

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSARA INC.
Petitioner

v.

MOTIVE TECHNOLOGIES, INC.
Patent Owner

Case IPR2025-00574
Patent No. 11,875,580

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 11,875,580**

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PETITIONER'S EXHIBIT LIST

Exhibit	Description
1001	U.S. Patent No. 11,875,580 to Hassan <i>et al.</i> (“Hassan”)
1002	Prosecution History of U.S. Patent No. 11,875,580
1003	Declaration of Dr. Trevor Darrell
1004	<i>Curriculum Vitae</i> of Dr. Trevor Darrell
1005	U.S. Publication No. 2020/0410704 to Choe <i>et al.</i> (“Choe”)
1006	Figures of U.S. Patent Application Publication No. 2020/0410704 to Choe <i>et al.</i> , <i>available at</i> the USPTO SCORE Database via Patent Center
1007	Khan <i>et al.</i> , “Lane Detection Using Lane Boundary Marker Network with Road Geometry Constraints,” <i>available at</i> https://ieeexplore.ieee.org/document/9093296 (May 14, 2020) and https://openaccess.thecvf.com/content_WACV_2020/html/Khan_Lane_detection_using_lane_boundary_marker_network_with_road_geometry_WACV_2020_paper.html (Mar. 2020) (“Khan”)
1008	Ali <i>et al.</i> , “Real-Time Vehicle Distance Estimation using Single View Geometry,” <i>available at</i> https://ieeexplore.ieee.org/document/9093634 (May 14, 2020) and https://openaccess.thecvf.com/content_WACV_2020/papers/Ali_Real-time_vehicle_distance_estimation_using_single_view_geometry_WACV_2020_paper.pdf (Mar. 2020) (“Ali”)
1009	He <i>et al.</i> , “Mask R-CNN” Version 3, <i>available at</i> https://arxiv.org/abs/1703.06870 (Jan. 24, 2018) (“He”)
1010	PCT Application Publication No. PCT/EP2019/056356 to Westmacot <i>et al.</i> (“Westmacot”)
1011	Scott Workman and Menghua Zhai and Nathan Jacobs, “Horizon Lines in the Wild,” <i>available at</i> https://arxiv.org/abs/1604.02129 (“Workman”)
1012	L. Jiao, <i>et al.</i> , “A Survey of Deep Learning-Based Object Detection,” IEEE Access vol. 7, p 128,837-128,868, 2019, <i>available at</i> https://arxiv.org/abs/1907.09408 . (“Jiao”)

Exhibit	Description
1013	B. C. Russell and A. Torralba, "Building a database of 3D scenes from user annotations," 2009 IEEE Conference on Computer Vision and Pattern Recognition, Miami, FL, USA, 2009, p 2711-2718 ("Russell")
1014	V. Bartl and A. Herout, "Fully Automatic Horizon Estimation for Surveillance Cameras," 2017 International Conference on Digital Image Computing: Techniques and Applications (DICTA), Sydney, NSW, Australia, 2017, p 1-8 ("Bartl")
1015	W. Rawat and Z. Wang, "Deep Convolutional Neural Networks for Image Classification: A Comprehensive Review," in Neural Computation, vol. 29, no. 9, p 2352-2449, Sept. 2017 ("Rawat")
1016	Declaration of Sylvia D. Hall-Ellis, Ph.D.
1017	Sylvia D. Hall-Ellis, Ph.D. Curriculum Vitae
1018	Attachment 1A to the Hall-Ellis Declaration – MARC Record for Ali
1019	Attachment 1B to the Hall-Ellis Declaration – MARC Record for Ali
1020	Attachment 1C to the Hall-Ellis Declaration – LOC Entry for Computer Vision Congresses
1021	Attachment 1D to the Hall-Ellis Declaration – LOC Entry for Optical Pattern Recognition Congresses
1022	Attachment 1E to the Hall-Ellis Declaration – IEEE Xplore Page for Ali, <i>available at</i> https://ieeexplore.ieee.org/document/9093634
1023	Attachment 1F to the Hall-Ellis Declaration – IEEE Digital Library Page for Ali, <i>available at</i> https://www.computer.org/csdl/proceedings-article/wacv/2020/09093634/1jPbBO7T7ji
1024	Attachment 1G to the Hall-Ellis Declaration – ResearchGate Page for Ali, <i>available at</i> https://www.researchgate.net/publication/341400645_Real-time_vehicle_distance_estimation_using_single_view_geometry
1025	Attachment 1H to the Hall-Ellis Declaration – SemanticScholar Page for Ali, <i>available at</i> https://www.semanticscholar.org/paper/Real-time-vehicle-distance-estimation-using-single-Ali-Has-san/1d48563e016ef0932c49a977944fafe61c4dea77

