



(51) International Patent Classification:

H04N 19/11 (2014.01) H04N 19/192 (2014.01)  
H04N 19/147 (2014.01) H04N 19/593 (2014.01)  
H04N 19/176 (2014.01)

(21) International Application Number:

PCT/US2016/035951

(22) International Filing Date:

6 June 2016 (06.06.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

14/738,808 12 June 2015 (12.06.2015) US

(71) Applicant: MICROSOFT TECHNOLOGY LICENSING, LLC [US/US]; Attn: Patent Group Docketing (Bldg. 8/1000), One Microsoft Way, Redmond, Washington 98052-6399 (US).

(72) Inventors: ZHOU, You; Microsoft Technology Licensing, Llc, Attn: Patent Group Docketing (Bldg. 8/1000), One Microsoft Way, Redmond, Washington 98052-6399 (US).

LIN, Chih-Lung; Microsoft Technology Licensing, Llc, Attn: Patent Group Docketing (Bldg. 8/1000), One Microsoft Way, Redmond, Washington 98052-6399 (US). LEE, Ming-Chieh; Microsoft Technology Licensing, Llc, Attn: Patent Group Docketing (Bldg. 8/1000), One Microsoft Way, Redmond, Washington 98052-6399 (US). LI, Binlong; Microsoft Technology Licensing, Llc, Attn: Patent Group Docketing (Bldg. 8/1000), One Microsoft Way, Redmond, Washington 98052-6399 (US).

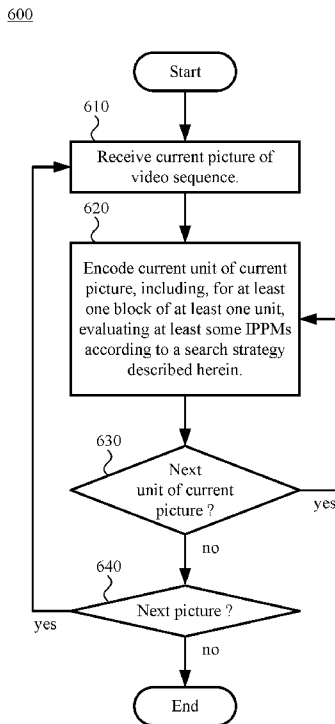
(74) Agents: MINHAS, Sandip et al.; Microsoft Corporation, Attn: Patent Group Docketing (Bldg. 8/1000), One Microsoft Way, Redmond, Washington 98052-6399 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,

[Continued on next page]

(54) Title: SEARCH STRATEGIES FOR INTRA-PICTURE PREDICTION MODES

FIG. 6



(57) Abstract: Innovations are presented that reduce the computational complexity of video encoding by selectively skipping certain evaluation stages during intra-picture prediction. A video encoder receives and encodes a current picture. As part of the encoding, for a current block of the current picture, the video encoder evaluates at least some intra-picture prediction modes ("IPPMs"). According to a search strategy, the video encoder selectively skips time-consuming evaluation of certain IPPMs for the current block when those IPPMs are not expected to improve rate-distortion performance, which can dramatically speed up the encoding process. For example, the video encoder conditionally performs a gradient search among angular IPPMs. Or, as another example, the video encoder selectively skips evaluation of IPPMs depending on a cost of encoding the current block using motion compensation. Or, as another example, the video encoder prioritizes IPPMs evaluated for a block of chroma sample values.

WO 2016/200714 A3



SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

**(84) Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

**Published:**

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

**(88) Date of publication of the international search report:**

26 January 2017

**Declarations under Rule 4.17:**

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2016/035951

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04N19/11 H04N19/147 H04N19/176 H04N19/192 H04N19/593  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
H04N  
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2013/128964 A1 (CHIEN WEI-JUNG [US] ET AL) 23 May 2013 (2013-05-23) paragraph [0073] - paragraph [0075]; figures 3, 6	1,7,12 2-6, 8-11, 13-15
X	----- ZHANG Z ET AL: "Improved intra prediction mode-decision method", VISUAL COMMUNICATIONS AND IMAGE PROCESSING; 12-7-2005 - 15-7-2005; BEIJING,, 12 July 2005 (2005-07-12), XP030080903, Section 2; Section 3 figure 4	12-15
A	----- -/--	1-11

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search <b>22 December 2016</b>	Date of mailing of the international search report <b>05/01/2017</b>
--	---

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer <b>Morbee, Marleen</b>
--	--

