motion information list length is 0, and, in that case, the decoder 1004 may directly infer or derive the MHP merge flag to be 0. The motion information list length check is described in detail, for example, with reference to the process 1300 below (e.g., around the steps 1308 and/or 1310 that determine the presence and value of the syntax element S1, which may correspond to the MHP merge flag).

[00149] When constructing the motion information list, the checking order in the existing MHP method is BLK_A_L0 then BLK_B_L1, where BLK_A is a first previously decode block and BLK_B is a second previously decoded block. In some aspects in which both the L0 motion vector and the L1 motion vector (if they are present) from a first previously decoded block are considered before moving on to check motion vectors from a second previously decoded block, the modified checking order may be BLK_A_L0, then BLK_A_L1, and then BLK_B_L1. In some aspects, if there is a third previously decoded block BLK_C, the modified checking order may be BLK_A_L0, BLK_A_L1 then BLK_B_L1, BLK_B_L0, and then BLK_C_L0 (instead of BLK_A_L0, BLK_B_L1, BLK_C_L0 as in the existing MHP method).

[00150] In some aspects, considering both the L0 motion vector and the L1 motion vector (if they are present) from a first previously decoded block before moving on to check motion vectors from a second previously decoded block may be activated or enabled only when the current picture is a non-low delay picture. In some aspects, both the L0 and L1 motion vectors may be considered when the current picture is a non-low delay picture because, when the current picture is a non-low delay picture, both the L0 and L1 motion vectors may give an equal amount of useful prediction information (e.g., because they are more likely to be referring to different directions). In some aspects, only one of the L0 and L1 motion vectors may be considered when

the current picture is a low delay picture because, when the current picture is a low delay picture, the L0 and L1 motion vectors may give similar prediction information. This is described in further detail below.

[00151] In some alternative aspects, the decoder 1004 may check the time direction of each motion vector of the first block (e.g., to determine whether the motion vector points to a block forward or backward in time). In some aspects, the time direction of the L0 motion vector of the first block may be determined, for example, by comparing the POC of the L0 picture with the POC of the current picture. In some aspects, if $L0_POC - POC < 0$, the time direction is negative, which indicates that the L0 motion vector is referring to a block in an earlier picture in the display order. In some aspects, if $L0_POC - POC > 0$ the time direction is positive, which indicates that the L0 motion vector is referring to a block in a later picture in the display order. In some aspects, the decoder 1004 may determine whether the time direction for L1 is positive or negative in a similar fashion. In some aspects, if the time directions are different, then the decoder 104 may consider both L0 and L1 of the first block before any motion vector of the second block (e.g., the checking order BLK_A_L0, then BLK_A_L1, and then BLK_B_L1 in the example above). In some aspects, if the time directions are the same, then the decoder 1004 may consider only one of the L0 and L1 motions vectors from each block before moving on to check a motion vector of the next block (e.g., the checking order BLK_A_L0 then BLK_B_L1 would be used in the example above). This is described in further detail below.

[00152] In some aspects, the already signaled or decoded motion information of the current block may be considered when constructing the motion information list for predicting an additional piece of motion information of a current block because using already signaled motion information of the current block can provide a better fit compared to the motion information from previously decoded blocks. This is described in further detail below.

[00153] In some aspects, the refinement process after the derivation of the motion information list that refines and/or reorders the entries in the motion information list may adjust or refine the motion information entries in the list to achieve a better prediction of a corresponding additional piece of motion information. This is described in further detail below.

[00154] FIG. 13 illustrates a process 1300 according to some aspects. In some aspects, the process 1300 may be for decoding a current block within a current picture inside a coded video bitstream. In some aspects, some or all of the steps of the process 1300 may be performed by a decoder 1004.

[00155] In some aspects, the process 1300 may include a step 1302 in which the decoder 1004 determines a first piece of motion information M0 of the current block based on at least a first syntax element S0 decoded from the bitstream.

[00156] In some aspects, the process 1300 may include a step 1304 in which the decoder 1004 determines whether there is at least a second piece of motion information M1 signaled for the current block in the bitstream. In some aspects, if the decoder 1004 determines in step 1304 that there is not at least a second piece of motion information M1 signaled for the current block in the bitstream, the process 1300 may proceed to a step 1306 in which the decoder 1004 stops decoding further MHP data of the current block.

[00157] In some aspects, if the decoder 1004 determines in step 1304 that there is not at least a second piece of motion information M1 signaled for the current block in the bitstream, the process 1300 may proceed to a step 1308 in which the decoder 1004 determines whether a second syntax element S1 is present in the bitstream. In some aspects, the second syntax element S1 may correspond to the MHP merge flag for the second piece of motion information M1. In some aspects, the syntax element S1 (if present) may have a value of A or B (e.g., 0 or 1).

[00158] In some aspects, determining in step 1308 whether a second syntax element S1 is present in the bitstream may include determining a value V1 based on a fifth syntax element S4 in a parameter set P. In some aspects, the parameter set P may be a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header. In some aspects, determining in step 1308 whether the second syntax element S1 is present in the bitstream may further include comparing the value V1 to a constant value C0. In some aspects, the syntax element S1 may be determined to be present when the value V1 is greater than the constant value C0. In some aspects, the constant value C0 may be equal to, for example, 0, 1, or 2. In some aspects, the value V1 may indicate a maximum length of the motion information list

CANDLIST_M1. That is, in some aspects, the value V1 may represent the maximum number of motion information that can be present in the motion information list CANDLIST_M1.

[00159] In some alternative aspects, the value V1 based on the fifth syntax element S4 in the parameter set P may indicate whether the encoder 1004 has disabled implicit signaling (e.g., to ensure that all of the additional motion information is accurately signaled). In some aspects, the fifth syntax element S4 may be a high-level switchable option (e.g., the signaling may be done above or higher than the block level, such as, for example, in the sequence level, picture level, or slice level). In some aspects, the parameter set P may be, for example, an SPS or a PPS. In some aspects, determining in step 1308 whether a second syntax element S1 is present in the bitstream may include determining whether implicit signaling has been disabled (e.g., by decoding the value V1).

[00160] In some alternative aspects, the value V1 based on the fifth syntax element S4 in the parameter set P may indicate whether the encoder 1004 has disabled explicit signaling (e.g., so that all the additional motion information is cheaply signaled via implicit signaling). For example, the encoder 1004 may disable explicit signaling where the objects inside a picture have the same or similar content and have the same or similar motion characteristics because, in these instances, the implicit signaling method may provide good prediction of motion information M1. In some aspects, the fifth syntax element S4 may be a high-level switchable option (e.g., the signaling may be done above or higher than the block level, such as, for example, in the sequence level, picture level, or slice level). In some aspects, the parameter set P may be, for example, an SPS or a PPS. In some aspects, determining in step 1308 whether a second syntax element S1 is present in the bitstream may include determining whether explicit signaling has been disabled (e.g., by decoding the value V1).

[00161] In some aspects, if the decoder 1004 determines in step 1308 that the second syntax element S1 is not present in the bitstream (e.g., because the encoder 1002 did not signal a value for the second syntax element S1), the step 1308 may include the decoder 1004 inferring or deriving a value (e.g., A or B) for the second syntax element S1 and setting the second syntax element S1 to the inferred or derived value. In some aspects, the decoder 1004 may infer a value of B (e.g., 0) for the second syntax element S1 if the value V1 based on a fifth syntax element S4 indicates a maximum length of the motion information list CANDLIST_M1 that is equal to or

less than the constant value C0 (e.g., 0, 1, or 2). In alternative aspects, the decoder 1004 may infer a value of B (e.g., 0) for the second syntax element S1 if the value V1 based on a fifth syntax element S4 indicates that implicit decoding is disabled. In some further alternative aspects, the decoder 1004 may infer a value of A (e.g., 1) for the second syntax element S1 if the value V1 based on the fifth syntax element S4 indicates that explicit decoding is disabled. Otherwise, if the decoder 1004 determines in step 1308 that the second syntax element S1 is present in the bitstream, the process 1300 may proceed to a step 1310 in which the decoder 1004 decodes and determines the value (e.g., A or B) for the second syntax element S1 from the bitstream.

[00162] In some aspects, if the value of the second syntax element S1 (either an inferred or derived value set by the decoder 1004 in step 1308 if the second syntax element S1 is not present in the bitstream or the value decoded and determined by the decoder 1004 in step 1310 if the second syntax element S1 is present in the bitstream) is equal to A (e.g., 1), the process 1300 may proceed from step 1308 or 1310 to steps 1312 and 1314. In some aspects, the step 1312 may include the decoder 1004 decoding at least a third syntax element S2 from the bitstream. In some aspects, the third syntax element S2 may correspond to the motion information index. In some aspects, the step 1314 may include the decoder 1004 determining (e.g., decoding) from the bitstream a weight factor W1 associated with the second piece of motion information M1. In some aspects, the steps 1312 and/or 1314 may include deriving the second piece of motion information M1 based on the value of the third syntax element S2. In some aspects, deriving the second piece of motion information M1 in steps 1312 and/or 1314 may include: (i) deriving a motion information list CANDLIST_M1 that is associated with the second piece of motion information M1, (ii) deriving an index value IDX based on the value of the third syntax element S2, and (iii) determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index IDX.

[00163] In some aspects, if the value of the second syntax element S1 (either an inferred or derived value set by the decoder 1004 in step 1308 if the second syntax element S1 is not present in the bitstream or the value decoded and determined by the decoder 1004 in step 1310 if the second syntax element S1 is present in the bitstream) is equal to B (e.g., 0), the process 1300 may proceed from step 1308 or 1310 to steps 1316 and 1318. In some aspects, the step 1316

may include the decoder 1004 decoding at least a fourth syntax element S3. In some aspects, the step 1318 may include the decoder 1004 determining (e.g., decoding) from the bitstream a weight factor W1 associated with the second piece of motion information M1. In some aspects, the steps 1316 and/or 1318 may include determining the second piece of motion information M1 of the current block based on the value of the fourth syntax element S3. In some aspects, determining the second piece of motion information M1 of the current block based on the value of the fourth syntax element S3 may include determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

[00164] In some aspects, the process 1300 may further include a step in which the decoder 1004 generates a prediction block Pb01 for the current block based on the first piece of motion information M0 (e.g., determined in step 1302), the second piece of motion information M1 (e.g., determined in step(s) 1312 and/or 1314 or determined in step(s) 1316 and/or 1318), and the weight W1 (e.g., determined in step 1314 or step 1318). In some aspects, generating the prediction block of the current block may include: (i) generating a first prediction block P0 for the current block based on the first piece of motion information M0, (ii) generating a second prediction block P1 for the current block (if the second piece motion information M1 is signaled) based on the second piece of motion information M1, and (iii) generating the prediction block Pb01 as a weighted combination of prediction block P0 and prediction block P1 based on the weight W1.