Exhibit	Description
1026	Attachment 1I to the Hall-Ellis Declaration – SJSU Library Page for Ali, <i>available at</i> https://csu-sjsu.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma991072196389102901&context=L&vid=01CALS_SJO:01CALS_SJO&lang=en&search_scope=MyInst_and_CI&adaptor=Local%20Search%20Engine&tab=Everything&query=any,contains,2020%20IEEE%20Winter%20Conference%20on%20Applications%20of%20Computer%20Vision
1027	Attachment 1J to the Hall-Ellis Declaration – WorldCat for Ali, <i>available at</i> https://search.worldcat.org/title/1183029756
1028	Attachment 2A to the Hall-Ellis Declaration – MARC Record for He
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1030	Attachment 2C to the Hall-Ellis Declaration – IEEE Xplore Page for He, <i>available at</i> https://ieeexplore.ieee.org/document/8237584
1031	Attachment 2D to the Hall-Ellis Declaration – arXiv Page for He, <i>available at</i> https://arxiv.org/abs/1703.06870
1032	Attachment 2E to the Hall-Ellis Declaration – SJSU Library Page for Ali, <i>available at</i> https://csu-sjsu.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma991068786465502901&context=L&vid=01CALS_SJO:01CALS_SJO&lang=en&search_scope=MyInst_and_CI&adaptor=Local%20Search%20Engine&tab=Everything&query=any,contains,2017%20IEEE%20International%20Conference%20on%20Computer%20Vision%20Workshops
1033	Attachment 2F to the Hall-Ellis Declaration – WorldCat for He, <i>available at</i> https://search.worldcat.org/title/1048182166
1034	He <i>et al.</i> , “Mask R-CNN,” <i>available at</i> https://ieeexplore.ieee.org/document/8237584
1035	Attachment 3A to the Hall-Ellis Declaration – MARC Record for Khan
1036	Attachment 3B to the Hall-Ellis Declaration – MARC Record for Khan
1037	Attachment 3C to the Hall-Ellis Declaration – IEEE Xplore Page for Khan, <i>available at</i> https://ieeexplore.ieee.org/document/9093296

Exhibit	Description
1038	Attachment 3D to the Hall-Ellis Declaration – ResearchGate for Khan, <i>available at</i> https://www.researchgate.net/publication/341400531_Lane_detection_using_lane_boundary_marker_network_with_road_geometry_constraints
1039	Attachment 3E to the Hall-Ellis Declaration – SJSU Library Page for Khan, <i>available at</i> https://csu-sjsu.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma991072196389102901&context=L&vid=01CALS_SJO:01CALS_SJO&lang=en&search_scope=MyInst_and_CI&adaptor=Local%20Search%20Engine&tab=Everything&query=any,contains,2020%20IEEE%20Winter%20Conference%20on%20Applications%20of%20Computer%20Vision
1040	Attachment 3F to the Hall-Ellis Declaration – WorldCat for Khan, <i>available at</i> https://search.worldcat.org/title/1183029756
1041	Attachment 4A to the Hall-Ellis Declaration – MARC Record for Workman
1042	Attachment 4B to the Hall-Ellis Declaration – LOC Entry for Image Processing Congresses
1043	Attachment 4C to the Hall-Ellis Declaration – LOC Entry for Artificial Intelligence Congresses
1044	Attachment 4D to the Hall-Ellis Declaration – Collection of Abstracts from the British Machine Vision Conference 2016
1045	Attachment 4E to the Hall-Ellis Declaration – Proceedings of the British Machine Vision Conference 2016, <i>available at</i> https://bmva-archive.org.uk/bmvc/2016/toc.html
1046	Attachment 4F to the Hall-Ellis Declaration – Proceedings of the British Machine Vision Conference 2016 Foreword, <i>available at</i> https://bmva-archive.org.uk/bmvc/2016/index.html
1047	Attachment 4G to the Hall-Ellis Declaration – British Machine Vision Conference 2016 Page for Workman, <i>available at</i> https://bmva-archive.org.uk/bmvc/2016/papers/paper020/index.html
1048	Attachment 4H to the Hall-Ellis Declaration – arXiv Page for Workman, <i>available at</i> https://arxiv.org/abs/1604.02129

