IPR2024-01164, -1165, -1186
U.S. Patent Nos. 10,958,840 & 10,574,894

Arashi Vision (U.S.) LLC (D/B/A Insta360) (Petitioner)

v.

GoPro, Inc. (Patent Owner)

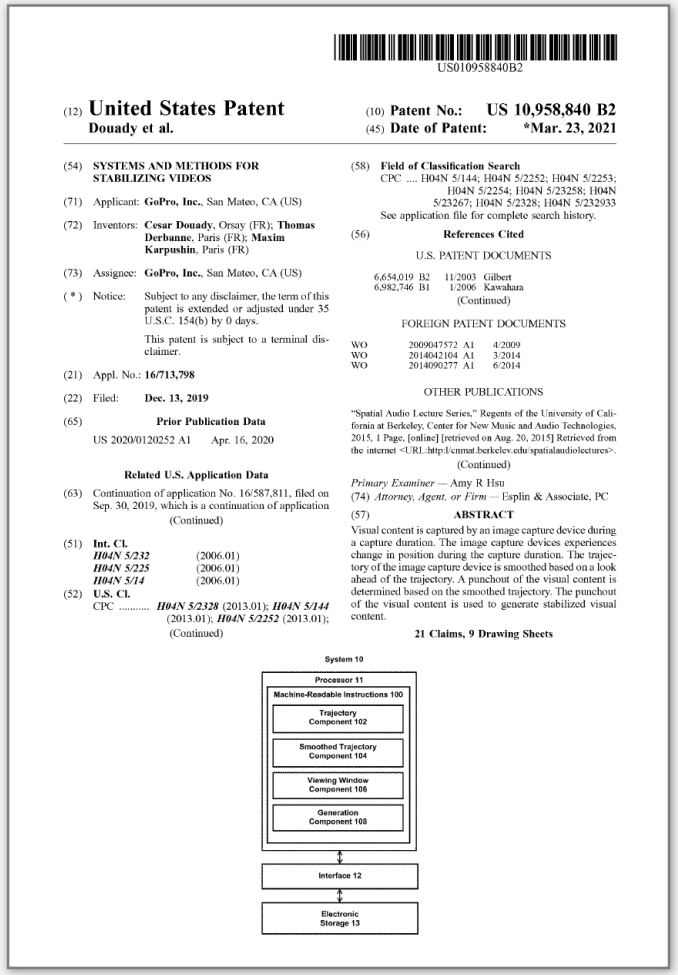
October 23, 2025

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. Instituted Grounds
4. Secondary Considerations

The ’840 Patent

’840 Patent



US010958840B2

(12) **United States Patent**
Douady et al.

(10) **Patent No.: US 10,958,840 B2**
(45) **Date of Patent: *Mar. 23, 2021**

(54) **SYSTEMS AND METHODS FOR STABILIZING VIDEOS**

(71) Applicant: **GoPro, Inc.**, San Mateo, CA (US)

(72) Inventors: **Cesar Douady**, Orsay (FR); **Thomas Derbanne**, Paris (FR); **Maxim Karpushin**, Paris (FR)

(73) Assignee: **GoPro, Inc.**, San Mateo, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/713,798**

(22) Filed: **Dec. 13, 2019**

(65) **Prior Publication Data**

US 2020/0120252 A1 Apr. 16, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/587,811, filed on Sep. 30, 2019, which is a continuation of application
(Continued)

(51) **Int. Cl.**
H04N 5/232 (2006.01)
H04N 5/225 (2006.01)
H04N 5/14 (2006.01)

(52) **U.S. Cl.**
CPC ***H04N 5/2328*** (2013.01); ***H04N 5/144*** (2013.01); ***H04N 5/2252*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04N 5/144; H04N 5/2252; H04N 5/2253; H04N 5/2254; H04N 5/23258; H04N 5/23267; H04N 5/2328; H04N 5/232933
See application file for complete search history.

(56) **References Cited**

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WO 2014090277 A1 6/2014

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(Continued)

Primary Examiner — Amy R Hsu
(74) *Attorney, Agent, or Firm* — Esplin & Associate, PC

(57) **ABSTRACT**

Visual content is captured by an image capture device during a capture duration. The image capture devices experiences change in position during the capture duration. The trajectory of the image capture device is smoothed based on a look ahead of the trajectory. A punchout of the visual content is determined based on the smoothed trajectory. The punchout of the visual content is used to generate stabilized visual content.

21 Claims, 9 Drawing Sheets

’840 Patent (Ex. 1001)

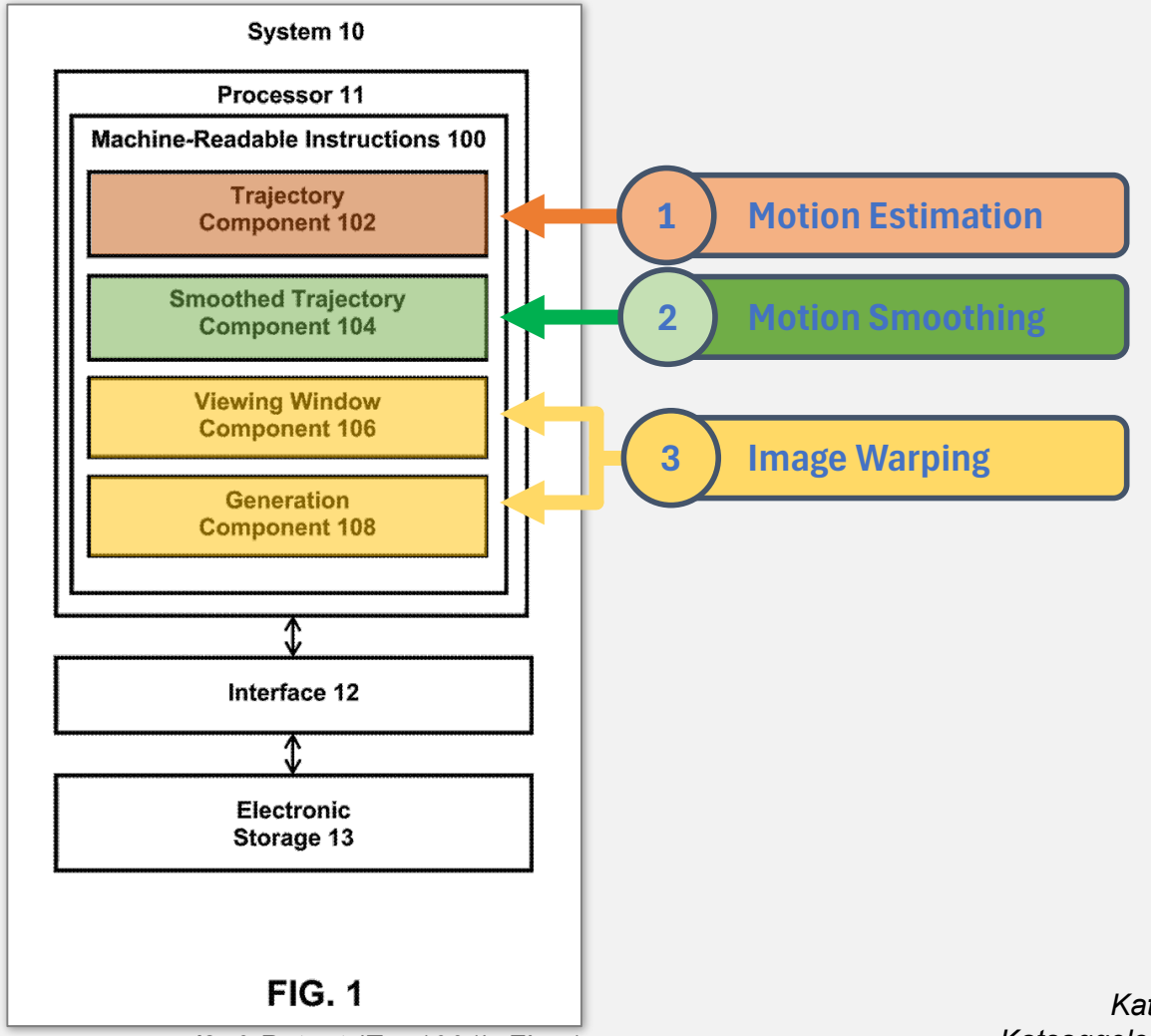
(57) **ABSTRACT**

Visual content is captured by an image capture device during a capture duration. The image capture devices experiences change in position during the capture duration. The trajectory of the image capture device is smoothed based on a look ahead of the trajectory. A punchout of the visual content is determined based on the smoothed trajectory. The punchout of the visual content is used to generate stabilized visual content.

’840 Patent (Ex. 1001), Abstract

Petition (-1164, -1165 Paper 2), 1, 2

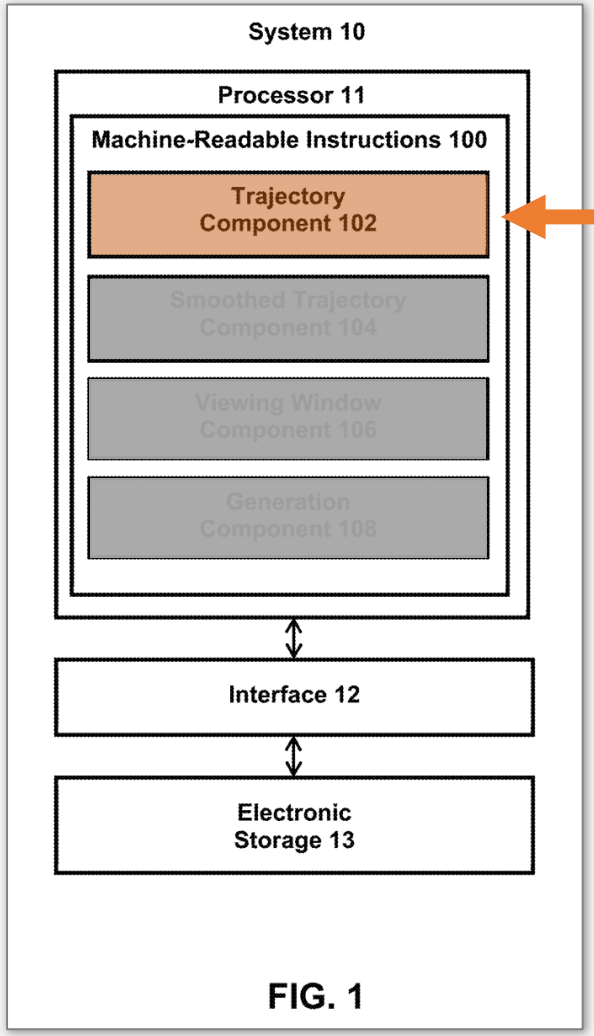
Video Stabilization



'840 Patent (Ex. 1001), Fig. 1

Reply (-1164 Paper 29), 8
Katsaggelos Dec. (-1164, -1165 Ex. 1003), ¶ 15
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 12, 50-53

Video Stabilization



'840 Patent (Ex. 1001), Fig. 1

1 Motion Estimation

determine a trajectory of the housing during the capture duration based on the position information, the trajectory reflecting the rotational positions of the housing at the different moments within the capture duration, the trajectory including a first portion corresponding to a first moment within the capture duration and a second portion corresponding to a second moment subsequent to the first moment within the capture duration;

'840 Patent (Ex. 1001), Claim 1

Reply (-1164 Paper 29), 8
Katsaggelos Dec. (-1164, -1165 Ex. 1003), ¶ 15
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 50-53

Video Stabilization

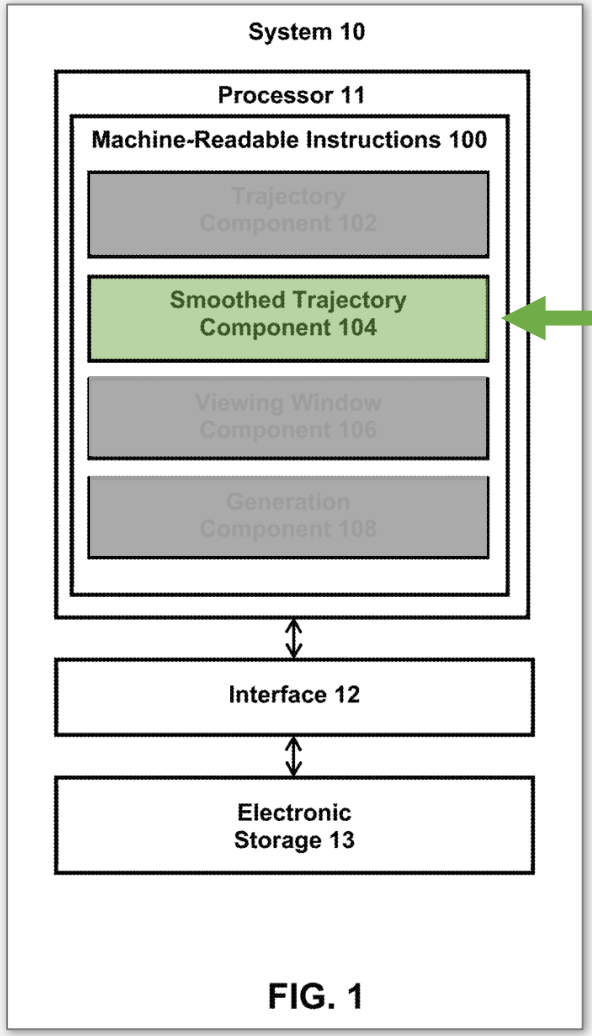


FIG. 1

'840 Patent (Ex. 1001), Fig. 1

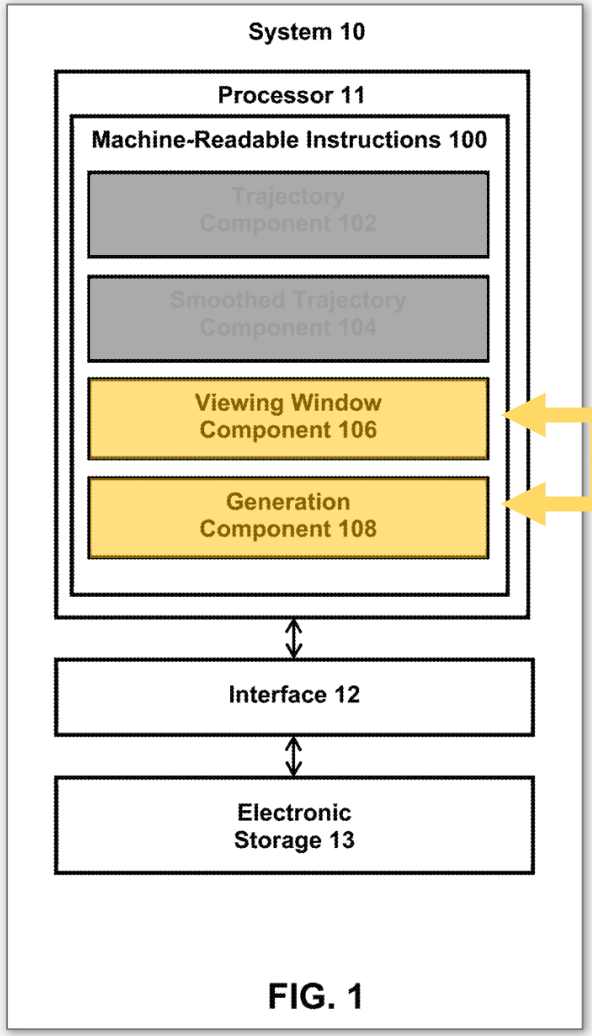
2 Motion Smoothing

determine a smoothed trajectory of the housing based on a look-ahead of the trajectory and one or more of a weight-balance parameter, a low-light high-pass parameter, and/or a stickiness parameter, the look-ahead of the trajectory including use of a subsequent portion of the trajectory to determine a preceding portion of the smoothed trajectory such that a portion of the smoothed trajectory corresponding to the first portion of the trajectory is determined based on the second portion of the trajectory, the smoothed trajectory having smoother changes in the rotational positions of the housing than the trajectory, wherein the determination of the smoothed trajectory based on the look-ahead of the trajectory includes use of a temporal horizon of motion experienced by the image capture device, the temporal horizon enabling approximation of intentional motion of the image capture device while causing a delay in the determination of the smoothed trajectory;