[00165] Entry of Motion Information List Associated with One Piece of Motion Information Derived Based on Another Piece of Motion Information

[00166] In some aspects, at least one motion information entry in the motion information list CANDLIST_M1 (e.g., derived in steps 1312 and/or 1314 of the process 1300) associated with the second piece of motion information M1 may be derived based on the first piece of motion information M0 of the current block. That is, in some aspects, the first piece of motion information M0 may be considered during the construction of the motion information list CANDLIST_M1 for deriving the second piece of motion information M1.

[00167] In an example, the first piece of motion information M0 may have the following elements and corresponding values:

RefPicListFlag = 1, which means only L0 is used	
RefPicIdx L0: 1	RefPicIdx L1: -
MV L0: (-5, 6)	MV L1: -

In some aspects, the motion information list CANDLIST_M1 may contain a motion information entry that is derived based on the M0. For instance, in the example of a motion information list CANDLIST_M1 shown below, the motion information with index 0 is derived based on the first piece of motion information M0 having the example elements and corresponding values shown above.

Index	Motion Information	
0	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-5, 6)	MV L1: -
1	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (4, 4)
2	RefPicListFlag = 1	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (1, 2)	MV L1: -

[00168] Similarly, when it is determined that there is a third piece of motion information M2 of the current block being signaled and present in the bitstream, the first piece of motion information M0 and the second piece of motion information M1 may be considered during the construction of the list of motion information candidates CANDLIST_M2 associated with the third piece of motion information M2.

[00169] In an example, the first piece of motion information M0 of the current block may be the same as the example above, and the second piece of motion information M1 may have the following elements and corresponding values:

RefPicListFlag = 2, which means only L1 is used	
RefPicIdx L0: -	RefPicIdx L1: 1
MV L0: -	MV L1: (0, 1)

The list of motion information candidates CANDLIST_M2 may contain one motion information entry that is derived based on the M0 and another motion information entry that is derived based on the M1. As shown in the below example list, the motion information entry with index 0 is derived based on the M0, the motion information entry with index 1 is derived based on the M1.

Index	Motion Information	
0	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-5, 6)	MV L1: -
1	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 1
	MV L0: -	MV L1: (0, 1)
2	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (4, 4)

[00170] Using One or Both Motion Vectors of a Block for Motion Information List Entries

[00171] In some aspects, each motion information list (e.g., derived in steps 1312 and/or 1314 of the process 1300) associated with an additional piece of signaled motion information may be a list of uni-motion information. That is, in some aspects, each motion information entry in the motion information list may contain only one of the L0 and L1 motion vector information. In some uni-motion information aspects, the construction of the motion information list associated with an additional piece of signaled motion information may depend on picture type (e.g., whether the current picture is a low delay picture).

[00172] In an example, there are two previously coded blocks BLK_A and BLK_B, and the motion information list construction process checks the previously coded block in a predefined order: first BLK_A and then BLK_B. When the current picture type is determined to be a non-low delay picture, both motion vectors for L0 and L1 of BLK_A (if both L0 and L1 are available) may be checked before checking the motion vector from the next candidate block BLK_B. When the current picture type is determined to be a low delay picture (i.e., all the reference pictures of the current picture have POC values that are smaller than the current POC), at most one of the motion vectors for L0 and L1 of BLK_A may be checked before checking the motion vector from the next candidate block BLK_B.

[00173] In the example, the motion information from the first decoded block BLK_A may be as follows:

RefPicListFlag = 2 (both L0 and L1 are used)	
RefPicIdx L0: 1	RefPicIdx L1: 0
MV L0: (-5, 6)	MV L1: (4, 4)

In the example, the motion information from a second decoded block BLK_B may be as follows:

RefPicListFlag = 1 (only L0 is used)	
RefPicIdx L0: 1	RefPicIdx L1: -
MV L0: (4, 2)	MV L1: -

In the example, when the current picture type is a non-low delay picture, the decoder 1004 may check both the L0 and L1 motion vectors of BLK_A before checking the motion vector from BLK_B, and a possible list of motion information candidates CANDLIST_M1 may be as follows:

Index	Motion information	
0 (Derived from the L0 of BLK_A)	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-5, 6)	MV L1: -
1 (Derived from the L1 of BLK_A)	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (4, 4)
2 (Derived from BLK_B)	RefPicListFlag = 1	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (4, 2)	MV L1: -

As can be seen from above, the L0 information and L1 information of BLK_A constitute two motion information entries (one with index 0 and the other with index 1) before the motion information entry (with index 2) derived from BLK_B.

[00174] In the example, when the current picture is a low delay picture, the decoder 1004 may check only one of the motion vectors of L0 and L1 from BLK_A before checking the motion vector from BLK_B, and a possible list of motion information candidates CANDLIST_M1 may be as follows:

Index	Motion information	
0 (Derived from the L0 of BLK_A)	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-5, 6)	MV L1: -
1 (Derived from the L0 of BLK_B)	RefPicListFlag = 2	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (4, 2)	MV L1: -
2 (Derived from the L0 of BLK_C)	RefPicListFlag = 1	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (3, 1)	MV L1: -

As can be seen from above, the motion information of BLK_A constitutes only one information entry (e.g., one with index 0 derived from the L0 information of BLK_A) before the motion information entry (with index 1) derived from BLK_B.

[00175] In some alternative aspects, the construction of the motion information list associated with an additional piece of signaled motion information may depend on whether the time direction of the L0 and L1 motion vector from a previously coded block is the same. That is, in some time direction aspects, instead of checking whether the current picture is a non-low delay picture, the time direction of the L0 motion vector of the first block (BLK_A) may be compared with the time direction of the L1 motion vector of the first block (BLK_A).

[00176] In some time direction aspects, the time direction of the L0 motion vector of the first block may be determined by forming the difference between (a) the POC of the L0 picture of the first block, here denoted as POC_L0, and (b) the POC of the current picture, here denoted POC_curr, as $\text{time_dir_L0} = \text{sign}(\text{POC_L0} - \text{POC_curr})$, where $\text{sign}(x)$ returns 1 if $x > 0$ and -1 if $x < 0$. Similarly, in some time direction aspects, the time direction of the L1 motion vector of the first block may be determined by forming the difference between (a) the POC of the L1 picture of the first block, here denoted POC_L1, and (b) the POC of the current picture, POC_curr, as $\text{time_dir_L1} = \text{sign}(\text{POC_L1} - \text{POC_curr})$.

[00177] In some time direction aspects, when time_dir_L0 is not equal to time_dir_L1 , both the L0 and L1 of BLK_A may be checked before checking the motion vector from BLK_B, and a possible list of motion information candidates CANDLIST_M1 may be as follows:

Index	Motion information	
0 (Derived from the L0 of BLK_A)	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-5, 6)	MV L1: -
1 (Derived from the L1 of BLK_A)	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (4, 4)
2 (Derived from BLK_B)	RefPicListFlag = 1	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (4, 2)	MV L1: -

As can be seen from above, when time_dir_L0 is not equal to time_dir_L1 , the L0 information and L1 information of BLK_A may constitute two motion information entries (one with index 0

and the other with index 1) before the motion information entry (with index 2) derived from BLK_B.

[00178] In some time direction aspects, when time_dir_L0 is equal to time_dir_L1, only one of the motion vectors of L0 and L1 from BLK_A may be checked before checking the motion vector from BLK_B, and a possible list of motion information candidates CANDLIST_M1 may be as follows:

Index	Motion information	
0 (Derived from the L0 of BLK_A)	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (-5, 6)	MV L1: -
1 (Derived from the L0 of BLK_B)	RefPicListFlag = 2	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (4, 2)	MV L1: -
2 (Derived from the L0 of BLK_C)	RefPicListFlag = 1	
	RefPicIdx L0: 0	RefPicIdx L1: -
	MV L0: (3, 1)	MV L1: -

As can be seen from above, when time_dir_L0 is equal to time_dir_L1, the motion information of BLK_A may constitute only one information entry (one with index 0, derived from the L0 information of BLK_A) before the motion information entry (with index 1) derived from BLK_B.

[00179] List of Motion Information Candidates Derivation

[00180] In some aspects, the derivation of the list of motion information candidates CANDLIST_M1 (e.g., in steps 1312 and/or 1314 of the process 1300) associated with the second piece of motion information M1 may further include the decoder 1004 (1) determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions, (2) determining a set PRED_SET0 of prediction samples for the same group GROUP_P based on the first piece of motion information M0, (3) for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i, and (4) reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values. In some aspects, determining the associated cost value COST_i may include the decoder 1004 (3a) determining a set CANDPRED_i of prediction samples for the same group GROUP_P based on the motion

information $cand_i$, (3b) determining a set $COMBI_i$ of prediction samples where its prediction sample values are a combination of the prediction sample set $PRED_SET0$ and $CANDPRED_i$ based on the weight $W1$, (3c) comparing the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$, and (3d) determining the cost value $COST_i$ based on a comparison of the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$.

[00181] In some aspects, the entries of the second list of motion information candidates $CANDLIST_M1$ may be reordered in step (4) in ascending cost values. That is, in some aspects, motion information with smaller cost values may be placed in first positions (e.g., with smaller index values) and get prioritized over motion information that have larger cost values.