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2016/035951

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/219342 A1 (YU YANG [US] ET AL) 7 August 2014 (2014-08-07) paragraph [0003] paragraph [0090] paragraph [0134] - paragraph [0170] figures 4A, 6-8	1-15
X	----- US 2014/219349 A1 (CHIEN WEI-JUNG [US] ET AL) 7 August 2014 (2014-08-07)	1,3
A	paragraphs [0054], [0056], [0068]-[0105]; figures 4A-8	2,4-15
X	----- ALI TABATABAI: "Description of Core Experiment 6 (CE6): Intra Prediction Improvement", 95. MPEG MEETING; 24-1-2011 - 28-1-2011; DAEGU; (MOTION PICTURE EXPERT GROUP OR ISO/IEC JTC1/SC29/WG11),, no. m19509, 19 February 2011 (2011-02-19), XP030048076,	7-11
A	Section 4.7	1-6, 12-15
A	----- LIN Y ET AL: "CE6 subset 5.2.2 and 6.2.2: Intra coding improvements", 99. MPEG MEETING; 6-2-2012 - 10-2-2012; SAN JOSÉ; (MOTION PICTURE EXPERT GROUP OR ISO/IEC JTC1/SC29/WG11),, no. m22927, 20 January 2012 (2012-01-20), XP030051452, Section 9	1-15
	-----	

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2016/035951

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2, 4, 5

video coding system in which for a current block of a current picture at least some of multiple intra-picture prediction modes (IPPMs) are evaluated using a search strategy. In order to reduce the computational complexity of the evaluation of the multiple intra-prediction modes, evaluating at least some of multiple prediction modes includes evaluating one or more most probable modes (MPMs) among the multiple IPPMs, the one or more MPMs including at least one angular IPPM. If a best IPPM, among the one or more MPMs, is an angular IPPM, evaluating at least some of multiple IPPMs further includes evaluating multiple additional angular IPPMs among the multiple IPPMs. Performance of the gradient search depends at least in part on whether a best MPM is an angular IPPM.

---

2. claim: 3

video coding system in which for a current block of a current picture at least some of multiple intra-picture prediction modes (IPPMs) are evaluated using a search strategy. In order to help the video encoder decide when to skip evaluation of most probable modes (MPMs) of the IPPMs or decide when to skip a gradient process for angular IPPMs, a cost of encoding the current block using motion compensation is compared to a threshold and an initial set of IPPMs is evaluated. If the cost of encoding the current block using motion compensation satisfies the threshold, the current block is encoded using motion compensation or one of the initial set of IPPMs without performing a gradient search.

---

3. claim: 6

video coding system in which for a current block of a current picture at least some of multiple intra-picture prediction modes (IPPMs) are evaluated using a search strategy. In order to find the most suitable angular IPPM from a set of multiple angular IPPMs, a gradient search is performed which is an iterative process in which in each of the one or more iterations, one or more offset angular IPPMs, each at an offset from the starting angular IPPM, are evaluated. The gradient search is finished when either the starting angular IPPM or the best of the one or more offset angular IPPMs becomes the final angular IPPM.

---

4. claims: 7-11

video coding system in which for a current block of a current picture at least some of multiple intra-picture prediction modes (IPPMs) are evaluated using a search strategy. In order to optimise the search strategy when evaluating IPPMs for a current block, diverse angular IPPMs are evaluated before selecting a starting angular IPPM for a gradient search. The evaluation of diverse angular IPPMs includes identifying an anchor angular IPPM among the multiple IPPMs (the multiple IPPMs having a range of angular IPPMs), identifying multiple new angular IPPMs (the anchor angular IPPM and the multiple new angular IPPMs being evenly spread throughout the range of angular IPPMs), and evaluating each of the multiple new angular IPPMs.

---

5. claims: 12-15

video coding system in which for a current block of a current picture at least some of multiple intra-picture prediction modes (IPPMs) are evaluated using a search strategy. In order to improve the performance of the search strategy for a block of chroma samples, the search strategy makes use of the IPPM already selected for the corresponding block of luma sample values. In particular, the search strategy includes, in a first stage, evaluating an IPPM selected for a corresponding block of luma sample values. Depending on results of the first-stage evaluation, in a second stage, one or more other possible IPPMs for the current block are evaluated. Depending on results of the second-stage evaluation, in a third stage, one or more remaining possible IPPMs for the current block are evaluated.

---

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/035951

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
US 2013128964	A1	23-05-2013	CN 103947205 A	23-07-2014
			EP 2781094 A1	24-09-2014
			JP 5866453 B2	17-02-2016
			JP 2015502093 A	19-01-2015
			KR 20140092405 A	23-07-2014
			US 2013128964 A1	23-05-2013
			WO 2013074935 A1	23-05-2013
-----				
US 2014219342	A1	07-08-2014	CN 104937936 A	23-09-2015
			EP 2951996 A1	09-12-2015
			JP 2016511975 A	21-04-2016
			KR 20150115833 A	14-10-2015
			US 2014219342 A1	07-08-2014
			WO 2014120389 A1	07-08-2014
-----				
US 2014219349	A1	07-08-2014	CN 104969552 A	07-10-2015
			EP 2954678 A1	16-12-2015
			JP 2016509433 A	24-03-2016
			KR 20150115886 A	14-10-2015
			US 2014219349 A1	07-08-2014
			WO 2014123650 A1	14-08-2014
-----				