'840 Patent (Ex. 1001), Claim 1

Reply (-1164 Paper 29), 8
Katsaggelos Dec. (-1164, -1165 Ex. 1003), ¶ 15
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 12, 50-53

Video Stabilization



'840 Patent (Ex. 1001), Fig. 1

3 Image Warping

determine placement of the viewing window for the visual content with respect to the field of view of the visual content based on the smoothed trajectory of the housing, the viewing window defining one or more extents of the visual content to be included within a punchout of the visual content; and

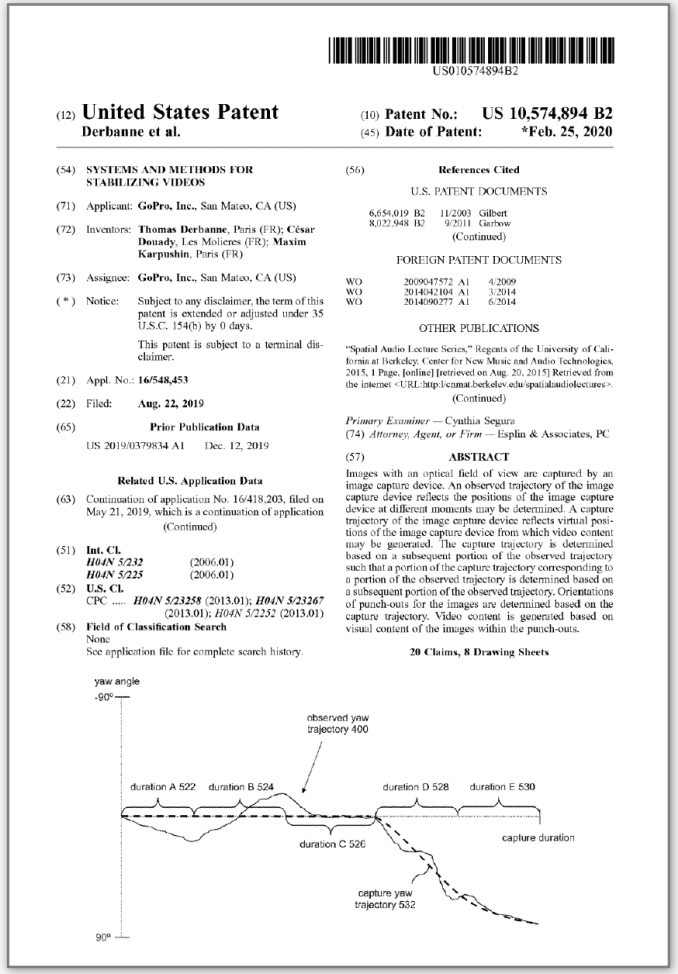
generate the stabilized visual content of a video based on the viewing window, the stabilized visual content including the punchout of the one or more extents of the visual content within the viewing window, wherein inclusion in the stabilized visual content of the one or more extents of the visual content within the viewing window effectuates stabilization of the visual content via selective cropping.

'840 Patent (Ex. 1001), Claim 1

Reply (-1164 Paper 29), 8
Katsaggelos Dec. (-1164, -1165 Ex. 1003), ¶ 15
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 50-53

The ’894 Patent

’894 Patent



US010574894B2

(12) **United States Patent**
Derbanne et al.

(10) **Patent No.: US 10,574,894 B2**
(45) **Date of Patent: *Feb. 25, 2020**

(54) **SYSTEMS AND METHODS FOR STABILIZING VIDEOS**

(71) Applicant: **GoPro, Inc.**, San Mateo, CA (US)

(72) Inventors: **Thomas Derbanne**, Paris (FR); **César Douady**, Les Molieres (FR); **Maxim Karpushin**, Paris (FR)

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This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/548,453**

(22) Filed: **Aug. 22, 2019**

(65) **Prior Publication Data**

US 2019/0379834 A1 Dec. 12, 2019

Related U.S. Application Data

(63) Continuation of application No. 16/418,203, filed on May 21, 2019, which is a continuation of application (Continued)

(51) **Int. Cl.**
H04N 5/232 (2006.01)
H04N 5/225 (2006.01)

(52) **U.S. Cl.**
CPC ***H04N 5/23258*** (2013.01); ***H04N 5/23267*** (2013.01); *H04N 5/2252* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,654,019 B2 11/2003 Gilbert
8,022,948 B2 9/2011 Garbow
(Continued)

FOREIGN PATENT DOCUMENTS

WO 2009047572 A1 4/2009
WO 2014042104 A1 3/2014
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(Continued)

Primary Examiner — Cynthia Segura
(74) *Attorney, Agent, or Firm* — Esplin & Associates, PC

(57) **ABSTRACT**

Images with an optical field of view are captured by an image capture device. An observed trajectory of the image capture device reflects the positions of the image capture device at different moments may be determined. A capture trajectory of the image capture device reflects virtual positions of the image capture device from which video content may be generated. The capture trajectory is determined based on a subsequent portion of the observed trajectory such that a portion of the capture trajectory corresponding to a portion of the observed trajectory is determined based on a subsequent portion of the observed trajectory. Orientations of punch-outs for the images are determined based on the capture trajectory. Video content is generated based on visual content of the images within the punch-outs.

20 Claims, 8 Drawing Sheets

’894 Patent (-1186 Ex. 1001)

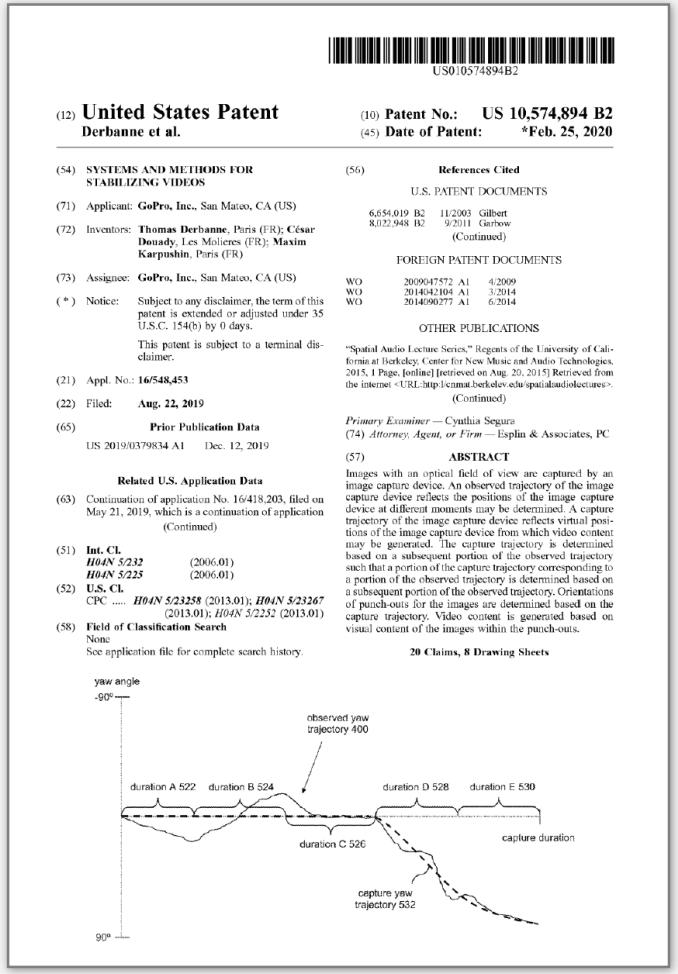
(57) **ABSTRACT**

Images with an optical field of view are captured by an image capture device. An observed trajectory of the image capture device reflects the positions of the image capture device at different moments may be determined. A capture trajectory of the image capture device reflects virtual positions of the image capture device from which video content may be generated. The capture trajectory is determined based on a subsequent portion of the observed trajectory such that a portion of the capture trajectory corresponding to a portion of the observed trajectory is determined based on a subsequent portion of the observed trajectory. Orientations of punch-outs for the images are determined based on the capture trajectory. Video content is generated based on visual content of the images within the punch-outs.

’894 Patent (-1186 Ex. 1001), Abstract

Petition (-1186 Paper 2), 1, 2

’894 Patent



US010574894B2

(12) **United States Patent**
Derbanne et al.

(10) **Patent No.: US 10,574,894 B2**
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(54) **SYSTEMS AND METHODS FOR STABILIZING VIDEOS**

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CPC ***H04N 5/23258*** (2013.01); ***H04N 5/23267*** (2013.01); *H04N 5/2252* (2013.01)

(58) **Field of Classification Search**
None
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(Continued)

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(57) **ABSTRACT**

Images with an optical field of view are captured by an image capture device. An observed trajectory of the image capture device reflects the positions of the image capture device at different moments may be determined. A capture trajectory of the image capture device reflects virtual positions of the image capture device from which video content may be generated. The capture trajectory is determined based on a subsequent portion of the observed trajectory such that a portion of the capture trajectory corresponding to a portion of the observed trajectory is determined based on a subsequent portion of the observed trajectory. Orientations of punch-outs for the images are determined based on the capture trajectory. Video content is generated based on visual content of the images within the punch-outs.

20 Claims, 8 Drawing Sheets

’894 Patent (-1186 Ex. 1001)

determining, by the one or more processors, a capture trajectory of the housing based on a look ahead of the observed trajectory . . . wherein the capture trajectory is determined to include a path that minimizes a combination of rotational velocity and rotational acceleration of the housing, the combination of the rotational velocity and the rotational acceleration of the housing weighing the rotational velocity and the rotational acceleration equally or differently;

’894 Patent (-1186 Ex. 1001), Claim 1

Petition (-1186 Paper 2), 1
Katsaggelos Dec. (-1186 Ex. 1002), ¶ 16

Roadmap

1. The ’840 and ’894 Patents
2. **Claim Construction**
3. Instituted Grounds
4. Secondary considerations

"low-light high-pass parameter" ('840 Patent)

Claim 1

1[g][i]

determine a smoothed trajectory of the housing based on a look-ahead of the trajectory and one or more of a weight-balance parameter, a low-light high-pass parameter, and/or a stickiness parameter, the look-

'840 Patent (Ex. 1001), Claim 1

Claim 14

14. The image capture system of claim **1**, wherein the low-light high-pass parameter controls amount or strength of smoothing performed in smoothed trajectory generation and an extent of motion blur compensation applied in determination of the smoothed trajectory.

'840 Patent (Ex. 1001), Claim 14

"low-light high-pass parameter" ('840 Patent)

Claim 16

16[d][i]

determining, by the one or more processors, a smoothed trajectory of the image capture device based on a look-ahead of the trajectory and one or more of a weight-balance parameter, a low-light high-pass parameter, and/or a stickiness parameter, the look-

'840 Patent (Ex. 1001), Claim 16

Claim 17

17[b]

the low-light high-pass parameter controls amount or strength of smoothing performed in smoothed trajectory generation and an extent of motion blur compensation applied in determination of the smoothed trajectory; and

'840 Patent (Ex. 1001), Claim 17

"low-light high-pass parameter" ('840 Patent)

Insta360's Construction and DI's Preliminary Construction	Parties' Interpretation in ITC	GoPro's Construction in IPRs
A parameter that controls the amount or strength of smoothing used in motion blur compensation	A parameter that controls the amount or strength of smoothing used in motion blur compensation	A parameter that controls the amount or strength of smoothing used in motion blur compensation **by allowing more high frequencies to pass through based on low-light conditions**
DI (-1164 Paper 11), 9; DI (-1165 Paper 10), 21 *Reply (-1164 Paper 29, -1165 Paper 28), 1*	*ITC Initial Determination (Ex. 2052), 102*	*POR (-1164 Paper 19), 24* *POR (-1165 Paper 19), 28*

"low-light high-pass parameter" ('840 Patent)

The specification supports Petitioner's construction

> **"[T]he specification** is always highly relevant to the claim construction analysis. Usually, it is dispositive; it **is the single best guide to the meaning of a disputed term**."

Phillips v. AWH Corp., 415 F.3d 1303, 1315 (Fed. Cir. 2005)

> "For this claim term the patentee offers an ascertainable definition in the body of the claim, and our cases do not support prescribing a more particularized meaning **unless a narrower construction is required by the specification** or prosecution history."