[00182] Similarly, if the decoder 1004 determines that there is a third piece of motion information $M2$ of the current block being signaled and present in the bitstream (e.g., in step 1304 of the process 1300), the derivation of the list of motion information candidates $CANDLIST_M2$ (e.g., in steps 1312 and/or 1314 of the process 1300) associated with the third piece of motion information $M2$ may further include the decoder 1004 (1) determining a set $RECON_SET$ of reconstruction samples from a group $GROUP_P$ of previously decoded sample positions, (2) determining a set $PRED_SET1$ of prediction samples for the same group $GROUP_P$ based on the first piece of motion information $M0$, the second piece of motion information $M1$, and the first weighting factor $W1$ associated with the second piece of motion information $M1$, (3) for each motion information entry $cand_i$ in the third list of motion information candidates $CANDLIST_M2$, determining an associated cost value $COST_i$, and (4) reordering the motion information entries in the third list of motion information candidates $CANDLIST_M2$ based on the cost values. In some aspects, determining the associated cost value $COST_i$ may include the decoder 1004 (3a) determining a set $CANDPRED_i$ of prediction samples for the same group $GROUP_P$ based on the motion information $cand_i$, (3b) determining a set $COMBI_i$ of prediction samples where its prediction sample values are a combination of the prediction sample set $PRED_SET1$ and $CANDPRED_i$ based on the weighting factor $W2$ associated with the third piece of motion information $M2$, (3c) comparing the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$, and (3d) determining the cost value $COST_i$ based on a comparison of the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$.

[00183] In some aspects, the derivation of RECON_SET may only be done once (e.g., during the derivation of CAND_LIST1 and not during the derivation of CAND_LIST2), and the decoder 1004 reuses the RECON_SET when deriving the possible additional piece of motion information of the current block (for example, M2, M3 if present).

[00184] In some aspects, the group GROUP_P of previously decoded sample positions may be the positions that are in the current picture or previously decoded pictures. In some aspects, the positions of the group GROUP_P of previously decoded sample positions may be spatially neighboring to the current block. FIGS. 14 and 15 illustrate examples of the group GROUP_P of previously decoded sample positions according to some aspects. In some aspects, as shown in FIGS. 14 and 15, the GROUP_P may include the spatial neighboring sample positions (marked with circles) that are above and to the left of the current block. In FIGS. 14 and 15, the number of above samples in the horizontal direction is denoted as tpW_A , and the number of above samples in the vertical direction is denoted as tpH_A . In FIGS. 14 and 15, the number of left samples in the horizontal direction is denoted as tpW_L , and the number of left samples in the vertical direction is denoted as tpH_L .

[00185] In some aspects, as shown in FIG. 14, the number of above samples in horizontal direction tpW_A may equal the width $curW$ of the current block, and/or the number of left samples in vertical direction tpH_L may equal the height $curH$ of the current block. In some aspects, as shown in FIG. 14, the number of above samples in vertical direction tpH_A may be equal to, for example and without limitation, 4, and/or the number of left samples in the horizontal direction may be equal to, for example and without limitation, 4.

[00186] In some alternative aspects, as shown in FIG. 15, the number of above samples in the horizontal direction tpW_A may be greater than the width $curW$ of the current block, and/or the number of left samples in the vertical direction tpH_L may be greater than the height $curH$ of the current block. For example, in some alternative aspects, as shown in FIG. 15, tpW_A may be equal to $curW + 4$, and/or tpH_L may be equal to $curH + 4$. In some aspects, usage of more above and/or left samples may help to avoid prioritizing motion information that corresponds to a local minimum.

[00187] In some aspects, the determination of the set PRED_SET0 of prediction samples (based on the first piece of motion information M0) for the group GROUP_P may involve: (1) determining boundary subblocks' motion information of the current block based on the first piece of motion information M0, (2) dividing the sample position group GROUP_P into subgroups that are each associated with a boundary subblock's motion information, and (3) for each subgroup in GROUP_P, generating its corresponding prediction samples for the subgroup based on the associated boundary subblock's motion information. In some aspects, the set PRED_SET0 may include the prediction samples from all the subgroups. In some aspects, the subgroups may be associated with its closest (in terms of sample position distance) boundary subblock's motion information.

[00188] FIG. 16 shows an example in which a current block contains four subblocks (Sub0, Sub1, Sub2 and Sub3), and each subblock of the current block maintains its own motion information. As shown in FIG. 16, the subblocks Sub0, Sub1, and Sub2 are boundary subblocks that are adjacent to either the above boundary or the left boundary of the current block. In some aspects, as shown in FIG. 16, the sample position group GROUP_P may be divided into subgroups: SubGroup0, SubGroup1, SubGroup2 and SubGroup3. In some aspects, each subgroup may be associated with its closest boundary subblock's motion information. For example, as shown by the arrows in FIG. 16, the SubGroup0 and SubGroup2 may be associated with the motion information from the boundary subblock Sub0, the SubGroup1 may be associated with the motion information from the boundary subblock Sub1, and the SubGroup3 may be associated with the motion information from the boundary subblock Sub2.

[00189] In some aspects, the determination of the associated cost value COST_i for each motion information entry cand_i in the second list of motion information candidates CANDLIST_M1 may include the decoder 1004: (1) determining a set of alternative motion information ALTERMI_SET based on the entry cand_i, and (2) determining a cost value ALTERCOST_j for each alternative motion information AMI_j in the set ALTERMI_SET. In some aspects, determining the cost value ALTERCOST_j for each alternative motion information AMI_j in the set ALTERMI_SET may include the decoder 1004: (2A) determining a set ALTERPRED_j of prediction samples for the sample position group GROUP_P based on the alternative motion information AMI_j, (2B) determining a set ALTERCOMBI_j of

prediction samples where its prediction sample values are a combination of the prediction sample set PRED_SET0 and ALTERPRED_j based on the weight W1, and (2C) determining the cost value ALTERCOST_j based on comparing the reconstruction set RECON_SET and the prediction set ALTERCOMBI_j. In some aspects, the determination of the associated cost value COST_i for each motion information entry cand_i in the CANDLIST_M1 may include the decoder 1004 (3) determining the motion information entry cand_i to be the alternative motion information that has the smallest cost value within the alternative motion information set ALTERMI_SET, and determine the associated cost value COST_i of the entry cand_i as the smallest cost value within the set ALTERMI_SET.

[00190] The table below an example in which second list of motion information candidates CANDLIST_M1 contains two motion information entries after the derivation process of motion information from previously decoded blocks.

Index	Motion information	
0	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (0, 0)	MV L1: -
1	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (4, 4)

[00191] In some aspects, when determining the associated cost value COST_0 for the first motion information entry cand_0 (with index 0), the decoder 1004 may determine a set of alternative motion information ALTERMI_SET based on the cand_0. In some aspects, the alternative motion information set may include the cand_0 and some other motion information that have motion vector (MV) that are slightly different from the MV of cand_0.

[00192] FIG. 17 illustrates the above example. In FIG. 17, MV_L0 corresponds to the L0 MV (0, 0) from cand_0, and the square corresponds to the sample where the MV_L0 is referring to. As shown in FIG. 17, the alternative motion information set may include motion information that contains motion vectors that correspond to the circles in the figure. The slightly different motion vectors may have values like (1, 0), (1, 1), (1, -1), (0, 1), (0, -1), (-1, 0), (-1, 1) and (-1, -1). That is, in some aspects, the alternative motion information set may include motion information that

contains neighboring motion vectors to the motion vector from the initial motion information cand_0.

[00193] In some aspects, the decoder 1004 may calculate, for each motion information in the alternative motion set, a cost value. In FIG. 17, the motion information that contains motion vector (-1, 1) is indicated by the MV'_L0. In the example, the motion information that contains motion vector (-1, 1) is the one with smallest cost (e.g., 500) within the alternative set ALTERMI_SET. In some aspects, the decoder 1004 may (i) update the motion vector of the motion information entry cand_0 to (-1, 1), as shown below, and (ii) set the cost associated with the entry cand_0 to 500.

Index	Motion information	
0	RefPicListFlag = 1	
	RefPicIdx L0: 1	RefPicIdx L1: -
	MV L0: (0, 0) (-1, 1)	MV L1: -
1	RefPicListFlag = 2	
	RefPicIdx L0: -	RefPicIdx L1: 0
	MV L0: -	MV L1: (4, 4)

[00194] In some aspects, when determining the associated cost value COST_1 for the motion information entry cand_1 (with index 1), its corresponding alternative motion information ALTERMI_SET may similarly include motion information that have motion vectors like, for example, (4, 4), (5, 5), (5, 4), (5, 3), (4, 5), (4, 3), (3, 5), (3, 4) and (3, 3).

[00195] In some aspects, the determination of the cost value COST_i based on comparing the reconstruction set RECON_SET and the prediction set COMBI_i may include the decoder 1004: (1) determining a cost value Ci for each sample position in the GROUP_P, (2) determining a cost weighting factor cWi for the sample position, and (3) determining the cost value COST_i as a sum of Ci * cWi.

[00196] In some aspects, the decoder 1004 may assign some of the sample positions with different cost weighting factors than the other sample positions. In some aspects, the decoder 1004 may additionally or alternatively assign sample positions that are closer to the current block boundary with higher cost weighting factor than the sample positions that are further away from the current block boundary. For example, in some aspects, the sample positions that are closer to the current block boundary may be assigned with a cost weighting factor cWi = 2, and the

sample positions that are further away from the current block boundary may be assigned with a cost weighting factor $cW_i = 1$. In some aspects, for the sample positions that are closer to the current block, their corresponding sample values are likely to have higher correlation with the sample values of the current block. Therefore, prioritizing those sample positions may help prioritizing motion information that is more suitable for the current block.

[00197] Refined Candidate Motion Information

[00198] In some aspects (e.g., any of the aspects described above), the decoder 1004 may obtain a first prediction of the current block using a first motion information (e.g., bi-prediction or from a first MHP). In some aspects, the decoder 1004 may then refine a second motion information for a MHP based on motion estimation (ME) using a second motion information to derive a second prediction of the current block that minimizes the difference to the first prediction of the current block. In some aspects, the decoder 1004 may replace the candidate second motion information with the refined candidate motion information. In some alternative aspects, the refined candidate motion information may be an additional candidate of second motion information.

[00199] In some aspects, the motion estimation (e.g., motion search) may search for a motion vector that minimizes a difference between a first block and a second block. In some aspects, the search may be done within a window (or region). Traditionally, the first block is the current block, and the second block is a reference prediction block. However, in some aspects, the first block may be the prediction block generated from M0, and the second block may be a prediction block generated from a possible M1. That is, in some aspects, for a second piece of motion information M1, the decoder 1004 may do a search (e.g., in a window around the motion vector/information M1) to find another possible motion information M1_refined in the window that gives a more similar prediction block to the first prediction block. If so, the M1 may be determined to be (replaced) the M1_refined.

[00200] In some sub-block aspects, the decoder 1004 may obtain a first prediction of a sub-block of the current block using a first motion information (e.g. bi-prediction). In some aspects, the decoder 1004 may then refine a second motion information based on ME using a second motion information to derive a second prediction of the sub-block of the current block that

minimizes the difference to the first prediction of the sub-block. In some aspects, the decoder 1004 may replace the second motion information for that sub-block with the refined candidate motion information. In some alternative aspects, the refined candidate motion information may be an additional candidate of second motion information for the sub-block.

[00201] Flowcharts

[00202] FIG. 18 illustrates a process 1800 according to some aspects. In some aspects, the process 1800 may be for decoding a current block within a current picture inside a coded video bitstream. In some aspects, some or all of the steps of the process 1800 may be performed by a decoder 1004.

[00203] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1802 in which the decoder 1004 decodes a first syntax element S0 from a coded video bitstream.

[00204] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1804 in which the decoder 1004 determines a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0.

[00205] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1806 in which the decoder 1004 determines that a second piece of motion information M1 for the current block is signaled in the coded video bitstream.

[00206] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1808 in which the decoder 1004, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determines whether a second syntax element S1 is present in the coded video bitstream. In some aspects, the second syntax element S1 may be a multi-hypothesis prediction (MHP) merge flag.

[00207] In some aspects, determining whether the second syntax element S1 is present in the coded video bitstream in step 1808 may include determining a value V1 based on a fifth syntax element S4 in a parameter set P and comparing the value V1 to a constant value C0 (e.g., 0, 1, or 2). In some aspects, the parameter set P may be a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header. In some aspects, the second syntax element S1 may be determined to be present in the coded video bitstream if the value V1 is

greater than the constant value C0, and the second syntax element S1 may be determined to be not present in the coded video bitstream if the value V1 is not greater than the constant value C0. In some aspects, the value V1 may indicate a maximum length of a motion information list CANDLIST_M1 associated with the second piece of motion information M1.

[00208] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1810 in which the decoder 1004, if the second syntax element S1 is determined to not be present in the coded video bitstream, infers which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1.

[00209] In some aspects, if the value V1 indicates a maximum length for the motion information list CANDLIST_M1 associated with the second piece of motion information M1 that is less than or equal to the constant value C0 (e.g., 0, 1, or 2), the second syntax element S1 may be determined to not be present in the coded video bitstream in step 1808, and explicit signaling may be inferred to be used to signal the second piece of motion information M1 associated with the second piece of motion information M1 in step 1810. In some alternative aspects, the fifth syntax element S4 may indicate whether implicit signaling is disabled, and, if the value V1 indicates that implicit signaling is disabled, the second syntax element S1 may be determined to not be present in the coded video bitstream in step 1808, and explicit signaling may be inferred to be used to signal the second piece of motion information M1 associated with the second piece of motion information M1 in step 1810. In some further alternative aspects, the fifth syntax element S4 may indicate whether explicit signaling is disabled, and, if the value V1 indicates that explicit signaling is disabled, the second syntax element S1 may be determined to not be present in the coded video bitstream in step 1808, and implicit signaling may be inferred to be used to signal the second piece of motion information M1 associated with the second piece of motion information M1 in step 1810.

[00210] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1812 in which the decoder 1004, if the second syntax element S1 is determined to be present in the coded video bitstream, decodes a value for the second syntax element S1 and determines which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1 based on the decoded value of the second syntax element S1.

[00211] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1814 in which the decoder 1004, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decodes a value of a third syntax element S2 from the coded video bitstream, determines a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derives the second piece of motion information M1 based on the decoded value of the third syntax element S2. In some aspects, the third syntax element S2 may be a motion information index. In some aspects, deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 in step 1814 may include: deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, deriving an index value IDX based on the value of the third syntax element S2, and determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX.

[00212] In some aspects, the process 1800 may further include determining whether the current picture is a low delay picture, and deriving the motion information list CANDLIST_M1 in step 1814 may be based on whether the current picture is determined to be a low delay picture. In some aspects, the motion information list CANDLIST_M1 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the current picture is determined to be a low delay picture, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the current picture is determined to not be a low delay picture.

[00213] In some aspects, the process 1800 may further include determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction, and deriving the motion information list CANDLIST_M1 in step 1814 may be based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction. In some aspects, the motion information list CANDLIST_M1 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the

first previously coded block BLK_A are determined to be in the same time direction, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to not be in the same time direction. In some aspects, determining whether the L0 and L1 motion vectors of the previously coded block are in the same time direction may include: determining the time direction of the L0 motion vector of the previously coded block, determining the time direction of the L1 motion vector of the previously coded block, and determining whether the time directions of the L0 and L1 motion vectors of the previously coded block are the same. In some aspects, determining the time direction of the L0 motion vector of the previously coded block may include comparing a picture order count (POC) value of an L0 picture of the previously coded block with a POC value of the current picture (e.g., $\text{time_dir_L0} = \text{sign}(\text{POC_L0} - \text{POC_curr})$ where POC_L0 is the POC of the L0 picture of the previously coded block, POC_curr is the POC of the current picture, and $\text{sign}(x)$ returns 1 if $x > 0$ and -1 if $x < 0$.), and determining the time direction of the L1 motion vector of the previously coded block may include comparing a POC value of an L1 picture of the previously coded block with the POC value of the current picture (e.g., $\text{time_dir_L1} = \text{sign}(\text{POC_L1} - \text{POC_curr})$ where POC_L1 is the POC of the L0 picture of the previously coded block).

[00214] In some aspects, deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 in step 1814 may include: (i) determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions; (ii) determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0; (iii) for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and (iv) reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values. In some aspects, determining the associated cost value COST_i for the motion information entry cand_i may include: (i) determining a set CANDPRED_i of prediction samples for the group GROUP_P

based on the motion information $cand_i$; (ii) determining a set $COMBI_i$ of prediction samples including prediction sample values that are a combination of the prediction sample set $PRED_SET0$ and the prediction sample set $CANDPRED_i$ based on the weight $W1$; (iii) comparing the reconstruction set $RECON_SET$ and the prediction sample set $COMBI_i$; and (iv) determining the cost value $COST_i$ based on a comparison of the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$. In some aspects, reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ based on the cost values may include reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ to have ascending cost values.

[00215] In some aspects, the group $GROUP_P$ of previously decoded sample positions may be sample positions in the current picture and/or one or more previously decoded pictures. In some aspects, as shown in FIGS. 14 and 15, the $GROUP_P$ of previously decoded sample positions may be sample positions that are spatially neighboring to the current block. In some aspects, as shown in FIGS. 14 and 15, the $GROUP_P$ of previously decoded sample positions may be sample positions that are above the current block and/or to the left of the current block. In some aspects, as shown in FIGS. 14 and 15, a width tpW_A of the sample positions of the $GROUP_P$ of previously decoded sample positions that are above the current block in a horizontal direction may equal or be greater than a width $curW$ of the current block, and a height tpH_L of the sample positions of the $GROUP_P$ of previously decoded sample positions that are to the left of the current block in a vertical direction may equal or be greater than a height $curH$ of the current block.

[00216] In some aspects, as shown in FIG. 16, determining the set $PRED_SET0$ of prediction samples for the group $GROUP_P$ may include: (i) determining motion information of boundary subblocks of the current block based on the first piece of motion information $M0$; (ii) dividing the sample position group $GROUP_P$ into subgroups that are each associated with motion information of a boundary subblock; and (iii) for each subgroup in $GROUP_P$, generating corresponding prediction samples for the subgroup based on the associated motion information of the boundary subblock. In some aspects, the determined set $PRED_SET0$ includes the prediction samples from all the subgroups.

[00217] In some aspects, determining an associated cost value $COST_i$ for a motion information entry $cand_i$ in the list of motion information candidates $CANDLIST_M1$ in step 1814 may include: (i) determining a set of alternative motion information $ALTERMI_SET$ based on the entry $cand_i$; (ii) determining a cost value $ALTERCOST_j$ for each alternative motion information AMI_j in the set $ALTERMI_SET$; (iii) determining the motion information entry $cand_i$ to be the alternative motion information that has the smallest cost value within the alternative motion information set $ALTERMI_SET$; and (iv) determining the associated cost value $COST_i$ of the entry $cand_i$ as the smallest cost value within the set $ALTERMI_SET$. In some aspects, determining the cost value $ALTERCOST_j$ for an alternative motion information AMI_j in the set $ALTERMI_SET$ may include: (i) determining a set $ALTERPRED_j$ of prediction samples for the sample position group $GROUP_P$ based on the alternative motion information AMI_j ; (ii) determining a set $ALTERCOMBI_j$ of prediction samples that is a combination of the prediction sample set $PRED_SET0$ and $ALTERPRED_j$ based on the weight $W1$; and (iii) determining the cost value $ALTERCOST_j$ based on comparing the reconstruction set $RECON_SET$ and the prediction set $ALTERCOMBI_j$.

[00218] In some aspects, determining the associated cost value $COST_i$ for the motion information entry $cand_i$ in step 1814 may include: (i) for each sample position in the group $GROUP_P$, determining a cost value C_i for the sample position and a cost weighting factor cW_i for the sample position; and (ii) determining the cost value $COST_i$ as a sum of $C_i * cW_i$ for the sample positions in the group $GROUP_P$. In some aspects, a cost weighting factor (e.g., $cW_i = 2$) determined for sample positions that are closer to a boundary of the current block may be higher than a cost weighting factor (e.g., $cW_i = 1$) determined for sample positions that are further away from a boundary of the current block.

[00219] In some aspects, deriving the motion information list $CANDLIST_M1$ associated with the second piece of motion information $M1$ in step 1814 may include: (i) for each motion information entry $cand_i$ in the motion information list $CANDLIST_M1$, finding a refined motion information $refinedCand_i$ based on motion estimation that generates a prediction block that minimizes a difference with the first prediction block $P0$ for the current block; and (ii) determining the motion information entry $cand_i$ to be the refined motion information $refinedCand_i$.