3M Innovative Props. Co. v. Tredegar Corp., 725 F.3d 1315, 1329 (Fed. Cir. 2013)

"low-light high-pass parameter" ('840 Patent)

Plain and ordinary meaning:

A parameter that controls the amount or strength of smoothing used in motion blur compensation.

DI (-1164 Paper 11), 9
Reply (-1164 Paper 29, -1165 Paper 28), 1-2

> A low-light high-pass parameter may refer to a parameter that controls the amount/strength of smoothing performed to generate the smoothed trajectory. For trajectory smoothing/

'840 Patent (Ex. 1001), 21:59-61

> A low-light high-pass parameter may range between 0 and 1, with 0 corresponding to no motion blur compensation and 1 corresponding to full motion blur compensation. The low-light high-pass parameter of 0 may result in the observed motion being fully attenuated and no image capture device motion during the exposure periods being taken into account. The low-light high-pass parameter of 1 may result in the smoothed trajectory being same as the (observed) trajectory during the exposure periods. That is, the

'840 Patent (Ex. 1001), 22:8-16

Reply (-1164 Paper 29), 1-7
Reply (-1165 Paper 28), 2-10
Katsaggelos Suppl. Dec. (-1164 -1165 Ex. 1017), ¶¶ 7-37

"low-light high-pass parameter" ('840 Patent)

Determined based on motion blur, not limited to low-light

may be attenuated based on the margin constraint. Intra-frame motion may refer to motion of the image capture device during an exposure period of individual video frames. The motion may be encrusted in the video frames through the motion blur, and attenuation of the intra-frame

'840 Patent (Ex. 1001), 21:66-22:3

capture device, and/or other information. For example, longer exposure time may be used with low light conditions and shorter exposure time may be used with high light conditions. For instance, referring to FIG. 7, exposure time of less

'840 Patent (EX1001), 19:18-21

"encrusted" in the image and may not be removed. Better visual characteristics (e.g., impression) may be provided when the intra-frame motion is taken into account so that the smoothed trajectory is smooth for inter-frame phases while corresponding to the original motion for intra-frame phases. That is, the smoothed trajectory may move/follow in the same direction and with the same speed as during the frame exposure phase, so that its motion is aligned with the motion blur in the image.

'840 Patent (Ex. 1001), 18:16-24

Reply (-1164 Paper 29), 2-4
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 20-31

"low-light high-pass parameter" ('840 Patent)

GoPro's expert concedes that
LLHP parameter is based on conditions other than "exposure time"

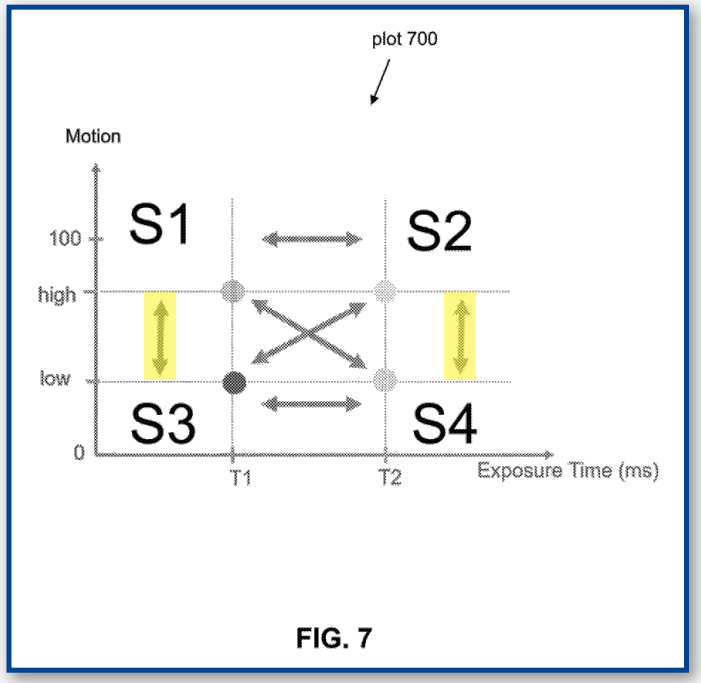


FIG. 7

'840 Patent (EX1001), Fig. 7

45. Fig. 7 of the '840 Patent illustrates this proactive approach, where the amount of smoothing is adjusted based on factors such as exposure time, motion of the image capture device, and other conditions. The system uses smoothing strengths (Ex. 1001, 22:2-7) and smoothing directions (Ex. 1001, 22:2-7) that are

Foroosh Dec. (-1164 EX2001), ¶ 45

image capture device. In some implementations, the exposure time of the image capture device may be automatically adjusted based on light conditions, motion of the image capture device, and/or other information. For example, lon-

'840 Patent (Ex. 1001), 19:15-18

Reply (-1164 Paper 29), 2-4
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 20-31

"low-light high-pass parameter" ('840 Patent)

LLHP is agnostic as to what causes the blur

30. Nor does Dr. Foroosh's arbitrary requirement of low light conditions make sense. Per Dr. Foroosh, the claimed "low-light high-pass" parameter mitigates blur due to ***only*** low light conditions. (EX2018, ¶40.) But the mechanism of the claimed "low-light high-pass" parameter would not be able to selectively mitigate blurs caused by only low light conditions, but not other conditions. As Dr. Foroosh concedes, the claimed invention addresses motion blur by, for example, keeping certain portions of high frequencies to make the motion blur. (*Id.* ¶39 (citing EX1001, 17:61-18:1, 22:16-21). This means that the motion blur compensation occurs after the blur has already occurred — or as the specification describes, the "intra-frame" motion is already "encrusted" in the video frame. (EX1001, 18:1-24, 21:66-22:7.) The "low-light high-pass parameter" then masks the already encrusted blur by performing less smoothing such as by keeping certain high-frequency movements. Thus, because the "low-light high-pass parameter" performs blur compensation after the blur is already formed, it is agnostic as to what causes the blur.

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 30

Reply (-1164 Paper 29), 6-7

"low-light high-pass parameter" ('840 Patent)

Does not require more high frequencies to pass through

"encrusted" in the image and may not be removed. Better visual characteristics (e.g., impression) may be provided when the intra-frame motion is taken into account so that the smoothed trajectory is smooth for inter-frame phases while corresponding to the original motion for intra-frame phases. That is, the smoothed trajectory may move/follow in the same direction and with the same speed as during the frame exposure phase, so that its motion is aligned with the motion blur in the image.

'840 Patent (Ex. 1001), 18:16-24

frames. The motion may be encrusted in the video frames through the motion blur, and attenuation of the intra-frame motion may result in motion blur pulsations that create poor visual impression. Such visual defect may be reduced by having the smoothed trajectory follow the (observed) trajectory during the exposure periods.

'840 Patent (Ex. 1001), 22:2-7

Reply (-1164 Paper 29), 4-5
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 32-37

"low-light high-pass parameter" ('840 Patent)

Does not require more high frequencies to pass through

information. For example, motion of the image capture device/image sensor during a frame exposure may be analyzed and used to generate/modify a capture trajectory that minimizes inter-frame motion (e.g., smooths inter-frame motion) while preserving the intra-frame motion, which may contain the high frequencies. This may provide for improved

'840 Patent (Ex. 1001), 18:1-6

into account. The low-light high-pass parameter of 1 may result in the smoothed trajectory being same as the (observed) trajectory during the exposure periods. That is, the output motion may include high frequencies that mask motion blur within the visual content. A value between 0 and

'840 Patent (Ex. 1001), 22:14-18

Reply (-1164 Paper 29), 4-5
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 32-37

“low-light high-pass parameter” (’840 Patent)

GoPro’s Cited Case Supports Petitioner

“In sum, the claim language and the specification indicate that “[t]he term ‘pipette guiding mechanism’ in the '549 and '175 patents is used broadly. The prosecution history discussed above does not change our conclusion. Thus, **the claim language and specification both support the conclusion** that ‘pipette guiding mechanism’ is a mechanism that guides the pipette assembly either manually or automatically.

Malvern Panalytical Inc. v. TA Instruments-Waters LLC, 85 F.4th 1365, 1374 (Fed. Cir. 2023)

Sur-Reply (-1164 Paper 33), 2
Sur-Reply (-1165 Paper 33), 3

"low-light high-pass parameter" ('840 Patent)

GoPro's Cited Case Supports Petitioner

"We conclude that **the claim construction of the 'fastening stem' limitation that is most consistent with the claims, specification, and prosecution history** does not confine claims 1 and 10 to embodiments in which the fuse end cap is formed from multiple pieces of material. We therefore do not agree with the district court that claims 1 and 10 do not cover single-piece embodiments (and thus that dependent claims 8, 9, 19, and 20 also do not cover single-piece embodiments, even though the language of those claims is expressly directed to such embodiments)."

Littelfuse, Inc. v. Mersen USA EP Corp., 29 F.4th 1376, 1381 (Fed. Cir. 2022)

Sur-Reply (-1164 Paper 33), 2
Sur-Reply (-1165 Paper 33), 3

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. **Instituted Grounds**
4. Secondary considerations

Instituted Grounds

’840 Patent—Instituted Grounds (IPR2024-01164)

Ground	35 U.S.C. §	Claims	Prior Art Reference
1	103	1-3, 5, 8-11, 14, 16, 18, 19	Bell, Shi
2	103	4, 20	Bell, Shi, Karpenko
3	103	6, 7, 21	Bell, Shi, Bell Paper
4	103	12	Bell, Shi, Sokeila
5	103	13	Bell, Shi, Kwatra
6	103	15	Bell, Shi, Corey
7	103	17	Bell, Shi, Kwatra, Corey

Petition (-1164 Paper 2), 7

Note: Claims 13 and 14 are at issue in ITC

’840 Patent—Instituted Grounds (IPR2024-01165)

Ground	35 U.S.C. §	Claims	Prior Art Reference
1	103	1-3, 5-11, 14-16, 18, 19, 21	Zhou, Cai
2	103	4, 20	Zhou, Cai, Karpenko
3	103	12	Zhou, Cai, Sokeila
4	103	13, 17	Zhou, Cai, Bell Paper

Petition (-1165 Paper 2), 8

Note: Claims 13 and 14 are at issue in ITC

’894 Patent—Instituted Grounds (IPR2024-01186)

Ground	35 U.S.C. §	Claims	Prior Art Reference
1	103	1-20	Zhou, Kwatra
2	103	2, 3, 7, 12, 13, 17	Zhou, Kwatra, Shi

Petition (-1186 Paper 2), 8

Note: Claims 1 and 5 are at issue in ITC

ITC Grounds

Patent	Claim(s)	ITC Ground(s)
’840 Patent	1, 14	Pixel 2 Bell + Zhou/Shi
	13	Pixel 2 + Kwatra Bell + Zhou/Shi + Kwatra
’894 Patent	1, 5	Pixel 2 + Kwatra
	1, 5	Bell + Kwatra

ITC Initial Determination (Ex. 2052), 57-75, 101-111

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. **Instituted Grounds**
4. Secondary considerations

- **“low-light high-pass parameter”**
- “temporal horizon enabling approximation of intentional motion”
- “stickiness parameter”
- motivation to combine:
  - Bell + Shi
  - Zhou + Cai
- “weight-balance parameter”
- motivation to combine:
  - Kwatra + Bell/Zhou + Shi

“low-light high-pass parameter” (-1164: Shi)

Shi Teaches a "low-light high-pass parameter"

Claims do not require LLHP to be part of the smoothing operation

GoPro

omitted."). Unlike the approach in Shi, the claims plainly require the low-light high-pass parameter control both operations in a single transformation. EX1001, claims 1 & 14.

Sur-Reply (-1164 Paper 33), 11

ITC

The claim, however, does not require that the low-light high-pass parameter be part of the entire smoothing operation. Instead, the claim requires that the smoothed trajectory be based on a low-light high-pass parameter. This parameter must be used to output what is the smoothed trajectory, in the case on Pixel 2, [redacted] In Pixel 2, [redacted]

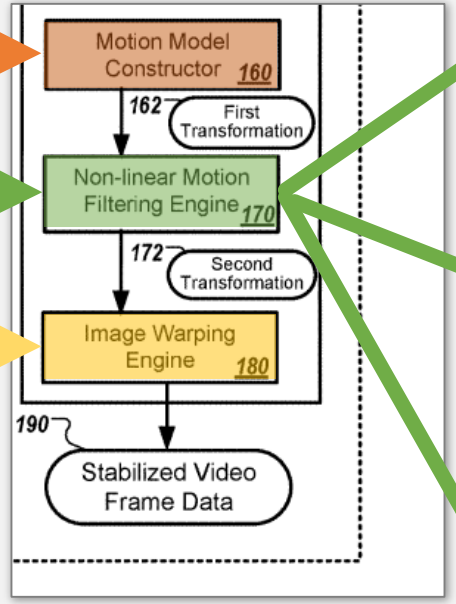
ITC Initial Determination (Ex. 2052), 103

Shi Teaches a "low-light high-pass parameter"

1 Motion Estimation

2 Motion Smoothing

3 Image Warping



Shi (-1164 Ex. 1007), Fig. 1

frame, instead of using $V_4(T)$ for that purpose. Accordingly, using any of filtered camera position $V_0(T)$, $V_1(T)$, and $V_2(T)$ to generate a stabilizing transformation may still improve stability of video. Similarly $V_3(T)$ may be effective

Shi (-1164 Ex. 1007), 14:33-36

A third virtual camera position, $V_2(T)$, can be generated by interpolating $V_1(T)$ with the real device position R(T) based on an amount of camera motion blur present in the frame **211**. This can reduce the amount of stabilization applied to reduce a viewer's perception of the blur. Since motion blur generally cannot be removed, this can decrease the stability of the video when appropriate, in order to produce a more natural result.