[00220] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1816 in which the decoder 1004, if explicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decodes a value of a fourth syntax element S3 from the coded video bitstream, determines the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determines the second piece of motion information M1 based on the decoded value of the fourth syntax element S3. In some aspects, determining the second piece of motion information M1 based on the value of the fourth syntax element S3 in step 1816 may include determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

[00221] In some aspects, at least one motion information entry in the motion information list CANDLIST_M1 associated with the second piece of motion information M1 may be derived in step 1814 or 1816 based on the first piece of motion information M0 of the current block.

[00222] In some aspects, as shown in FIG. 18, the process 1800 may include a step 1818 in which the decoder 1004 generates a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1. In some aspects, generating the prediction block Pb01 for the current block in step 1818 may include: (i) generating a first prediction block P0 for the current block based on the first piece of motion information M0; (ii) generating a second prediction block P1 for the current block based on the second piece of motion information M1; and (iii) generating the prediction block Pb01 as a weighted combination of the first and second prediction blocks P0 and P1 based on the weight factor W1. In some aspects, generating the second prediction block P1 for the current block based on the second piece of motion information M1 may include: (i) refining the second piece of motion information M1 based on motion estimation such that the refined second piece of motion information M1 generates a prediction block for the current block that minimizes a difference with the first prediction block P0 for the current block; and (ii) using the refined second piece of motion information M1 to generate the second prediction block P1 for the current block.

[00223] FIG. 19 illustrates a process 1900 according to some aspects. In some aspects, the process 1900 may be for decoding a current block within a current picture inside a coded video

bitstream. In some aspects, some or all of the steps of the process 1900 may be performed by a decoder 1004.

[00224] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1902 in which the decoder 1004 decodes a first syntax element S0 from a coded video bitstream.

[00225] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1904 in which the decoder 1004 determines a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0.

[00226] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1906 in which the decoder 1004 determines that a second piece of motion information M1 for the current block is signaled in the coded video bitstream.

[00227] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1908 in which the decoder 1004, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determines that a second syntax element S1 is not present in the coded video bitstream. In some aspects, the second syntax element S1 may be a multi-hypothesis prediction (MHP) merge flag.

[00228] In some aspects, determining that the second syntax element S1 is not present in the coded video bitstream in step 1908 may include determining a value V1 based on a fifth syntax element S4 in a parameter set P and comparing the value V1 to a constant value C0 (e.g., 0, 1, or 2). In some aspects, the parameter set P may be a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header. In some aspects, the second syntax element S1 may be determined to be not present in the coded video bitstream if the value V1 is not greater than the constant value C0. In some aspects, the value V1 may indicate a maximum length of a motion information list CANDLIST_M1 associated with the second piece of motion information M1. In some aspects, the value V1 may indicate a maximum length for the motion information list CANDLIST_M1 associated with the second piece of motion information M1 that is less than or equal to the constant value C0 (e.g., 0, 1, or 2). In some alternative aspects, the fifth syntax element S4 may indicate whether implicit signaling is disabled, and, if the value V1 based on the fifth syntax element S4 indicates that implicit signaling is disabled, the second syntax element S1 may be determined to not be present in the coded video bitstream.

[00229] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1910 in which the decoder 1004, if the second syntax element S1 is determined to not be present in the coded video bitstream, infers that explicit signaling is used to signal the second piece of motion information M1.

[00230] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1912 in which the decoder 1004, if explicit signaling is inferred to be used to signal the second piece of motion information M1, decodes a value of a fourth syntax element S3 from the coded video bitstream, determines the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determines the second piece of motion information M1 based on the decoded value of the fourth syntax element S3. In some aspects, determining the second piece of motion information M1 based on the value of the fourth syntax element S3 in step 1912 may include determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

[00231] In some aspects, as shown in FIG. 19, the process 1900 may include a step 1914 in which the decoder 1004 generates a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00232] FIG. 20 illustrates a process 2000 according to some aspects. In some aspects, the process 2000 may be for decoding a current block within a current picture inside a coded video bitstream. In some aspects, some or all of the steps of the process 2000 may be performed by a decoder 1004.

[00233] In some aspects, as shown in FIG. 20, the process 2000 may include a step 2002 in which the decoder 1004 decodes a first syntax element S0 from a coded video bitstream.

[00234] In some aspects, as shown in FIG. 20, the process 2000 may include a step 2004 in which the decoder 1004 determines a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0.

[00235] In some aspects, as shown in FIG. 20, the process 2000 may include a step 2006 in which the decoder 1004 determines that a second piece of motion information M1 for the current block is signaled in the coded video bitstream.

[00236] In some aspects, as shown in FIG. 20, the process 2000 may include a step 2008 in which the decoder 1004, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infers (e.g., if the second syntax element S1 is not present in the coded video bitstream) or determines (e.g., if the second syntax element S1 is present in the coded video bitstream) that implicit signaling is used to signal the second piece of motion information M1.

[00237] In some aspects, as shown in FIG. 20, the process 2000 may include a step 2010 in which the decoder 1004, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decodes a value of a third syntax element S2 from the coded video bitstream, determines a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derives the second piece of motion information M1 based on the decoded value of the third syntax element S2. In some aspects, deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include: (i) determining whether the current picture is a low delay picture, (ii) deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, (iii) deriving an index value IDX based on the value of the third syntax element S2, and (iv) determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. Deriving the motion information list CANDLIST_M1 may be based on whether the current picture is determined to be a low delay picture.

[00238] In some aspects, the motion information list CANDLIST_M1 derived in step 2010 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the current picture is determined to be a low delay picture, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of

a second previously coded block BLK_B if the current picture is determined to not be a low delay picture.

[00239] In some aspects, as shown in FIG. 20, the process 2000 may include a step 2012 in which the decoder 1004 generates a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00240] FIG. 21 illustrates a process 2100 according to some aspects. In some aspects, the process 2100 may be for decoding a current block within a current picture inside a coded video bitstream. In some aspects, some or all of the steps of the process 2100 may be performed by a decoder 1004.

[00241] In some aspects, as shown in FIG. 21, the process 2100 may include a step 2102 in which the decoder 1004 decodes a first syntax element S0 from a coded video bitstream.

[00242] In some aspects, as shown in FIG. 21, the process 2100 may include a step 2104 in which the decoder 1004 determines a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0.

[00243] In some aspects, as shown in FIG. 21, the process 2100 may include a step 2106 in which the decoder 1004 determines that a second piece of motion information M1 for the current block is signaled in the coded video bitstream.

[00244] In some aspects, as shown in FIG. 21, the process 2100 may include a step 2108 in which the decoder 1004, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infers or determines that implicit signaling is used to signal the second piece of motion information M1.

[00245] In some aspects, as shown in FIG. 21, the process 2100 may include a step 2110 in which the decoder 1004, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decodes a value of a third syntax element S2 from the coded video bitstream, determines a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derives the second piece of motion information M1 based on the decoded value of the third syntax element S2. Deriving the second

piece of motion information M1 based on the decoded value of the third syntax element S2 may include: (i) determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction; (ii) deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1; (iii) deriving an index value IDX based on the value of the third syntax element S2; and (iv) determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX. In some aspects, deriving the motion information list CANDLIST_M1 may be based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction.

[00246] In some aspects, the motion information list CANDLIST_M1 derived in step 2110 may include only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to be in the same time direction, and the motion information list CANDLIST_M1 may include both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to not be in the same time direction.

[00247] In some aspects, determining whether the L0 and L1 motion vectors of the previously coded block are in the same time direction in step 2110 may include: (i) determining the time direction of the L0 motion vector of the previously coded block; (ii) determining the time direction of the L1 motion vector of the previously coded block; and (iii) determining whether the time directions of the L0 and L1 motion vectors of the previously coded block are the same. In some aspects, determining the time direction of the L0 motion vector of the previously coded block may include comparing a picture order count (POC) value of an L0 picture of the previously coded block with a POC value of the current picture (e.g., $\text{time_dir_L0} = \text{sign}(\text{POC_L0} - \text{POC_curr})$ where POC_L0 is the POC of the L0 picture of the previously coded block, POC_curr is the POC of the current picture, and $\text{sign}(x)$ returns 1 if $x > 0$ and -1 if $x < 0$), and determining the time direction of the L1 motion vector of the previously coded block may include comparing a POC value of an L1 picture of the previously coded block with the POC

value of the current picture (e.g., $\text{time_dir_L1} = \text{sign}(\text{POC_L1} - \text{POC_curr})$ where POC_L1 is the POC of the L0 picture of the previously coded block).

[00248] In some aspects, as shown in FIG. 21, the process 2100 may include a step 2112 in which the decoder 1004 generates a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00249] FIG. 22 illustrates a process 2200 according to some aspects. In some aspects, the process 2200 may be for decoding a current block within a current picture inside a coded video bitstream. In some aspects, some or all of the steps of the process 2200 may be performed by a decoder 1004.

[00250] In some aspects, as shown in FIG. 22, the process 2200 may include a step 2202 in which the decoder 1004 decodes a first syntax element S0 from a coded video bitstream.

[00251] In some aspects, as shown in FIG. 22, the process 2200 may include a step 2204 in which the decoder 1004 determines a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0.

[00252] In some aspects, as shown in FIG. 22, the process 2200 may include a step 2206 in which the decoder 1004 determines that a second piece of motion information M1 for the current block is signaled in the coded video bitstream.

[00253] In some aspects, as shown in FIG. 22, the process 2200 may include a step 2208 in which the decoder 1004, if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infers or determines that implicit signaling is used to signal the second piece of motion information M1.

[00254] In some aspects, as shown in FIG. 22, the process 2200 may include a step 2210 in which the decoder 1004, if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decodes a value of a third syntax element S2 from the coded video bitstream, determines a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derives the second piece of motion information M1 based on the decoded value of the third syntax element S2. In some aspects,

deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may include deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1. In some aspects, deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 may include: (i) determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions; (ii) determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0; (iii) for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and (iv) reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values. In some aspects, deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 may further include deriving an index value IDX based on the value of the third syntax element S2 and determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX.

[00255] In some aspects, determining the associated cost value COST_i for the motion information entry cand_i in step 2210 may include: (i) determining a set CANDPRED_i of prediction samples for the group GROUP_P based on the motion information cand_i; (ii) determining a set COMBI_i of prediction samples including prediction sample values that are a combination of the prediction sample set PRED_SET0 and the prediction sample set CANDPRED_i based on the weight W1; (iii) comparing the reconstruction set RECON_SET and the prediction sample set COMBI_i; and (iv) determining the cost value COST_i based on a comparison of the reconstruction set RECON_SET and the prediction set COMBI_i. In some aspects, reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values in step 2210 may include reordering the motion information entries in the list of motion information candidates CANDLIST_M1 to have ascending cost values.

[00256] In some aspects, the group GROUP_P of previously decoded sample positions may be sample positions in the current picture and/or one or more previously decoded pictures. In some aspects, as shown in FIGS. 14 and 15, the GROUP_P of previously decoded sample

positions may be sample positions that are spatially neighboring to the current block. In some aspects, as shown in FIGS. 14 and 15, the GROUP_P of previously decoded sample positions may be sample positions that are above the current block and/or to the left of the current block. In some aspects, as shown in FIGS. 14 and 15, a width tpW_A of the sample positions of the GROUP_P of previously decoded sample positions that are above the current block in a horizontal direction may equal or be greater than a width curW of the current block, and a height tpH_L of the sample positions of the GROUP_P of previously decoded sample positions that are to the left of the current block in a vertical direction may equal or be greater than a height curH of the current block.

[00257] In some aspects, as shown in FIG. 16, determining the set PRED_SET0 of prediction samples for the group GROUP_P may include: (i) determining motion information of boundary subblocks of the current block based on the first piece of motion information M0; (ii) dividing the sample position group GROUP_P into subgroups that are each associated with motion information of a boundary subblock; and (iii) for each subgroup in GROUP_P, generating corresponding prediction samples for the subgroup based on the associated motion information of the boundary subblock. In some aspects, the determined set PRED_SET0 includes the prediction samples from all the subgroups.

[00258] In some aspects, determining an associated cost value COST_i for a motion information entry cand_i in the list of motion information candidates CANDLIST_M1 in step 2210 may include: (i) determining a set of alternative motion information ALTERMI_SET based on the entry cand_i; (ii) determining a cost value ALTERCOST_j for each alternative motion information AMI_j in the set ALTERMI_SET; (iii) determining the motion information entry cand_i to be the alternative motion information that has the smallest cost value within the alternative motion information set ALTERMI_SET; and (iv) determining the associated cost value COST_i of the entry cand_i as the smallest cost value within the set ALTERMI_SET. In some aspects, determining the cost value ALTERCOST_j for an alternative motion information AMI_j in the set ALTERMI_SET may include: (i) determining a set ALTERPRED_j of prediction samples for the sample position group GROUP_P based on the alternative motion information AMI_j; (ii) determining a set ALTERCOMBI_j of prediction samples that is a combination of the prediction sample set PRED_SET0 and ALTERPRED_j based on the weight

W1; and (iii) determining the cost value ALTERCOST_j based on comparing the reconstruction set RECON_SET and the prediction set ALTERCOMBI_j.

[00259] In some aspects, determining the associated cost value COST_i for the motion information entry cand_i in step 2210 may include: (i) for each sample position in the group GROUP_P, determining a cost value C_i for the sample position and a cost weighting factor cW_i for the sample position; and (ii) determining the cost value COST_i as a sum of C_i * cW_i for the sample positions in the group GROUP_P. In some aspects, a cost weighting factor (e.g., cW_i = 2) determined for sample positions that are closer to a boundary of the current block may be higher than a cost weighting factor (e.g., cW_i = 1) determined for sample positions that are further away from a boundary of the current block.

[00260] In some aspects, as shown in FIG. 22, the process 2200 may include a step 2212 in which the decoder 1004 generates a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

[00261] FIG. 23 is a block diagram of an apparatus 2301 for implementing the encoder 1002 or the decoder 1004 according to some aspects. That is, apparatus 2301 can be adapted to perform the methods disclosed herein. In aspects where the apparatus 2301 implements the encoder 1002, the apparatus 2301 may be referred to as “encoding apparatus 2301,” and, in aspects where the apparatus 2301 implements the decoder 1004, the apparatus 2301 may be referred to as a “decoding apparatus 2301.” As shown in FIG. 23, the apparatus 2301 may comprise: processing circuitry (PC) 2302, which may include one or more processors (P) 2355 (e.g., a general purpose microprocessor and/or one or more other processors, such as an application specific integrated circuit (ASIC), field-programmable gate arrays (FPGAs), and the like), which processors may be co-located in a single housing or in a single data center or may be geographically distributed (i.e., apparatus 2301 may be a distributed computing apparatus); at least one network interface 2348 comprising a transmitter (Tx) 2345 and a receiver (Rx) 2347 for enabling apparatus 2301 to transmit data to and receive data from other nodes connected to a network 1010 (e.g., an Internet Protocol (IP) network) to which network interface 2348 is connected (directly or indirectly) (e.g., network interface 2348 may be wirelessly connected to the network 1010, in which case network interface 2348 is connected to an antenna

arrangement); and/or a storage unit (a.k.a., “data storage system”) 2308, which may include one or more non-volatile storage devices and/or one or more volatile storage devices. In aspects where PC 2302 includes a programmable processor, a computer program product (CPP) 2341 may be provided. In some aspects, the CPP 2341 may include a computer readable medium (CRM) 2342 storing a computer program (CP) 2343 comprising computer readable instructions (CRI) 2344. The CRM 2342 may be a non-transitory computer readable medium, such as, magnetic media (e.g., a hard disk), optical media, memory devices (e.g., random access memory, flash memory), and the like. In some aspects, the CRI 2344 of computer program 2343 is configured such that when executed by PC 2302, the CRI causes apparatus 2301 to perform steps described herein (e.g., steps described herein with reference to the flow charts of FIGS. 18-22). In some other aspects, the apparatus 2301 may be configured to perform steps described herein without the need for code. That is, for example, PC 2302 may consist merely of one or more ASICs. Hence, the features of the embodiments described herein may be implemented in hardware and/or software.

[00262] Embodiments

A1. A method (1800) for processing (e.g., decoding) a current block within a current picture, the method comprising:

 decoding a first syntax element S0 from a coded video bitstream;

 determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

 determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

 if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determining whether a second syntax element S1 is present in the coded video bitstream;

 if the second syntax element S1 is determined to not be present in the coded video bitstream, inferring which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1;

 if the second syntax element S1 is determined to be present in the coded video bitstream, decoding a value for the second syntax element S1 and determining which one of implicit

signaling and explicit signaling is used to signal the second piece of motion information M1 based on the decoded value of the second syntax element S1;

if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2;

if explicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a fourth syntax element S3 from the coded video bitstream, determining the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determining the second piece of motion information M1 based on the decoded value of the fourth syntax element S3; and

generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

A2. The method of embodiment A1, wherein the second syntax element S1 is a multi-hypothesis prediction (MHP) merge flag.

A3. The method of embodiment A1 or A2, wherein the third syntax element S2 is a motion information index.

A4. The method of any one of embodiments A1-A3, wherein determining whether the second syntax element S1 is present in the coded video bitstream comprises:

determining a value V1 based on a fifth syntax element S4 in a parameter set P; and
comparing the value V1 to a constant value C0 (e.g., 0, 1, or 2).

A5. The method of embodiment A4, wherein the parameter set P is a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header.

A6. The method of embodiment A4 or A5, wherein the second syntax element S1 is determined to be present in the coded video bitstream if the value V1 is greater than the constant value C0, and the second syntax element S1 is determined to be not present in the coded video bitstream if the value V1 is not greater than the constant value C0.

A7. The method of any one of embodiments A4-A6, wherein the value V1 indicates a maximum length of a motion information list CANDLIST_M1 associated with the second piece of motion information M1.

A8. The method of embodiments A7, wherein, if the value V1 indicates a maximum length of 0 for the motion information list CANDLIST_M1 associated with the second piece of motion information M1, the second syntax element S1 is determined to not be present in the coded video bitstream, and explicit signaling is inferred to be used to signal the second piece of motion information M1 associated with the second piece of motion information M1.

A9. The method of any one of embodiments A1-A8, wherein determining the second piece of motion information M1 based on the value of the fourth syntax element S3 includes determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

A10. The method of any one of embodiments A1-A9, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:
 deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1;
 deriving an index value IDX based on the value of the third syntax element S2; and
 determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX.

A11. The method of embodiment A10, wherein at least one motion information entry in the motion information list CANDLIST_M1 associated with the second piece of motion information M1 is derived based on the first piece of motion information M0 of the current block.

A12. The method of embodiment A10 or A11, further comprising determining whether the current picture is a low delay picture, wherein deriving the motion information list CANDLIST_M1 is based on whether the current picture is determined to be a low delay picture.

A13. The method of embodiment A12, wherein the motion information list CANDLIST_M1 includes only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the current picture is determined to be a low delay picture, and the motion information list CANDLIST_M1 includes both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the current picture is determined to not be a low delay picture.

A14. The method of embodiment A10 or A11, further comprising determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction, wherein deriving the motion information list CANDLIST_M1 is based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction.

A15. The method of embodiment A14, wherein the motion information list CANDLIST_M1 includes only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the previously coded block are determined to be in the same time direction, and the motion information list CANDLIST_M1 includes both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an

entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to not be in the same time direction.

A16. The method of embodiment A14 or A15, wherein determining whether the L0 and L1 motion vectors of the previously coded block are in the same time direction comprises:

- determining the time direction of the L0 motion vector of the previously coded block;
- determining the time direction of the L1 motion vector of the previously coded block; and
- determining whether the time directions of the L0 and L1 motion vectors of the previously coded block are the same.

A17. The method of embodiment A16, wherein determining the time direction of the L0 motion vector of the previously coded block comprises comparing a picture order count (POC) value of an L0 picture of the previously coded block with a POC value of the current picture, and determining the time direction of the L1 motion vector of the previously coded block comprises comparing a POC value of an L1 picture of the previously coded block with the POC value of the current picture.