Shi (-1164 Ex. 1007), 13:16-23

The computing system then adjusts the second virtual camera position, $V_1(T)$, toward the real device position R(T) to an extent determined based on the amount of blur identified (**322**). For example, the computing system can determine a coefficient based on the motion blur kernel, and use the coefficient to weight a spherical interpolation between positions $V_1(T)$ and R(T). This coefficient may be based on

Shi (-1164 Ex. 1007), 18:27-33

Reply (-1164 Paper 29), 7-10;
Katsaggelos Suppl. Dec. (Ex. 1017), ¶¶ 12, 50-78

Shi Teaches "low-light high-pass parameter"

Shi teaches LLHP under GoPro's construction requiring "low-light"

111. A POSITA at the time of '840 patent filing would understand that blurs can be caused by low-light conditions because a shutter is open for a longer time in video capture under low-light conditions, causing movement to add more blur to a frame. References in the field of video stabilization before the time of the '840 patent filing disclose this. For example, U.S. Patent No. 9,674,438 ("Zhou") discloses that "[m]otion blur results when the composition of the image being recorded changes during the recording of a single frame, either due to rapid movement (of the camera or objects in the scene being captured) or long exposure, i.e., integration, times. The difficulties associated with stabilizing video frames exhibiting motion blur are further exacerbated in low light conditions due to the increased integration times needed to capture sufficient light in the recorded video frames. Longer integration times result in more motion blur in the recorded video frame." (EX1015, 1:51-61.)

Katsaggelos Dec. (Ex. 1003), ¶ 111

Reply (-1164 Paper 29), 7-10

Shi Teaches "low-light high-pass parameter"

Shi teaches LLHP under GoPro's construction requiring "high frequencies"

"encrusted" in the image and may not be removed. Better visual characteristics (e.g., impression) may be provided when the intra-frame motion is taken into account so that the smoothed trajectory is smooth for inter-frame phases while corresponding to the original motion for intra-frame phases. That is, the smoothed trajectory may move/follow in the same direction and with the same speed as during the frame exposure phase, so that its motion is aligned with the motion blur in the image.

'840 Patent (Ex. 1001), 18:16-24

become very noticeable and unnatural. To reduce a viewer's perception of the blur, the change in the virtual camera position from one frame to the next may be allowed to at least partially track the real camera position, consistent with the natural blur in the image. This can hide the blur to an extent. Accordingly, based on a determination of an amount of image blur in the frame **211**, at least a portion of the real motion of the recording device **102** can be used to adjust the virtual camera position $V_1(T)$, for example, by interpolating between $V_1(T)$ and $R(T)$ according to the amount of image blur detected.

Shi (-1164 Ex. 1007), 17:63-18:6

Reply (-1164 Paper 29), 8-10
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 89-90

Shi Teaches "low-light high-pass parameter"

Shi teaches LLHP under GoPro's construction requiring "high frequencies"

(EX2018, ¶98.) This is wrong. As he argues, "Shi's system performs an interpolation between the smoothed and original trajectories." (*Id.*) When Shi's system keeps more of the original trajectory (i.e., stronger motion blur compensation), more high-frequency movement is likely preserved. This is because the original motion likely contains more high frequency movement. In that situation, Shi's system constitutes the so-called high-pass system.

Katsaggelos Suppl. Dec. (Ex. 1017), ¶ 89

(EX1007, 17:57-18:1.) The goal of Shi's blur compensation technique is to make the video less stable, and often that means more high-frequency movement. This confirms that Shi's blur compensation technique preserves high-frequency movement.

Katsaggelos Suppl. Dec. (Ex. 1017), ¶ 90

Reply (-1164 Paper 29), 8-10

“low-light high-pass parameter” (-1165: Zhou)

"low-light high-pass parameter"

Insta360's Construction and DI's Preliminary Construction	GoPro's Construction
A parameter that controls the amount or strength of smoothing used in motion blur compensation.	A parameter that controls the amount or strength of smoothing used in motion blur compensation **by allowing more high frequencies to pass through based on low-light conditions**.
DI (-1164 Paper 11), 8-9 *Reply (-1164 Paper 29, -1165 Paper 28), 1*	*POR (-1164 Paper 19), 24* *POR (-1165 Paper 19), 28*

Zhou Teaches a "low-light high-pass parameter"

Zhou teaches LLHP under GoPro's construction requiring "low light"

(54) **LOW LIGHT VIDEO IMAGE STABILIZATION STRENGTH MODULATION**

Zhou (-1165 Ex. 1006), Title

This approach—or any other approach to video image stabilization—may be aided by the low light video image stabilization strength modulation techniques described herein. In particular, whatever value is determined for the

Zhou (-1165 Ex. 1006), 4:5-8

Reply (-1165 Paper 28), 10-12
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 57-60

Zhou Teaches a "low-light high-pass parameter"

Zhou teaches LLHP under GoPro's construction requiring "high frequencies"

"shimmering" artifacts in the stabilized video. On the other hand, if the amount of blur in the image is larger (typically found in darker images with longer integration times), smaller stabilization strengths may be employed in an effort to mitigate the appearance of the aforementioned unwanted "shimmering" artifacts in the stabilized video (i.e., by letting the image sequence jitter slightly, rather than holding it

Zhou (-1165 Ex. 1006), 6:45-51

quency motion than unintentional motion. Unintentional motion may be characterized by higher frequency motion (e.g., jitter, shake) than intentional motion. To identify

'840 Patent (Ex. 1001), 9:18-20

In some implementations, information on high frequencies (jitters) of image capture may be used to improve visual characteristics of generated video content/stabilized visual

'840 Patent (Ex. 1001), 17:61-63

Reply (-1165 Paper 28), 10-11
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 57-60

Zhou Teaches a "low-light high-pass parameter"

GoPro mischaracterized Insta360's arguments

GoPro

Petitioner does not dispute that Zhou applies its stabilization strength equally across all motion frequencies. While Petitioner argues it "allows high-frequency motion to pass," Reply, 11, it is undisputed Zhou treats high- and low-frequency motion equally—its approach is not selective, as in a high-pass system. POR, 31, EX2020, 94:6-15; EX2018, ¶42.

PO Sur-Reply (-1165 Paper 33), 12

Insta360 expert

latter case filters with low-pass spectral shape will be applied. Overall, the statement by Dr. Foroosh, that "Zhou's stabilization strength parameter is applied to impact smoothing equally across the entire spectrum of motion frequencies," is not correct, since the resulting smoothing is not equal across the entire spectrum of motion frequencies.

Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶ 55

Reply (-1165 Paper 28), 10-12

Roadmap

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  - Zhou + Cai
- “weight-balance parameter”
- motivation to combine:
  - Kwatra + Bell/Zhou + Shi

"temporal horizon" ('840 Patent)

Claim 1

1[g][v]

on the look-ahead of the trajectory includes use of a temporal horizon of motion experienced by the image capture device, the temporal horizon enabling approximation of intentional motion of the image capture device while causing a delay in the determi-

'840 Patent (Ex. 1001), Claim 1

Claim 5

5. The image capture system of claim **1**, wherein a longer interval of the temporal horizon enables better approximation of the intentional motion of the image capture device while causing a longer delay in the determination of the smoothed trajectory.

'840 Patent (Ex. 1001), Claim 5

"temporal horizon" ('840 Patent)

Claim 16

16[d]

look-ahead of the trajectory includes use of a temporal horizon of motion experienced by the image capture device, the temporal horizon enabling approximation of intentional motion of the image capture device while causing a delay in the determination of the smoothed

'840 Patent (Ex. 1001), Claim 16

-1164: Ground 1 (Bell + Shi)

Bell Teaches "temporal horizon enabling approximation of intentional motion"

GoPro concedes Bell discloses "temporal horizon"

> *Second,* Bell notes that while the previously described "algorithm works well," it "occasionally has to make quick changes in velocity when the crop polygon suddenly hits the edge." Ex. 1006 at 10:8-10. Only in this context—*i.e.*, to avoid abrupt corrections—does Bell propose "a small buffer of future frames, e.g., five or less," *id.* at 8:66-67, and only for the purpose of ensuring that "sharp changes can be preemptively avoided," *id.* at 10:10-16; Ex. 2018, ¶ 120.

POR (-1164 Paper 19), 39

Petition (-1164 Paper 2), 37-41; Reply (-1164 Paper 29), 11-13
Katsaggelos Dec. (-1164 Ex. 1003), ¶¶ 142-148; Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 104-114

Bell Teaches "temporal horizon enabling approximation of intentional motion"

Bell discloses using a buffer of future frames to approximate intentional motion

orientation and angular velocity. The goal of the smoothing method is to define a new virtual camera that stays static when the motion is so small that the intention is probably that the camera should remain static, and otherwise follows the original camera with smooth changes in angular velocity.

The physical and virtual camera orientations at frame k are represented with the quaternions p(k) and v(k). The physical and virtual angular velocities are represented as the discrete angular changes from frame k to frame k+1, and are represented as $p_\Delta(k)$ and $v_\Delta(k)$. Since the frame rate is constant, time is implicit in this representation of the velocity. For each new frame k, our smoothing algorithm determines v(k) and $v_\Delta(k)$ using the virtual camera parameters from the last frame and the physical camera parameters from the last frame, the current frame, and, optionally, a small buffer of future frames, e.g., five or less.

Bell (-1164 Ex. 1006), 8:52-67

Petition (-1164 Paper 2), 37-41
Reply (-1164 Paper 29), 11-13
Katsaggelos Dec. (-1164 Ex. 1003), ¶¶ 142-148; Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 104-114

Bell Teaches "temporal horizon enabling approximation of intentional motion"

Bell discloses using a buffer of future frames to approximate intentional motion

This algorithm works well, but it occasionally has to make quick changes in velocity when the crop polygon suddenly hits the edge. If frames can be buffered within the camera pipeline for a short time before being processed, then a larger time window of motion sensing system data can be examined, and sharp changes can be preemptively avoided. In the remainder of this section, the method is extended to use data from a look-ahead buffer to calculate a smoother path.

Bell (-1164 Ex. 1006), 10:8-16

Embodiments in accordance with the present invention project the orientation forward in time and compare it to the orientation at the "future" time. Let α be the number of

Bell (-1164 Ex. 1006), 10:17-19

described for the no-lookahead case. If the projection of the crop polygon a frames into the future is outside the inner region, $v_\Delta(k)$ may be updated to:

$$v_\Delta(k)=\text{slerp}(v_\Delta(k+\alpha),v_\Delta(k),\gamma) \qquad \text{(Relation 11)}$$

where γ is a mixing factor that defines how much of the lookahead angular change to be mixed with the current angular change. Using values of γ close to 1 provides a preemptive nudge in the right direction, without being a hard constraint. Note that the virtual camera position previously

Bell (-1164 Ex. 1006), 10:25-34

Reply (-1164 Paper 29), 11-13
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 104-114

Bell Teaches "temporal horizon enabling approximation of intentional motion"

GoPro ignores that the crop polygon's position is based on the virtual camera trajectory

112. Third, Dr. Foroosh is wrong that Bell's look-ahead buffer is only about whether the crop polygon is too close to the boundary, but not about intentional motion. He appears to not understand the relationship between the camera trajectory and the crop polygon. As I explained earlier, the crop polygon corresponds to the smoothed trajectory. By avoiding sharp changes that cause the crop polygon to hit the boundary suddenly, Bell's system essentially prevents sharp changes in the virtual camera movement ("smoothed trajectory"). That is consistent with the user's intention.

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 112; Reply (-1164 Paper 29), 12-13

Bell Teaches "temporal horizon enabling approximation of intentional motion"

GoPro's argument rests on limitations not in the claims

GoPro

motion." Reply, 13. Not so. When Bell's look-ahead determines a future collision is likely, it does *not* adjust the position of the current frame to approximate intentional motion. Rather, it adjusts the velocity used in

Sur-Reply (-1164 Paper 33), 14

840 Patent

on the look-ahead of the trajectory includes use of a temporal horizon of motion experienced by the image capture device, the temporal horizon enabling approximation of intentional motion of the image capture device while causing a delay in the determi-

'840 Patent (Ex. 1001), Claim 1

Petition (-1164 Paper 2), 38-40; Reply (-1164 Paper 29), 13

Shi teaches "temporal horizon enabling approximation of intentional motion"

GoPro does not dispute that Shi teaches "temporal horizon"

GoPro

2. Shi's look-ahead does not approximate intentional motion

Petitioner cites Shi's use of look-ahead frames to "gradually prepare for large changes in movement" and to "evaluate whether consistent movement, such as panning" is occurring. Reply, 13-14. But Shi's look-ahead serves a different purpose: spreading motion across frames to avoid sudden changes—not approximating whether a given motion was intentional. POR, 41-42; EX2018, ¶126. Petitioner's only response is that "Shi explains that sudden

Sur-Reply (-1164 Paper 33), 15

Shi

techniques to provide high-quality stabilization. For example, when processing a frame, the system can use future frames (e.g., later-captured or look-ahead frames) to detect possible large motion and start compensating for it even before the large motion occurs. This can help avoid

In some implementations, the system can reduce the impact of large or sudden movements using look-ahead frames to increase the accuracy of EIS processing. Based on analysis of subsequent frames, video frames can be adjusted to gradually prepare for large changes in movement before the movement occurs. The system can evaluate whether consistent movement, such as panning, is occurring and adjust the video frames to reflect the consistent movement.

Shi (-1164 Ex. 1007), 1:61-65, 5:17-24

Petition (-1164 Paper 2), 40-41

Shi teaches "temporal horizon enabling approximation of intentional motion"

Shi discloses "approximation of intentional motion"

devices. In many cases, videos recorded using handheld recording devices suffer from unintentional movement that reduces video quality. One of the major causes of movement is hand shake, e.g., when a user's unintentional or involuntary movements while holding the recording device affects a quality of the video. Inconsistent panning and other

Shi (-1164 Ex. 1007), 1:7-12

In some implementations, the system can reduce the impact of large or sudden movements using look-ahead frames to increase the accuracy of EIS processing. Based on analysis of subsequent frames, video frames can be adjusted to gradually prepare for large changes in movement before the movement occurs. The system can evaluate whether consistent movement, such as panning, is occurring and adjust the video frames to reflect the consistent movement.

Shi (-1164 Ex. 1007), 5:17-24

without imposing a predetermined shape or pattern. By contrast, $V_3(T)$ is generated by filtering the device patterns to conform to a predetermined, consistent motion pattern, such as substantially linear panning or other movement that may be potentially intended by a user of the recording device **102**.

Shi (-1164 Ex. 1007), 13:35-40

Reply (-1164 Paper 29), 13-14
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 115-122

Shi Teaches "temporal horizon enabling approximation of intentional motion"

GoPro mischaracterized Insta360's arguments

GoPro

Petitioner also offers no response to PO's argument that Shi's motion spreading approach is based on ***alteration*** of the current frame to "***introduce apparent movement***," EX1007, 10:46–54, which is the opposite of approximating intentional motion. POR, 41-42; EX2018, ¶126.