A18. The method of any one of embodiments A10-A17, wherein deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 comprises:

- determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions;
- determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0;
- for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and
- reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values.

A19. The method of embodiment A18, determining the associated cost value $COST_i$ for the motion information entry $cand_i$ comprises:

determining a set $CANDPRED_i$ of prediction samples for the group $GROUP_P$ based on the motion information $cand_i$;

determining a set $COMBI_i$ of prediction samples including prediction sample values that are a combination of the prediction sample set $PRED_SET0$ and the prediction sample set $CANDPRED_i$ based on the weight $W1$;

comparing the reconstruction set $RECON_SET$ and the prediction sample set $COMBI_i$; and

determining the cost value $COST_i$ based on a comparison of the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$.

A20. The method of embodiment A18 or A19, wherein reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ based on the cost values comprises reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ to have ascending cost values.

A21. The method of any one of embodiments A18-A20, wherein the group $GROUP_P$ of previously decoded sample positions are sample positions in the current picture and/or one or more previously decoded pictures.

A22. The method of any one of embodiments A18-A21, wherein the $GROUP_P$ of previously decoded sample positions are sample positions that are spatially neighboring to the current block.

A23. The method of any one of embodiments A18-A22, wherein the $GROUP_P$ of previously decoded sample positions are sample positions that are above the current block and/or to the left of the current block.

A24. The method of embodiment A23, wherein a width tpW_A of the sample positions of the $GROUP_P$ of previously decoded sample positions that are above the current block in a

horizontal direction equals or is greater than a width $curW$ of the current block, and a height tpH_L of the sample positions of the $GROUP_P$ of previously decoded sample positions that are to the left of the current block in a vertical direction equals or is greater than a height $curH$ of the current block.

A25. The method of any one of embodiments A18-A24, wherein determining the set $PRED_SET0$ of prediction samples for the group $GROUP_P$ comprises:

- determining motion information of boundary subblocks of the current block based on the first piece of motion information $M0$;

- dividing the sample position group $GROUP_P$ into subgroups that are each associated with motion information of a boundary subblock; and

- for each subgroup in $GROUP_P$, generating corresponding prediction samples for the subgroup based on the associated motion information of the boundary subblock, wherein the determined set $PRED_SET0$ includes the prediction samples from all the subgroups.

A26. The method of any one of embodiments A18-A25, wherein determining an associated cost value $COST_i$ for a motion information entry $cand_i$ in the list of motion information candidates $CANDLIST_M1$ comprises:

- determining a set of alternative motion information $ALTERMI_SET$ based on the entry $cand_i$;

- determining a cost value $ALTERCOST_j$ for each alternative motion information AMI_j in the set $ALTERMI_SET$;

- determining the motion information entry $cand_i$ to be the alternative motion information that has the smallest cost value within the alternative motion information set $ALTERMI_SET$;
- and

- determining the associated cost value $COST_i$ of the entry $cand_i$ as the smallest cost value within the set $ALTERMI_SET$.

A27. The method of embodiment A26, wherein determining the cost value $ALTERCOST_j$ for an alternative motion information AMI_j in the set $ALTERMI_SET$ comprises:

determining a set ALTERPRED_j of prediction samples for the sample position group GROUP_P based on the alternative motion information AMI_j;

determining a set ALTERCOMBI_j of prediction samples that is a combination of the prediction sample set PRED_SET0 and ALTERPRED_j based on the weight W1; and

determining the cost value ALTERCOST_j based on comparing the reconstruction set RECON_SET and the prediction set ALTERCOMBI_j.

A28. The method of any one of embodiments A18-A27, wherein determining the associated cost value COST_i for the motion information entry cand_i comprises:

for each sample position in the group GROUP_P, determining a cost value C_i for the sample position and a cost weighting factor cW_i for the sample position; and

determining the cost value COST_i as a sum of C_i * cW_i for the sample positions in the group GROUP_P.

A29. The method of embodiment A28, wherein a cost weighting factor (e.g., cW_i = 2) determined for sample positions that are closer to a boundary of the current block is higher than a cost weighting factor (e.g., cW_i = 1) determined for sample positions that are further away from a boundary of the current block.

A30. The method of any one of embodiments A1-A29, wherein generating the prediction block Pb01 for the current block comprises:

generating a first prediction block P0 for the current block based on the first piece of motion information M0;

generating a second prediction block P1 for the current block based on the second piece of motion information M1; and

generating the prediction block Pb01 as a weighted combination of the first and second prediction blocks P0 and P1 based on the weight factor W1.

A31. The method of embodiment A30, wherein generating the second prediction block P1 for the current block based on the second piece of motion information M1 comprises:

refining the second piece of motion information M1 based on motion estimation such that the refined second piece of motion information M1 generates a prediction block for the current block that minimizes a difference with the first prediction block P0 for the current block; and
using the refined second piece of motion information M1 to generate the second prediction block P1 for the current block.

A32. The method of any one of embodiments A10-A31, wherein deriving the motion information list CANDLIST_M1 associated with the second piece of motion information M1 comprises:

for each motion information entry cand_i in the motion information list CANDLIST_M1, finding a refined motion information refinedCand_i based on motion estimation that generates a prediction block that minimizes a difference with the first prediction block P0 for the current block; and

determining the motion information entry cand_i to be the refined motion information refinedCand_i.

B1. A decoder (1004) configured to:

decode a first syntax element S0 of a current block within a current picture from a coded video bitstream;

determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determine whether a second syntax element S1 is present in the coded video bitstream;

if the second syntax element S1 is determined to not be present in the coded video bitstream, infer which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1;

if the second syntax element S1 is determined to be present in the coded video bitstream, decode a value for the second syntax element S1 and determine which one of implicit signaling and explicit signaling is used to signal the second piece of motion information M1 based on the decoded value of the second syntax element S1;

if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2;

if explicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a fourth syntax element S3 from the coded video bitstream, determine the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determine the second piece of motion information M1 based on the decoded value of the fourth syntax element S3; and

generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

C1. A method (1900) for processing (e.g., decoding) a current block within a current picture, the method comprising:

decoding a first syntax element S0 from a coded video bitstream;

determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determining that a second syntax element S1 is not present in the coded video bitstream;

if the second syntax element S1 is determined to not be present in the coded video bitstream, inferring that explicit signaling is used to signal the second piece of motion information M1;

if explicit signaling is inferred to be used to signal the second piece of motion information M1, decoding a value of a fourth syntax element S3 from the coded video bitstream, determining the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determining the second piece of motion information M1 based on the decoded value of the fourth syntax element S3; and

generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

C2. The method of embodiment C1, wherein the second syntax element S1 is a multi-hypothesis prediction (MHP) merge flag.

C3. The method of embodiment C1 or C2, wherein determining that the second syntax element S1 is not present in the coded video bitstream comprises:

determining a value V1 based on a fifth syntax element S4 in a parameter set P; and comparing the value V1 to a constant value C0 (e.g., 0, 1, or 2).

C4. The method of embodiment C3, wherein the parameter set P is a sequence parameter set (SPS), a picture parameter set (PPS), a slice header, or a picture header.

C5. The method of embodiment C3 or C4, wherein the second syntax element S1 is determined to be not present in the coded video bitstream if the value V1 is not greater than the constant value C0.

C6. The method of any one of embodiments C3-C5, wherein the value V1 indicates a maximum length of a motion information list CANDLIST_M1 associated with the second piece of motion information M1.

C7. The method of embodiments C6, wherein the value V1 indicates a maximum length of 0 for the motion information list CANDLIST_M1 associated with the second piece of motion information M1.

C8. The method of any one of embodiments C1-C7, wherein determining the second piece of motion information M1 based on the value of the fourth syntax element S3 includes determining the value for one element (e.g., reference picture index) of the motion information M1 motion vector to be the value of the fourth syntax element S3.

D1. A decoder (1004) configured to:

- decode a first syntax element S0 of a current block within a current picture from a coded video bitstream;

- determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

- determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

- if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, determine that a second syntax element S1 is not present in the coded video bitstream;

- if the second syntax element S1 is determined to not be present in the coded video bitstream, infer that explicit signaling is used to signal the second piece of motion information M1;

- if explicit signaling is inferred to be used to signal the second piece of motion information M1, decode a value of a fourth syntax element S3 from the coded video bitstream, determine the weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and determine the second piece of motion information M1 based on the decoded value of the fourth syntax element S3; and

- generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

E1. A method (2000) for processing (e.g., decoding) a current block within a current picture, the method comprising:

- decoding a first syntax element S0 from a coded video bitstream;

determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, inferring or determining that implicit signaling is used to signal the second piece of motion information M1;

if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:

determining whether the current picture is a low delay picture;

deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, wherein deriving the motion information list CANDLIST_M1 is based on whether the current picture is determined to be a low delay picture;

deriving an index value IDX based on the value of the third syntax element S2;
and

determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX; and
generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

E2. The method of embodiment E1, wherein the motion information list CANDLIST_M1 includes only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the current picture is determined to be a low delay picture, and the motion information

list CANDLIST_M1 includes both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the current picture is determined to not be a low delay picture.

F1. A decoder (1004) configured to:

- decode a first syntax element S0 of a current block within a current picture from a coded video bitstream;

- determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

- determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

- if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infer or determine that implicit signaling is used to signal the second piece of motion information M1;

- if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:

 - determining whether the current picture is a low delay picture;

 - deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, wherein deriving the motion information list CANDLIST_M1 is based on whether the current picture is determined to be a low delay picture;

 - deriving an index value IDX based on the value of the third syntax element S2;

 - and

determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX; and generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

G1. A method (2100) for processing (e.g., decoding) a current block within a current picture, the method comprising:

- decoding a first syntax element S0 from a coded video bitstream;

- determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

- determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

- if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, inferring or determining that implicit signaling is used to signal the second piece of motion information M1;

- if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:

 - determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction;

 - deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, wherein deriving the motion information list CANDLIST_M1 is based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction;

 - deriving an index value IDX based on the value of the third syntax element S2;
 - and

determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX; and generating a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

G2. The method of embodiment G1, wherein the motion information list CANDLIST_M1 includes only one entry derived from an L0 or L1 motion vector of a first previously coded block BLK_A before an entry derived from a motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to be in the same time direction, and the motion information list CANDLIST_M1 includes both a first entry derived from an L0 motion vector of the first previously coded block BLK_A and a second entry derived from the L1 motion vector of the first previously coded block BLK_A before an entry derived from an L0 or L1 motion vector of a second previously coded block BLK_B if the L0 and L1 motion vectors of the first previously coded block BLK_A are determined to not be in the same time direction.

G3. The method of embodiment G1 or G2, wherein determining whether the L0 and L1 motion vectors of the previously coded block are in the same time direction comprises:
determining the time direction of the L0 motion vector of the previously coded block;
determining the time direction of the L1 motion vector of the previously coded block; and
determining whether the time directions of the L0 and L1 motion vectors of the previously coded block are the same.

G4. The method of embodiment G3, wherein determining the time direction of the L0 motion vector of the previously coded block comprises comparing a picture order count (POC) value of an L0 picture of the previously coded block with a POC value of the current picture, and determining the time direction of the L1 motion vector of the previously coded block comprises comparing a POC value of an L1 picture of the previously coded block with the POC value of the current picture.

H1. A decoder (1004) configured to:

- decode a first syntax element S0 of a current block within a current picture from a coded video bitstream;

- determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

- determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

- if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infer or determine that implicit signaling is used to signal the second piece of motion information M1;

- if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:

 - determining whether L0 and L1 motion vectors of a previously coded block are in the same time direction;

 - deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, wherein deriving the motion information list CANDLIST_M1 is based on whether the L0 and L1 motion vectors of the previously coded block are in the same time direction;

 - deriving an index value IDX based on the value of the third syntax element S2;

and

 - determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX; and

generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

I1. A method (2200) for processing (e.g., decoding) a current block within a current picture, the method comprising:

- decoding a first syntax element S0 from a coded video bitstream;

- determining a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

- determining that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

- if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, inferring or determining that implicit signaling is used to signal the second piece of motion information M1;

- if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decoding a value of a third syntax element S2 from the coded video bitstream, determining a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:

- deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, wherein deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 comprises:

- determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions;

- determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0;

- for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and

- reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values;

deriving an index value IDX based on the value of the third syntax element $S2$;
and
determining the second piece of motion information $M1$ of the current block based on the motion information list $CANDLIST_M1$ and the index value IDX ; and
generating a prediction block $Pb01$ for the current block based on the first piece of motion information $M0$, the second piece of motion information $M1$, and the weight factor $W1$.

I2. The method of embodiment I1, determining the associated cost value $COST_i$ for the motion information entry $cand_i$ comprises:

determining a set $CANDPRED_i$ of prediction samples for the group $GROUP_P$ based on the motion information $cand_i$;

determining a set $COMBI_i$ of prediction samples including prediction sample values that are a combination of the prediction sample set $PRED_SET0$ and the prediction sample set $CANDPRED_i$ based on the weight $W1$;

comparing the reconstruction set $RECON_SET$ and the prediction sample set $COMBI_i$;
and

determining the cost value $COST_i$ based on a comparison of the reconstruction set $RECON_SET$ and the prediction set $COMBI_i$.

I3. The method of embodiment I1 or I2, wherein reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ based on the cost values comprises reordering the motion information entries in the list of motion information candidates $CANDLIST_M1$ to have ascending cost values.

I4. The method of any one of embodiments I1-I3, wherein the group $GROUP_P$ of previously decoded sample positions are sample positions in the current picture and/or one or more previously decoded pictures.

I5. The method of any one of embodiments I1-I4, wherein the $GROUP_P$ of previously decoded sample positions are sample positions that are spatially neighboring to the current block.

I6. The method of any one of embodiments I1-I5, wherein the GROUP_P of previously decoded sample positions are sample positions that are above the current block and/or to the left of the current block.

I7. The method of embodiment I6, wherein a width tpW_A of the sample positions of the GROUP_P of previously decoded sample positions that are above the current block in a horizontal direction equals or is greater than a width curW of the current block, and a height tpH_L of the sample positions of the GROUP_P of previously decoded sample positions that are to the left of the current block in a vertical direction equals or is greater than a height curH of the current block.

I8. The method of any one of embodiments I1-I7, wherein determining the set PRED_SET0 of prediction samples for the group GROUP_P comprises:

- determining motion information of boundary subblocks of the current block based on the first piece of motion information M0;

- dividing the sample position group GROUP_P into subgroups that are each associated with motion information of a boundary subblock; and

- for each subgroup in GROUP_P, generating corresponding prediction samples for the subgroup based on the associated motion information of the boundary subblock, wherein the determined set PRED_SET0 includes the prediction samples from all the subgroups.

I9. The method of any one of embodiments I1-I8, wherein determining an associated cost value COST_i for a motion information entry cand_i in the list of motion information candidates CANDLIST_M1 comprises:

- determining a set of alternative motion information ALTERMI_SET based on the entry cand_i;

- determining a cost value ALTERCOST_j for each alternative motion information AMI_j in the set ALTERMI_SET;

determining the motion information entry $cand_i$ to be the alternative motion information that has the smallest cost value within the alternative motion information set $ALTERMI_SET$; and

determining the associated cost value $COST_i$ of the entry $cand_i$ as the smallest cost value within the set $ALTERMI_SET$.

I10. The method of embodiment I9, wherein determining the cost value $ALTERCOST_j$ for an alternative motion information AMI_j in the set $ALTERMI_SET$ comprises:

determining a set $ALTERPRED_j$ of prediction samples for the sample position group $GROUP_P$ based on the alternative motion information AMI_j ;

determining a set $ALTERCOMBI_j$ of prediction samples that is a combination of the prediction sample set $PRED_SET0$ and $ALTERPRED_j$ based on the weight $W1$; and

determining the cost value $ALTERCOST_j$ based on comparing the reconstruction set $RECON_SET$ and the prediction set $ALTERCOMBI_j$.

I11. The method of any one of embodiments I1-I10, wherein determining the associated cost value $COST_i$ for the motion information entry $cand_i$ comprises:

for each sample position in the group $GROUP_P$, determining a cost value C_i for the sample position and a cost weighting factor cWi for the sample position; and

determining the cost value $COST_i$ as a sum of $C_i * cWi$ for the sample positions in the group $GROUP_P$.

I12. The method of embodiment I11, wherein a cost weighting factor (e.g., $cWi = 2$) determined for sample positions that are closer to a boundary of the current block is higher than a cost weighting factor (e.g., $cWi = 1$) determined for sample positions that are further away from a boundary of the current block.

J1. A decoder (1004) configured to:

decode a first syntax element $S0$ of a current block within a current picture from a coded video bitstream;

determine a first piece of motion information M0 of the current block based on at least the decoded first syntax element S0;

determine that a second piece of motion information M1 for the current block is signaled in the coded video bitstream;

if the second piece of motion information M1 for the current block is determined to be signaled in the coded video bitstream, infer or determine that implicit signaling is used to signal the second piece of motion information M1;

if implicit signaling is inferred or determined to be used to signal the second piece of motion information M1, decode a value of a third syntax element S2 from the coded video bitstream, determine a weight factor W1 associated with the second piece of motion information M1 from the coded video bitstream, and derive the second piece of motion information M1 based on the decoded value of the third syntax element S2, wherein deriving the second piece of motion information M1 based on the decoded value of the third syntax element S2 comprises:

deriving a motion information list CANDLIST_M1 associated with the second piece of motion information M1, wherein deriving the list of motion information candidates CANDLIST_M1 associated with the second piece of motion information M1 comprises:

determining a set RECON_SET of reconstruction samples from a group GROUP_P of previously decoded sample positions;

determining a set PRED_SET0 of prediction samples for the group GROUP_P based on the first piece of motion information M0;

for each motion information entry cand_i in the list of motion information candidates CANDLIST_M1, determining an associated cost value COST_i; and

reordering the motion information entries in the list of motion information candidates CANDLIST_M1 based on the cost values;

deriving an index value IDX based on the value of the third syntax element S2;

and

determining the second piece of motion information M1 of the current block based on the motion information list CANDLIST_M1 and the index value IDX; and

generate a prediction block Pb01 for the current block based on the first piece of motion information M0, the second piece of motion information M1, and the weight factor W1.

K1. A computer program comprising instructions for adapting a apparatus (1004, 2301) to perform the method of any one of embodiments A1-A31, C1-C8, E1, E2, G1-G4, and I1-I12.

L1. A carrier containing the computer program of embodiment K1, wherein the carrier is one of an electronic signal, optical signal, radio signal, or compute readable storage medium.

M1. An apparatus (1004, 2301), the apparatus comprising:
processing circuitry (2302); and
a memory (2342), said memory containing instructions (1744) executable by said processing circuitry, whereby said apparatus is operative to perform the method of any one of the embodiments A1-A31, C1-C8, E1, E2, G1-G4, and I1-I12.

N1. An apparatus (1004, 2301) adapted to perform the method of any one of embodiments A1-A31, C1-C8, E1, E2, G1-G4, and I1-I12.

O1. Any combination of the embodiments set forth above.

[00263] While various embodiments are described herein, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of this disclosure should not be limited by any of the above-described exemplary embodiments. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

[00264] Additionally, while the processes described above and illustrated in the drawings are shown as a sequence of steps, this was done solely for the sake of illustration. Accordingly, it is contemplated that some steps may be added, some steps may be omitted, the order of the steps may be re-arranged, and some steps may be performed in parallel.

ABSTRACT

Methods and apparatuses for processing (e.g., decoding) a current block within a current picture. The processing may include determining whether a second syntax element S1 is present in a coded video bitstream. The processing may include, if the S1 is not present, inferring which one of implicit signaling and explicit signaling is used to signal a second piece of motion information M1, or, if the S1 is present, determining which one of implicit signaling and explicit signaling is used to signal the M1 based on a decoded value of the S1. The processing may include, if implicit signaling is inferred or determined, deriving the M1, or, if explicit signaling is inferred or determined, determining the M1. The processing may include generating a prediction block Pb01 for the current block based on a first piece of motion information M0, the M1, and a weight factor W1.

(FIG. 18)