Sur-Reply (-1164 Paper 33), 15

Insta360's Expert

117. His only criticism appears to be that Shi does not approximate intentional motion because it "teaches a different approach of intentionally altering motion." (EX2018, ¶126). That is wrong.

122. But Dr. Foroosh ignores that Shi specifically teaches that the "predetermined, consistent motion pattern, such as substantially linear panning or other movement," "may be potentially intended by a user of the recording device." (EX1007, 13:35-40.) A POSITA would have understood that this teaches that Shi's system "adjust the video frames to reflect the consistent movement." (*Id.* 5:22-25.) Because the predetermined shape or pattern reflects the intentional motion, imposing the predetermined shape or pattern means approximation of intentional motion.

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 117, 122; see also ¶¶ 118-121
Reply (-1164 Paper 29), 13-14

-1165: Ground 1 (Zhou + Cai)

Cai Teaches "temporal horizon enabling approximation of intentional motion"

Cai's zero-motion detection considers future frames

GoPro

and clamping steps, not zero-motion detection. As Dr. Foroosh explains, Cai's zero-motion detection occurs earlier, based solely on past and current filtered frames, separate from the clamping procedure used to smooth transitions in the stabilized trajectory. POR, 20-21, 46–48; EX2018, ¶¶75, 112–115. Again,

Sur-Reply (-1165 Paper 33), 20

Cai

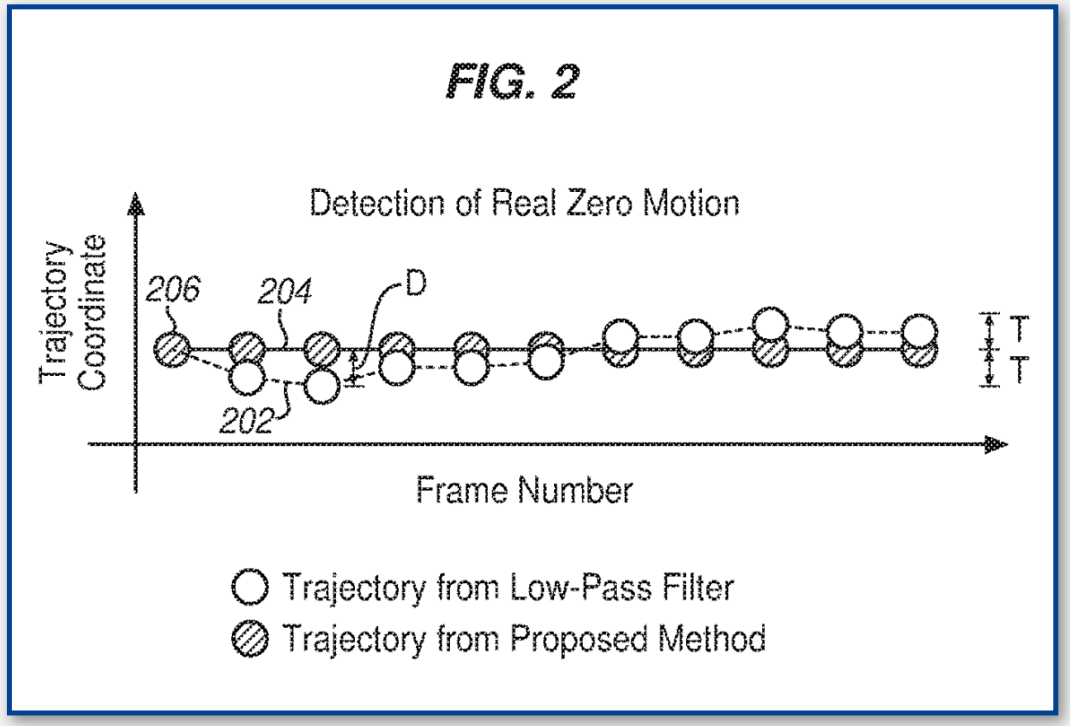
ments that the Gaussian filter cannot remove. As an example, the smoothed trajectory from the zero motion stabilization is projected into future frames, for example, the next five frames. This is compared to the Gaussian filtered next five frames to characterize the video as zero motion or not.

Cai (-1165 Ex. 1009), 9:13-18

Petition (-1165 Paper 2), 33-34; Reply (-1165 Paper 28), 17-25
Katsaggelos Dec. (-1165 Ex. 1003), ¶¶ 111-115; Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 100-127

Cai Teaches "temporal horizon enabling approximation of intentional motion"

Cai's zero-motion detection considers future frames



Cai (-1165 Ex. 1009), Fig. 2

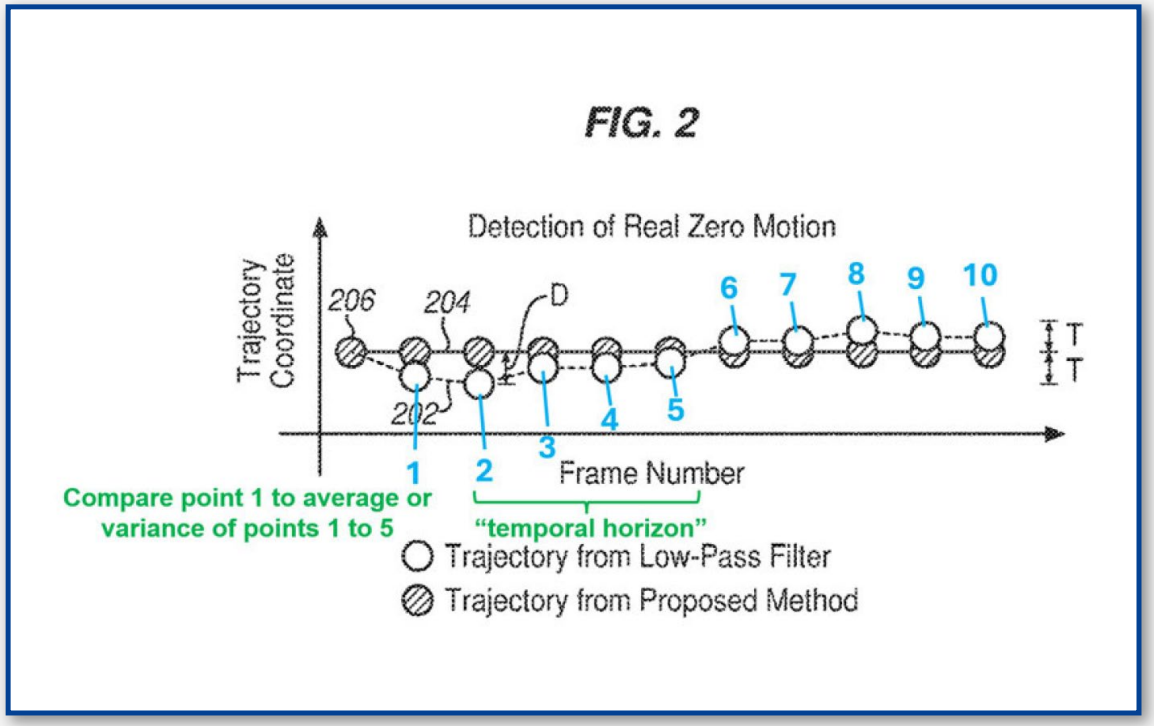
The filtered video frames are then supplied to zero motion detection **706**. If the video is determined to be a zero motion video, then the frames are further stabilized **708** based on a selected anchor point. This eliminates even small movements that the Gaussian filter cannot remove. As an example, the smoothed trajectory from the zero motion stabilization is projected into future frames, for example, the next five frames. This is compared to the Gaussian filtered next five frames to characterize the video as zero motion or not.

Cai (-1165 Ex. 1009), 9:8-18

Petition (-1165 Paper 2), 33-34; Reply (-1165 Paper 28), 17-25
Katsaggelos Dec. (-1165 Ex. 1003), ¶¶ 111-115; Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 100-127

Cai Teaches "temporal horizon enabling approximation of intentional motion"

Cai's zero-motion detection considers future frames



Cai (-1165 Ex. 1009), Fig. 2 (annotated)
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 106-107

> As a further alternative, a mean or a variance or both of the coordinate values for a short set of frames, e.g. five or ten of the low-pass filtered predicted trajectory frames may be compared to each of the frames in the short set of frames. If the difference between the mean and any one particular frame is less than a threshold, then the sequence may be determined to be a zero-motion sequence for that frame.

Cai (-1165 Ex. 1009), 5:16-22

Petition (-1165 Paper 2), 33-34; Reply (-1165 Paper 28), 17-25
Katsaggelos Dec. (-1165 Ex. 1003), ¶¶ 111-115; Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 100-127

Cai Teaches "temporal horizon enabling approximation of intentional motion"

GoPro cherry-picked embodiments and ignored embodiments that consider future frames

GoPro

and future frames. The actual discussion describes two techniques for comparing the filtered and zero-motion trajectories: (1) comparing a threshold to "the gap between the ***last*** low pass filter coordinate and the current low pass filter coordinate," EX1009, 4:33-36, and (2) comparing a threshold to the gap between the current filtered coordinate and the ***corresponding*** zero-motion coordinate, *id.*, 4:45-56. Neither involves a "look-ahead" to future frames.

PO Sur-Reply (-1165 Paper 33), 19-20

Cai

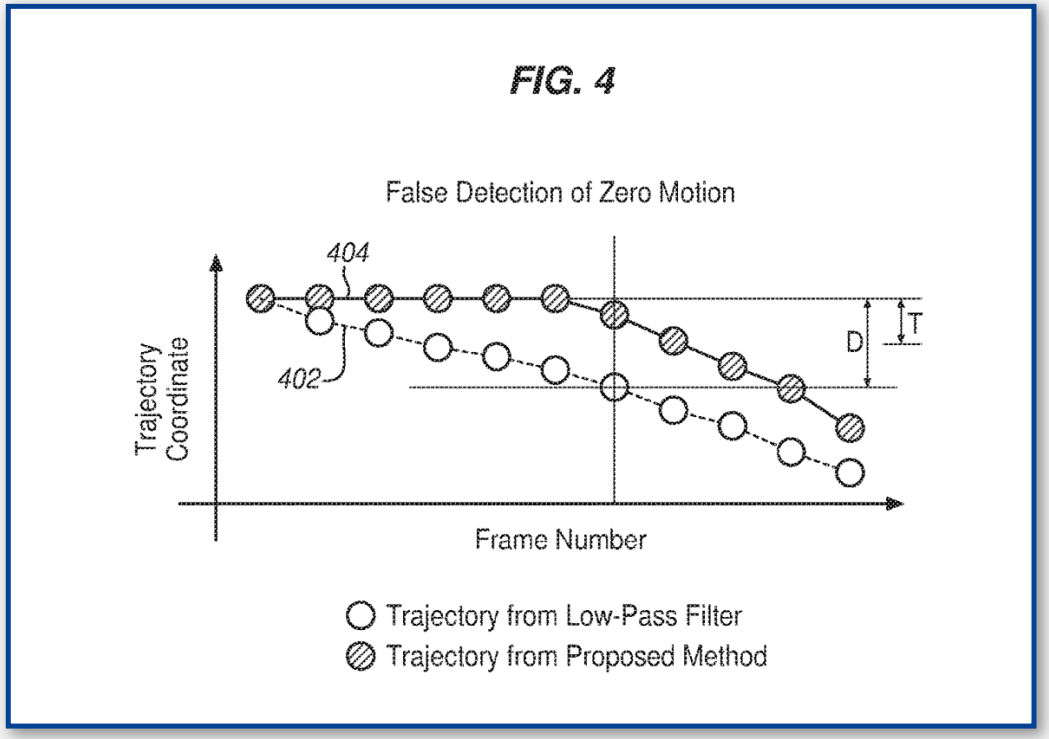
The comparison of coordinates may be performed in a variety of different ways. First, the coordinates of one

Cai (-1165 Ex. 1009), 4:57-58

Reply (-1165 Paper 28), 17, 23
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 108, 118

Cai Teaches "temporal horizon enabling approximation of intentional motion"

GoPro misunderstands Figure 4



Cai (-1165 Ex. 1009), Fig. 4

Cai distinguishes the following movements:

True zero motion. Cai teaches a variety of ways to detect zero motion. In this scenario, the user intended for the camera to stay still. (Ex. 1009, 3:65-66.)

Unintended motion. When Cai determines a true zero motion, all movement is unintended. The unintended motion, or jitter, is removed. (Ex. 1009, 5:37-40.)

Intended motion. When Cai determines a motion is not zero-motion, the low-pass filtered result of that motion is the intended motion. The unintended motion is the motion filtered out by the low-pass filter. (Ex. 1009, 4:7-9.)

Reply (-1165 Paper 28), 17
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 93-97

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3. **Instituted Grounds** →
4. Secondary considerations

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- “temporal horizon enabling approximation of intentional motion”
- **“stickiness parameter”**
- motivation to combine:
  - Bell + Shi
  - Zhou + Cai
- “weight-balance parameter”
- motivation to combine:
  - Kwatra + Bell/Zhou + Shi

“stickiness parameter” (claims 1, 15, 16, 17) -1165: Ground 1 (Zhou + Cai)

"stickiness parameter"

A "stickiness parameter" need not be independent or to prefer past frames

Insta360 and GoPro's interpretation

A parameter that controls the extent by which preceding portion(s) of the (observed) trajectory impacts determination of the smoothed trajectory

Reply (-1165 Paper 28), 13; POR (-1165 Paper 19), 38

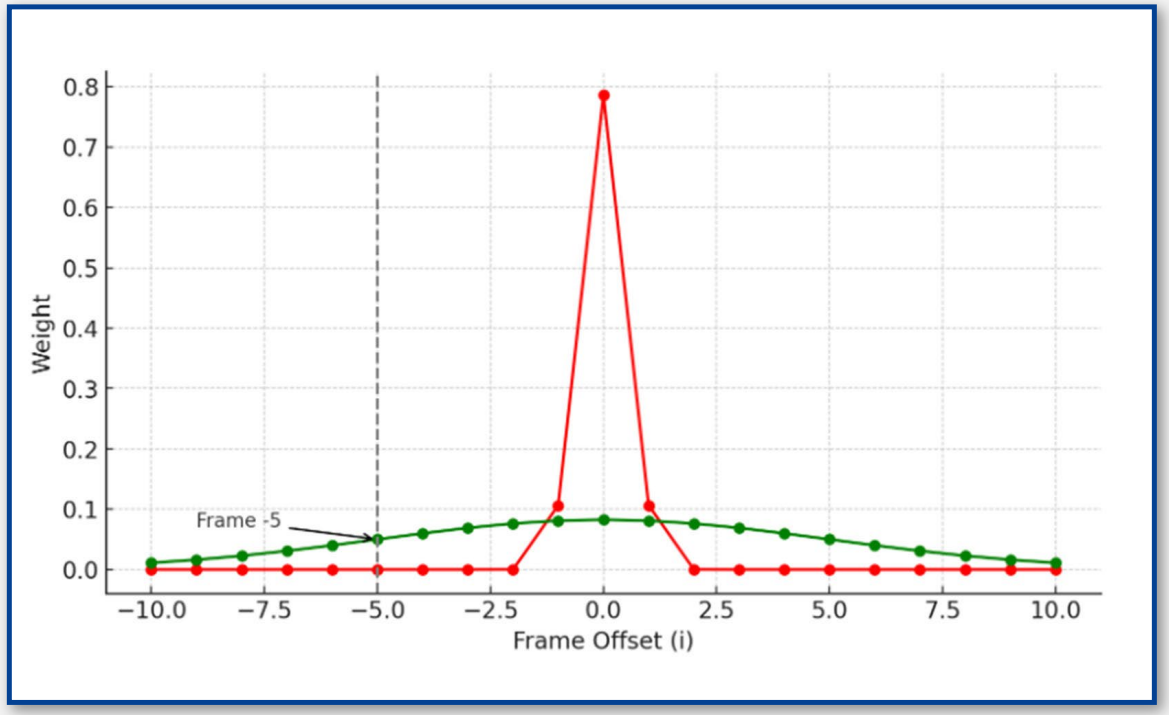
A stickiness parameter may refer to a parameter that control the extent by which preceding portion(s) of the (observed) trajectory impacts determination of the smoothed trajectory. A stickiness parameter may range between 0 and 1. The stickiness parameter of 1 may result in a "lazy" stabilizer that maximizes the impact of the preceding motion/position, unless the future motion/position indicate that the lazily determined smoothed trajectory will result in the violation of the margin constraint. The stickiness parameter of 0 may result in the smoothed trajectory being generated without taking the preceding portion(s) of the (observed) trajectory into account. A value between 0 and 1 may change the extent by which preceding portion(s) of the (observed) trajectory impacts determination of the smoothed trajectory. The value of the stickiness parameter may impact

'840 Patent (Ex. 1001), 22:22-36

Reply (-1165 Paper 28), 13
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 77-83

Zhou Teaches "stickiness parameter"

Zhou's stickiness parameter has different impact on past frames



Reply (-1165 Paper 28), 16;
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶ 83

83. The weighting function in Zhou satisfies that. As shown in the below figure, one can adjust the weight function (red curve) so that the weight for frame -5 is zero. Or one can adjust the weighting function (green curve) so that the weight for frame -5 is maximized or at least significant. Moreover, the use of a Gaussian is one embodiment (example). A POSITA could use a non-symmetric function, such as the skew normal distribution.

Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶ 83
Reply (-1165 Paper 28), 15

Roadmap

1. The ’840 and ’894 Patents
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- “low-light high-pass parameter”
- “temporal horizon enabling approximation of intentional motion”
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  - **Bell + Shi**
  - Zhou + Cai
- “weight-balance parameter”
- motivation to combine:
  - Kwatra + Bell/Zhou + Shi

Obvious to Combine Bell and Shi

GoPro's sole argument mischaracterizes Bell

GoPro

Petitioner provides no explanation for how Bell's system can accommodate Shi's coefficient based on a motion blur kernel without compromising the balance that Bell establishes between dampening and accelerating the virtual camera motion. *See Juniper*, --- F.4th ---, 2024 WL 3517862, at *6 (Fed. Cir.

POR (-1164 Paper 19), 35

and that hypothesis should be used. If the hypothetical crop polygon **340** falls outside the inner region, then the virtual camera needs to move faster or slower to match the physical camera and avoid letting the crop polygon go out of frame.

Bell (-1164 Ex. 1006), 9:22-25

video stabilization. All Bell teaches is that the virtual camera position (*i.e.*, the "smoothed trajectory") is adjusted so that the corresponding crop polygon ("viewing window") can fit in the output frame. (EX1003, ¶¶171-178.) The '840

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 100
see also ¶ 99, Reply (-1164 Paper 29), 10-11

Reply (-1164 Paper 29), 10-11
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 99-100

Obvious to combine Bell and Shi

In some implementations, the determination of the smoothed trajectory of the housing based on the subsequent portion of the trajectory may further include: (1) determining whether the placement of the viewing window for the visual content at the first moment results in one or more portions of the viewing window exceeding the field of view of the visual content; and (2) responsive to a determination that the portion(s) of the viewing window for the visual content at the first moment exceeds the field of view of the visual content, adjusting the corresponding rotational position of the housing within the smoothed trajectory at the first moment such that the viewing window for the visual content at the first moment does not exceed the field of view of the visual content.

'840 Patent (Ex. 1001), 3:38-51

stabilization works. The so-called "delicate balance" in Bell to keep the virtual camera crop window within the boundaries of the image frame is a standard part of video stabilization. All Bell teaches is that the virtual camera position (*i.e.*, the

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 100

101. Shi also discloses this standard step of video stabilization.

Specifically, Shi teaches:

> ***[T]he virtual camera position can be adjusted*** through filtering of device positions based on movement detected before and after a frame, based on an amount of blur in the frame, based on a likelihood that panning is occurring, through adjustments to prepare for motion in future frames, and/or ***to ensure that image data covers an entire output frame***.

(EX1007, 11:18-24 (emphasis added).) It further teaches:

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 101

Reply (-1164 Paper 29), 10-11

Obvious to Combine Bell and Shi

Combining Shi's coefficient with Bell would not compromise Bell's stabilization

> 102. Accordingly, Shi's video stabilization system involves (a) a similar step of making sure that the projection corresponding to the virtual camera motion ("viewing window" corresponding to "smoothed trajectory") matches the output frame and (b) the coefficient for motion blur compensation ("low-light high-pass parameter"). A POSITA would have been motivated to combine Shi's coefficient with Bell's system, which also involves the standard step of making sure that the crop polygon corresponding to the virtual camera motion ("viewing window" corresponding to "smoothed trajectory") matches the output frame.

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 102; Reply (-1164 Paper 29), 10-11

ITC Has a Higher Standard of Proof

ITC Requires Clear & Convincing Evidence.

D. Validity

Patents are presumed valid. *See* 35 U.S.C. § 282; *Microsoft Corp. v. i4i Ltd. P'ship*, 131 S. Ct. 2238, 2242–43 (2011). A party asserting patent invalidity has the burden of overcoming this presumption by clear and convincing evidence. *See Microsoft*, 131 S. Ct. at 2243.

550 U.S. 398, 417–418 (2007). Thus, when a respondent relies on a combination of multiple prior art references to show obviousness, "the burden falls on the patent challenger to show by clear and convincing evidence that a person of ordinary skill in the art would have had reason to attempt to make the composition or device, or carry out the claimed process, and would have had a reasonable expectation of success in doing so." *PharmaStem Therapeutics, Inc. v. ViaCell, Inc.*, 491 F.3d 1342, 1360 (Fed. Cir. 2007) (citations omitted). Because obviousness is not determined at the time

ITC Initial Determination (Ex. 2052), 57, 58

ITC found claims 1 and 14 invalid in view of Pixel 2, which inventors of Shi worked on.

The evidence also supports a "low-light high pass parameter" is present in Pixel 2.

irrelevant. The evidence supports that element 1[h] is disclosed in Pixel 2 and that claim 1 is invalid as anticipated.

The evidence supports that claim 14 is anticipated by Pixel 2.

ITC Initial Determination (Ex. 2052), 102, 105, 106

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. **Instituted Grounds** →
4. Secondary considerations

- “low-light high-pass parameter”
- “temporal horizon enabling approximation of intentional motion”
- “stickiness parameter”
- **motivation to combine:**
  - Bell + Shi
  - **Zhou + Cai**
- “weight-balance parameter”
- motivation to combine:
  - Kwatra + Bell/Zhou + Shi

Obvious to Combine Zhou and Cai

Cai is not limited to a strict zero-motion condition.
Regardless, Zhou disclose a zero-motion detection.

and blur compensation. A POSITA combining Zhou and Cai would have known to apply less stabilization strength when motion is detected in order to address blur. When zero motion is detected, a POSITA would apply the same approach disclosed by Zhou and Cai, and classify the motion as stationary and apply "very strict stabilization."

Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 132-133

and the low-pass filter outputs a filtered trajectory. Since the low-pass filter removes most of the jitter motion, the filtered trajectory primarily shows the real intended motion of the camera. Consequently, video sequences can be determined to be either zero-motion video or non-zero motion by analyzing features of the filtered trajectory.

Cai (-1165 Ex. 1009), 4:6-11

accordance with that value. For example, if no motion is detected, it may be possible to classify the "type of motion" as stationary and, as a result, apply very strict stabilization. If, on the other hand, a lot of camera motion is detected along a single axis, it may be possible to classify the type of motion as "strolling" (i.e., akin to what would be captured if the video was being recorded while the user was walking), at which point a different video stabilization strength value may be applied. One approach to video stabilization

Zhou (-1165 Ex. 1006), 3:51-59

Reply (-1165 Paper 28), 25

Obvious to Combine Zhou and Cai

Zhou expresses motivation for distinguishing between intentional and unintentional motion

GoPro

approximation of intentional notion" feature. Ex. 2018, ¶ 122. Zhou expresses no motivation for distinguishing between intentional and unintentional motion, focusing instead on the general blur problem that it seeks to address. *Id.* Zhou,

POR (-1165 Paper 19), 54

One approach to video stabilization that makes use of a tunable video stabilization strength value is to first determine what sort of activity is causing the detected camera motion, set the tuning value accordingly, and stabilize in accordance with that value. For example, if no motion is

Zhou (-1165 Ex. 1006), 3:47-51

100's ability to look into the "future" provides it a unique ability to anticipate abrupt movements in the future and begin adjusting the strength value of values before the abruptness occurs so that visible jumps or glitches in the final video sequence may be reduced or eliminated. Next, a the same.) As will be discussed in more detail, operation

Zhou (-1165 Ex. 1006), 10:1-10:5

Reply (-1165 Paper 28), 26
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 131-133, 140-148

Obvious to Combine Zhou and Cai

Zhou does not discourage a "sufficiently long" temporal horizon

GoPro

focusing instead on the general blur problem that it seeks to address. *Id.* Zhou, in fact, discourages the type of "sufficiently long" temporal horizon that would be required to enable approximation of intentional motion, teaching instead how buffering frames "can be expensive in terms of memory (e.g., one frame at 1080p video resolution can be between 2 and 3 megabytes, MB)." Ex. 1006 at 4:62-5:2.

POR (-1165 Paper 19), 54

looks into the "future." In one embodiment, frame buffer **205** may store a specified number of frames (e.g., 16, 24, 32).

Zhou (-1165 Ex. 1006), 4:60-61

As a further alternative, a mean or a variance or both of the coordinate values for a short set of frames, e.g. five or ten of the low-pass filtered predicted trajectory frames may be compared to each of the frames in the short set of frames. If

Cai (-1165 Ex. 1009), 5:16-19

Reply (-1165 Paper 28), 27
Katsaggelos Suppl. Dec. (-1165 Ex. 1017), ¶¶ 135-139

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. **Instituted Grounds** →
4. Secondary considerations

- “low-light high-pass parameter”
- “temporal horizon enabling approximation of intentional motion”
- “stickiness parameter”
- motivation to combine:
  - Bell + Shi
  - Zhou + Cai
- **“weight-balance parameter”**
- motivation to combine:
  - Kwatra + Bell/Zhou + Shi

"weight-balance parameter" ('840 Patent)

Claim 13

13. The image capture system of claim 1, wherein the weight-balance parameter controls types of motion that are minimized in smoothed trajectory generation, the types of motion including rotational velocity and rotational acceleration.

'840 Patent (Ex. 1001), Claim 13

"minimizes a combination of rotational velocity and rotational acceleration" ('894 Patent)

Claim 1

1[g][v]

observed trajectory, wherein the capture trajectory is determined to include a path that minimizes a combination of rotational velocity and rotational acceleration of the housing, the combination of the rota-

'894 Patent (Ex. 1001), Claim 1

Claim 11

11[d]

smoother changes than the observed trajectory, wherein the capture trajectory is determined to include a path that minimizes a combination of rotational velocity and rotational acceleration of the housing, the combination

'894 Patent (Ex. 1001), Claim 11

“weight-balance parameter” (claims 13, 17) -1165: Ground 4 (Zhou + Cai + Bell Paper)

Zhou, Cai, and Bell Paper Teach a "weight-balance parameter"

Bell Paper teaches "minimiz[ing] motion in smoothed trajectory generation, the types of motion including rotational velocity and rotational acceleration"

inside the input frame. When the camera is nearly still, our virtual camera is fixed, removing all jitter. When moving, our method acts like a variable IIR

Bell Paper (-1165 Ex. 1004), 296

filtering of [1], and a stabilized video produced with our method. Our method dramatically reduces the jitter in angular velocity, and even removes it when possible, thus producing smoother results. The fountain video shows that we

Bell Paper (-1165 Ex. 1004), 304

camera smoothly. In the walking video, our method removes most of the angular acceleration, producing an output video which is pleasing to view. The smoothed

Bell Paper (-1165 Ex. 1004), 304

Petition (-1165 Paper 2), 72; Reply (-1165 Paper 28), 27-29

Zhou, Cai, and Bell Paper Teach a "weight-balance parameter"

GoPro misrepresents that Insta360 made new argument

GoPro

In its Reply, Petitioner concedes that the Bell Paper itself does not disclose a "weight-balance parameter," claiming that the Petition instead relies on Zhou's "stabilization strength parameter as the claimed 'weight-balance parameter.'" Reply, 29. This is an improper new argument—the Petition nowhere asserts that Zhou discloses a "weight-balance parameter." Petition, 23-28, 71-72. Rather, it asserts that Zhou discloses that its "stabilization strength parameter controls the amount of smoothing applied to generate the smoothed trajectory" and that "video may be stabilized . . . against rotation," but concedes that Zhou "does not specify the types of rotational motion minimized." Petition, 71.

Sur-Reply (-1165 Paper 33), 28

As discussed for claim element 1[g][i], Zhou discloses that the stabilization strength parameter controls the amount of smoothing applied to generate the smoothed trajectory. (*Supra* § IV.A.3.1.)

Petition (-1165 Paper 2), 71

The Zhou, Cai, and Bell Paper combination teach that the video stabilization operation can use the stabilization strength parameter to minimize angular velocity and angular acceleration. (EX1003, ¶¶263-265.)

Petition (-1165 Paper 2), 72

Katsaggelos Dec. (-1165 Ex. 1003), ¶¶ 259-265

“weight-balance parameter” (claims 13, 17)

-1164: Ground 5 (Bell + Shi + Kwatra)

“minimizes a combination of rotational velocity and rotational acceleration” (claims 1, 11)

-1186: Ground 1 (Zhou + Kwatra)

Kwatra Teaches Minimizing Rotational Motion

’840 and ’894 Patents

$$\min\left(\left\| \frac{d}{dt}\theta \right\|^2 + \left\| \frac{d^2}{dt^2}\theta \right\|^2 + \dots \right)$$

First derivative (velocity)

Second derivative (acceleration)

’840 Patent (Ex. 1001),17:48-53
see also ’894 Patent (Ex. 1001),11:10-15

Kwatra

from Equation (5). The optimization may determine a stable camera path P(t) by minimizing the cost function:

$$a\left|\frac{dP}{dt}\right| + b\left|\frac{d^2P}{dt^2}\right| + c\left|\frac{d^3P}{dt}\right|$$

Equation (7)

First derivative (velocity)

Second derivative (acceleration)

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005),13:66-14:5

Petition (-1186 paper 2), 1, 2, 10, 31-33

Kwatra Teaches Minimizing Rotational Motion

31. Because the motion models that Kwatra uses to represent the original camera motion path can and do encompass rotational movement, the original camera motion path must also include rotational movement. Kwatra discloses that first, "an estimate of the original camera path motion is received." (EX1005, 13:5-6.) Kwatra discloses that afterwards, the "optimization may determine a stable camera path P(t) by minimizing the cost function" in equation 7:

$$a\left|\frac{dP}{dt}\right| + b\left|\frac{d^2P}{dt^2}\right| + c\left|\frac{d^3P}{dt}\right|$$

Ex. 1005, 13:62-14:12. The path that is being minimized in equation 7 must also encompass rotational movement.

Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶ 31
see also -1164 Ex. 1017, ¶ 136

Reply (-1186 Paper 25), 3-4
Reply (-1164 Paper 29), 15

Kwatra Teaches Minimizing Rotational Motion

Kwatra's original camera path encompasses rotational movement.

exposure. Image stabilization techniques may compensate for pan and tilt (angular movement) of a camera or other imaging device. With still cameras, camera shake can be

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 1:17-19

able motion models. In still another example, if a highest dimension motion model is deemed unreliable (e.g., too much rotation, scale or perspective) other computed models may be flagged as unreliable. A heuristic may be used that labels each

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 11:63-66

formations. For example, in a similarity transform, a combination of scale, rotation and translation can be used. A

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 17:7-8

results in a constant feature point velocity. As still another example, for camera rotation, feature point motion derivatives may diminish as a square of angular velocity.

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 18:54-56

Reply (-1186 Paper 25), 3-15; Reply (-1164 Paper 29), 14-24
Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶¶ 19-74; Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 124-178

Kwatra Teaches Minimizing Rotational Motion

GoPro's Development Document

[redacted]

GOPRO_00183699 (-1164, -1186 EX. 1022), 18

Kwatra

from Equation (5). The optimization may determine a stable camera path P(t) by minimizing the cost function:

$$a\left|\frac{dP}{dt}\right| + b\left|\frac{d^2P}{dt^2}\right| + c\left|\frac{d^3P}{dt}\right| \qquad \text{Equation (7)}$$

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 13:66-14:5

Kwatra Paper

video. The optimization serves to find the optimal stable camera path $P(t)$ minimizing the objective

$$\mathcal{O}(P) = w_1|D(P)|_1 + w_2|D^2(P)|_1 + w_3|D^3(P)|_1 \quad (3)$$

Kwatra Paper (-1164, -1186 Ex. 1023), 227

Reply (-1186 Paper 25), 13-14
Reply (-1164 Paper 29), 22-24

Kwatra Teaches Minimizing Rotational Motion

Imposing smoothness constraints on "a" and "b" smoothes rotation θ

a]*x+t]. While t corresponds to translation, scale and rotation are related to a,b as:

Scale: $s=\sqrt{(a^2+b^2)}$ Equation (17)

Rotation angle: $\theta=a\tan(b/a)$ Equation (18)

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 17:11-16

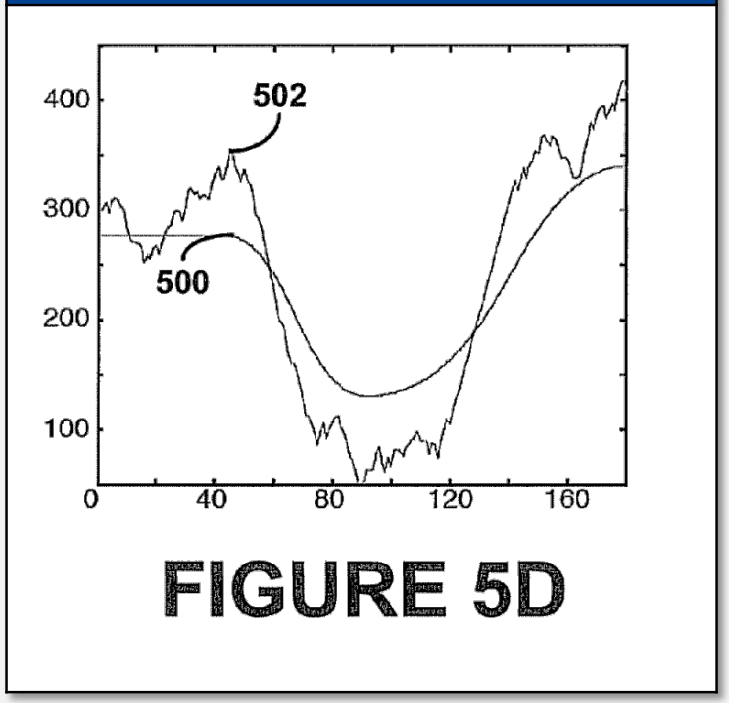
Because rotation (θ) is only related to a and b, a POSITA would understand that imposing smoothness constraints on a and b smoothes rotation (θ). (EX1017, ¶142.) Although Kwatra does not operate directly on rotation (θ), constraining a and b achieves the same functional result. (EX1017, ¶¶142-143.) Thus, GoPro's argument that rotation (θ) is not directly bounded misses the point. Bounding a and b mathematically controls and smooths rotation. (EX1017, ¶143.)

Reply (-1164 Paper 29), 17
see also Reply (-1186 Paper 25), 6-7

Reply (-1164 Paper 29), 16; Reply (-1186 Paper 25), 5-6
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 139-143; Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶¶ 35-38

Kwatra Teaches Minimizing Rotational Motion

Minimizing Rotation Velocity and Rotational Acceleration



Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), Fig. 5D
Katsaggelos Depo. (EX. 2020), 67:21-68:2

exposure. Image stabilization techniques may compensate for pan and tilt (angular movement) of a camera or other imaging device. With still cameras, camera shake can be

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 1:17-19

When recasting the video, original camera motions may result in equivalent smooth motion of feature points with certain assumptions. For example, for camera translation, if a

results in a constant feature point velocity. As still another example, for camera rotation, feature point motion derivatives may diminish as a square of angular velocity.

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 18:44-46, 18:54-56

Reply (-1186 Paper 25), 9; Reply (-1164 Paper 29), 19
Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶¶ 44-46; Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 148-150

Kwatra Teaches Minimizing Rotational Motion

Non-Limiting Exemplary Graphs

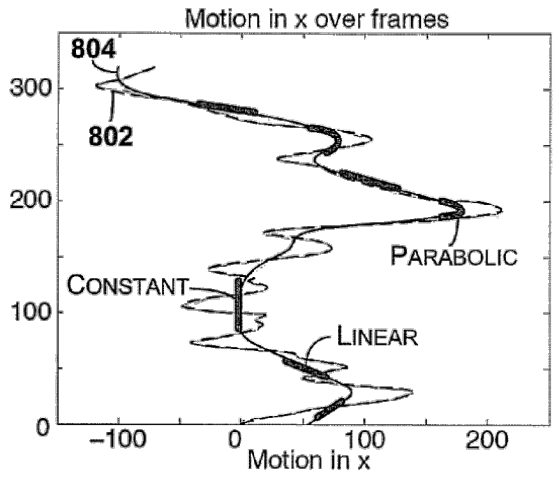


FIGURE 8A

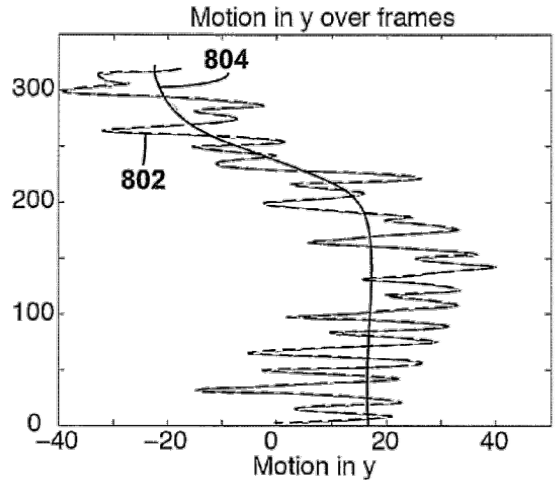


FIGURE 8B

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), Figs. 8A, 8B

FIGS. **8A-8B** illustrate example graphs of an original camera path motion **802** versus an updated or smooth camera path motion **804**. For example, FIG. **8A** illustrates motion along

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 19:4-6

Reply (-1186 Paper 25), 9; Reply (-1164 Paper 29), 19

Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶¶ 44-46; Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 148-150

Kwatra Teaches Minimizing Rotational Motion

Kwatra's provisional application undercuts GoPro's position

When the camera motion model is pure translation, minimizing derivatives of P(t) is straightforward. When it is a similarity transform however, it is a combination of scale, rotation and translation. Our model imposes smoothness on the parameters of P(t), which are a,b,t (see similarity equation above). While t directly corresponds to translation, scale, and rotation are related to a,b as:

Scale, s = sqrt(a^2 + b^2)
Rotation angle, theta = atan(b/a)

Kwatra Provisional (Ex. 2019), 5

Reply (-1186 Paper 25), 7-9; Reply (-1164 Paper 29), 17-19
Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶¶ 40-43; Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶¶ 144-147

Kwatra Teaches Minimizing Rotational Motion of the Housing

The ’894 and ’840 Patents are not limited to 3D

53. Finally, GoPro and Dr. Foroosh’s emphasis on 2D vs 3D modelling misses the point. The ’894 patent does not mention 2D or 3D motion at all. The ’894 patent at no point limits its invention to 3D motion only. Nor does Dr. Foroosh or GoPro identify any. Dr. Foroosh in fact concedes that “the claims do not explicitly” reference 3D rotation. (EX2018, ¶37.)

Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶ 53
see also -1164 Ex. 1017, ¶ 157

GoPro does not dispute certain 2D models can represent 3D motion

50. Other models such as homography, on the other hand, can represent types of 3D motion. A homography, although in strict terms, is a 2D projective transformation, can represent 3D motions and simulate the visual effects of certain 3D motions in the image plane. For example, it captures perspective distortion, vanishing points, and projective warping, which are key perceptual indicators of 3D camera movement.

Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶ 50
see also -1164 Ex. 1017, ¶ 154

Reply (-1186 Paper 25), 10-11
Reply (-1164 Paper 29), 20-21

Kwatra Teaches Minimizing Rotational Motion of the Housing

GoPro's expert confirms 3D information can be reconstructed from a 2D video

Q. So, when you were calculating the depth, you were looking at how fast the pixel moved between frames?

A. You can -- the better way of describing it, for each pixel, we found that parallax effect or disparity, we calculated disparity, and you need to take additional steps like camera calibration and so on and so forth. In this case, we have multiple cameras. They are a lot more involved, you know, synchronization and so on and so forth.

But more or less, you're right in the sense that you look at how much each pixel is moving plus additional information that you have, you convert that into depth information.

Foroosh Depo. (-1164 Ex. 1018), 24:16-25:5

Reply (-1186 Paper 25), 12
Reply (-1164 Paper 29), 22

Kwatra Teaches Minimizing Rotational Motion of the Housing

Kwatra discloses estimating motion of a camera

may distort motion estimation. Linear motion models (e.g., translation, similarity, affine) may be fit to the tracked features to estimate a motion of the camera between two frames, and the motion models can be transformed to a common coordinate system and concatenated to yield an estimated original camera path over all frames of the video.

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 5:48-53

lation engine. The camera path estimation engine may be configured to receive a video, and to estimate an original motion path of a camera that recorded the video based on motion of objects within the video. The video stabilization

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 2:28-31

Reply (-1186 Paper 25), 12-13
Reply (-1164 Paper 29), 22

Bell, Shi, and Zhou teach 3D motion

Embodiments in accordance with the present invention model the camera motion as a rotation in a global coordinate frame. The motion sensing system provides a series of

Bell (-1164 Ex. 1006), 7:40-42

a particular view or perspective of a scene. In general, any camera position can be represented by its rotation and translation with respect to a global reference frame. The

Shi (-1164 Ex. 1007), 11:1-3

4.) Calculating the camera rotation during the exposure period, i.e., the camera orientation change from the start of integration to the end of integration; and

Zhou (-1186 Ex. 1004), 5:48-50

the image, e.g., location-adaptive blur, blur estimates that take rotational motion in all three axes into account, etc. For

Zhou (-1186 Ex. 1004), 6:4-5

relies upon from Zhou and Shi teach video image stabilization strategies, implemented in mobile devices that make use of an on-board position sensor to estimate the 3-dimensional motion of the mobile device itself. *Id.* Kwatra,

POR (-1186 Paper 17), 30

Reply (-1186 Paper 25), 10-11
Reply (-1164 Paper 29), 20-21

Kwatra Teaches Minimizing Rotational Motion

ITC found Kwatra does not minimize rotational motion based on incorrect understanding of "linear motion model"

> to the function in its equation (7). RX-1565 at 13:61–14:5 and 19:4–38. That Kwatra is focused on linear motion is supported not only by Mr. Goodin's deposition testimony, but by its disclosure that "[l]inear motion models (e.g., translation, similarity, affine) may be fit to the tracked features to estimate a motion of the camera between two frames, and the motion models can be transformed to a common coordinate system and concatenated to yield an estimated original camera path over

ITC Initial Determination (Ex. 2052), 67

Reply (-1164 Paper 29), 14-15; Reply (-1186 Paper 25), 3-4

Kwatra Teaches Minimizing Rotational Motion

ITC found Kwatra does not minimize rotational motion based on incorrect understanding of "linear motion model"

127. **Linear motion model.** A linear motion model is a mathematical model that describes how the state of a moving object evolves over time using linear transformations. While some linear motion models are traditionally associated with translational movement, they can also encompass rotational movement. For example, a similarity linear model, an affine linear model, a linearized 6-DOF model, a homography linear model, and a Euclidean linear model can all describe motions including rotational movement. Kwatra, for example, teaches that a linear motion model can include "similarity (2 DOF translation, 1 DOF scale, 1 DOF rotation), affine (6 DOF), or a homography (8 DOF)." (EX1012, 11:9-11.)

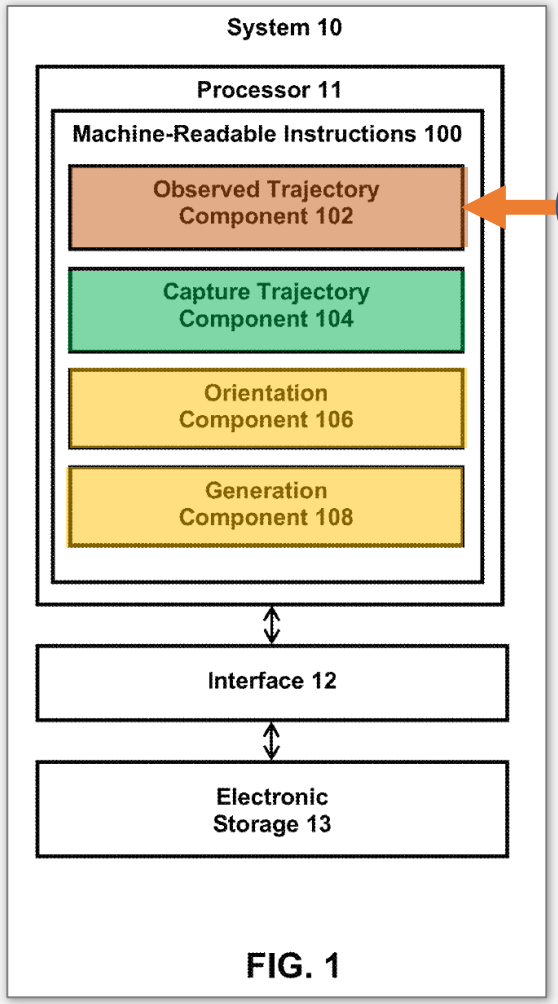
Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 127
see also -1186 Ex. 1017, ¶ 22

Reply (-1164 Paper 29), 14-15; Reply (-1186 Paper 25), 3-4

“the position information is determined independent of the image information” (claim 5)

-1186: Ground 1 (Zhou + Kwatra)

Zhou and Kwatra Disclose Claim 5



'894 Patent (Ex. 1001), Fig. 1

1 Motion Estimation

5. The system of claim **1**, wherein the position sensor includes a gyroscope, an accelerometer, and/or an inertial measurement unit, and the position information is determined independent of the image information.

'894 Patent (Ex. 1001), Claim 5

The method includes capturing a first time-sequenced set of images (e.g., a video stream), where each image has a capture time and motion information (the motion information provided by one or more motion sensors such as gyroscopes or accelerometers). Next, the method includes

Zhou (-1186 Ex. 1004), 2:12-16

Petition (-1186 Paper 2), 16-18
Reply (-1186 Paper 25), 16-27
Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶¶ 83-84

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. **Instituted Grounds** →
4. Secondary considerations

- “low-light high-pass parameter”
- “temporal horizon enabling approximation of intentional motion”
- “stickiness parameter”
- motivation to combine:
  - Bell + Shi
  - Zhou + Cai
- “weight-balance parameter”
- **motivation to combine:**
  - **Kwatra + Bell/Zhou + Shi**

GoPro Mischaracterizes Kwatra

Kwatra is not limited to image-based motion estimation

on motion of objects or images within the received video. A camera path may be estimated by extracting trackable features in frames of the video, matching features, and performing local outlier rejection to remove spurious matches that may distort motion estimation. Linear motion models (e.g.,

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 5:43-46

166. The industry standard methods in video stabilization, augmented reality, and visual SLAM routinely rely on 2D pixel displacement to infer and smooth camera motion — including rotation — in the 3D space. In other words, pixel displacement is the observable manifestation of 3D rotation in image-based systems.

Katsaggelos Suppl. Dec. (-1164 Ex. 1017), ¶ 166
Katsaggelos Suppl. Dec. (-1186 Ex. 1017), ¶ 62

Reply (-1164 Paper 29), 21
Reply (-1186 Paper 25), 11-12

GoPro Mischaracterizes Kwatra

Kwatra is not limited to server application

GoPro

and contradicted by Kwatra itself. Ex. 2018, ¶ 90. For example, while Dr. Katsaggelos cites Figure 13 and its associated discussion, Ex. 1002 at ¶ 117, that discussion merely provides that generic "computing device 1300" can comprise a server or a mobile device and "may be implemented as a client device, a server, a system, a combination thereof, or as a portion of components ***described in FIGS. 1-2***." Ex. 1005 at 26:11-21 (emphasis added); Ex. 2018, ¶ 90. Figures 1 and 2 provide an architecture in which the "camera

POR (-1186 Paper 17), 30

FIG. **3** is an example block diagram of a method to process a video to estimate an original motion of the camera or camera path, in accordance with at least some embodiments described herein. Method **300** shown in FIG. **3** presents an embodiment of a method that, for example, could be used with the systems **100** and **200**, for example, and may be performed by a device, a server, or a combination of the device and the server. Method **300** may include one or more

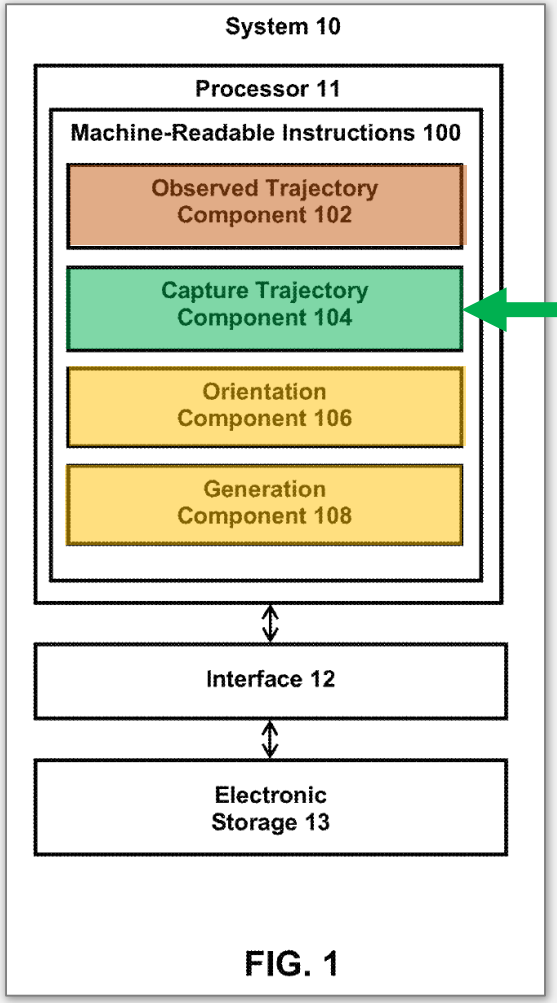
Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 7:6-13

FIG. **4** is an example block diagram of a method to process a video to estimate an updated or modified motion of the camera or camera path, in accordance with at least some embodiments described herein. Method **400** shown in FIG. **4** presents an embodiment of a method that, for example, could be used with the systems **100** and **200**, for example, and may be performed by a device, a server, or a combination of the device and the server. Method **400** may include one or more

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 12:57-64

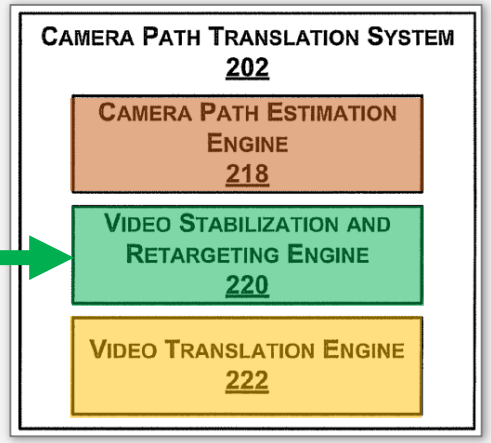
Reply (-1164 Paper 29), 24-27; Reply (-1186 Paper 25), 19-23, 27

Obvious to Combine Kwatra with Zhou or Bell +Shi



'894 Patent (Ex. 1001), Fig. 1
see also -1164 Ex. 1001, Fig. 1

2 Motion Smoothing



Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), Fig. 2

> The video stabilization and retargeting engine **220** may then estimate a new steady/smooth camera path based on constraints. For example, a base vertical line may be estab-

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 5:54-56

> A smooth camera path can be estimated using minimization of derivatives of the original camera path as estimated by the camera path estimation engine **218**. For example, a con-

Kwatra (-1164 Ex. 1012, -1186 Ex. 1005), 5:64-66

Reply (-1186 Paper 25), 16-27; Reply (-1164 Paper 29), 24-29

Obvious to Combine Kwatra with Zhou or Bell +Shi

Reply (-1186 Paper 25), 25-27; Reply (-1164 Paper 29), 27-29

Roadmap

1. The ’840 and ’894 Patents
2. Claim Construction
3. Instituted Grounds
4. **Secondary considerations**

GoPro Failed to Show HERO7 Practices the '840 and '894 Claims

Reply (-1186 Paper 25), 29; Reply (-1164 Paper 29), 29-30

GoPro Failed to Show HERO7 Practices the '840 and '894 Claims

GoPro

Dr. Foroosh also independently confirmed HERO7 practices the claims. He reviewed PO's DI charts (EX2016), analyzed the HyperSmooth "White Paper" (EX2026, CX-609C) and code. POR, 61-62, EX2018, ¶¶166-204.

PO Sur-Reply (-1164 Paper 33), 30
see also -1165 Paper 33, 30, -1186 Paper 32, 25-26

Decision on Institution

Patent Owner here has not attempted a nexus analysis in its Preliminary Response. At best, it improperly incorporates by reference a claim chart (Exhibit 2016) served in the related ITC proceeding. Prelim. Resp. 25; 37 C.F.R. § 42.6(a)(3) ("Arguments must not be incorporated by reference from one document into another document."). Even then, the

Decision on Institution (-1164 Paper 11), 16
see also -1165 Paper 11, 14, -1186 Paper 9, 37

Reply (-1164 Paper 29), 29-30; Reply (-1186 Paper 25), 28-29

GoPro Failed to Show the Requisite Nexus

Decision on Institution

its patents would have been non-obvious. For us to give substantial weight to objective indicia of non-obviousness, a proponent must establish a nexus between the evidence and the merits of the *claimed* invention. *ClassCo, Inc., v. Apple, Inc.*, 838 F.3d 1214, 1220 (Fed. Cir. 2016). "[T]here is no nexus unless the evidence presented is 'reasonably commensurate with the scope of the claims.'" *Id.* (quoting *Rambus Inc. v. Rea*, 731 F.3d 1248, 1257 (Fed. Cir. 2013)); *see also Wyers v. Master Lock Co.*, 616 F.3d 1231, 1246 (Fed. Cir. 2010) ("For objective evidence of secondary considerations to be accorded substantial weight, its proponent must establish a nexus between the evidence and the merits of the claimed invention.") (cleaned up).

Decision on Institution (-1164 Paper 11), 16

Reply (-1164 Paper 29), 30-32; Reply (-1186 Paper 25), 29-32

No Nexus to Commercial Success or Industry Praise

Reply (-1164 Paper 29), 30-32; Reply (-1186 Paper 25), 29-32

No Nexus to Commercial Success or Industry Praise

Reply (-1164 Paper 29), 30-32; Reply (-1186 Paper 25), 29-32

No Evidence of No Long-Felt but Unmet Need

Reply (-1164 Paper 29), 30-32; Reply (-1186 Paper 25), 29-32

No Evidence of Unexpected Results/Failure of Others

Reply (-1164 Paper 29), 30-32; Reply (-1186 Paper 25), 29-32

GoPro Admits Benchmarking Is Not Copying

Certificate of Service (37 C.F.R. § 42.6(e)(4))

I hereby certify that the attached PETITIONER'S ORAL ARGUMENT DEMONSTRATIVES was served as of the below date via email (by agreement) to the following counsel of record for Patent Owner:

James M. Glass, Registration No. 46,729
John T. McKee, Registration No. 65,926
Quincy Lu, Registration No. 76,954
Patrick Schmidt (*pro hac vice*)
Quinn Emanuel Urquhart & Sullivan LLP
Email: jimglass@quinnemanuel.com
Email: johnmckee@quinnemanuel.com
Email: quincylu@quinnemanuel.com
Email: patrickschmidt@quinnemanuel.com

Dated: October 21, 2025

/s/ Alex S. Yap
Alex S. Yap