Exhibit	Description
1049	Attachment 4I to the Hall-Ellis Declaration – Multimodal Vision Research Laboratory Page for Workman, <i>available at</i> https://mvrl.cse.wustl.edu/datasets/hlw/
1050	Attachment 4J to the Hall-Ellis Declaration – ResearchGate Page for Workman, <i>available at</i> https://www.researchgate.net/publication/317193732_Horizon_Lines_in_the_Wild
1051	Attachment 4K to the Hall-Ellis Declaration – BMVC History and Description, <i>available at</i> https://www.bmva.org/bmvc
1052	Attachment 4L to the Hall-Ellis Declaration – WorldCat for Workman, <i>available at</i> https://search.worldcat.org/title/34231812
1053	Khan YouTube Video (Mar. 20, 2020), <i>available at</i> https://www.youtube.com/watch?v=Lj-FylnEboQ&t=3280s
1054	Khan YouTube Webpage (Mar. 20, 2020), <i>available at</i> https://www.youtube.com/watch?v=Lj-FylnEboQ&t=3280s
1055	Ali YouTube Video (Mar. 20, 2020), <i>available at</i> https://www.youtube.com/watch?v=0RYqfwR5YNk
1056	Ali YouTube Webpage (Mar. 20, 2020), <i>available at</i> https://www.youtube.com/watch?v=0RYqfwR5YNk
1057	U.S. Patent Application Publication No. 2019/0034740 to Kwant <i>et al.</i> (“Kwant1”)
1058	U.S. Patent Application Publication No. 2019/0102674 to Kwant <i>et al.</i> (“Kwant2”)
1059	Complaint, <i>Motive Technologies Inc. f/k/a Keep Truckin, Inc. v. Samsara Inc.</i> , Case No. 3:24-cv-00902 (N.D. Cal.), Dkt. 1, February 15, 2024
1060	Order, <i>Motive Technologies Inc. f/k/a Keep Truckin, Inc. v. Samsara Inc.</i> , Case No. 3:24-cv-00902 (N.D. Cal.), Dkt. 52, June 4, 2024

I. INTRODUCTION

U.S. Patent No. 11,875,580 (“the ’580 patent”) describes methods for calibrating a camera used to perform lane detection for automotive systems.

Using a camera and predictive models to detect traffic lanes was well known before the 2021 priority date of the ’580 patent, as demonstrated by Choe, Khan, Ali, Workman, and Westmacot. Calibrating a camera to perform such lane detection was also well known. As the art in this Petition explains, these calibration processes would, similar to the ’580 patent, identify a horizon line. They would then use that horizon line to calculate camera parameters (e.g., the camera’s pitch, yaw, and roll) to ensure the lane detection was accurate. The specific predictive models used by the ’580 patent were also known—the inventors disclosed them to the public in IEEE conference presentations and papers more than a year before filing the patent. Others, such as Workman, did so years prior.

The six Grounds in this Petition disclose every claim element of claims 1-7 of the ’580 patent, and a POSA would have been motivated to combine the references with a reasonable expectation of success. The Board should institute trial and find these claims unpatentable.

II. U.S. PATENT NO. 11,875,580

A. Overview

The ’580 patent is titled “Camera Initialization for Lane Detection and Distance Estimation using Single-View Geometry” and describes well-known,

conventional algorithms to detect lanes and objects in traffic images. In general, the '580 patent describes “automotive systems and ... machine learning systems for analyzing sensor data in such systems.” EX1001, 1:1-9. More specifically, the '580 patent describes “a network-based initialization system” for “receiv[ing] a video comprising a set of image frames and identif[ying] one or more lines in the video using a predictive model” to “compute[] some camera parameters.” *Id.*, 1:36-44. The '580 patent also describes a “neural network” embodiment that “records a video comprising one or more image frames,” “generates a set of intermediate features representing the video,” “predict[s] a horizon line,” and “compute[s] a camera parameter ... based on the horizon line.” *Id.*, 1:53-64. Finally, the '580 “records a video comprising one or more image frames,” “generates a set of intermediate features representing the video,” “predict[s] camera parameters using the output of the camera estimation head, the camera parameter estimation head trained using an output of the backbone network, and an output of a lane and horizon line prediction head.” *Id.*, 1:65-2:08.

The '580 patent starts by describing at a high level the device 230, camera initialization service 232, annotator device 234, and initialization service 236. EX1001, 4:58-7:10. Device 230 is “a camera and processor installed in a vehicle” that “captures a video, represented as, for example, a set of one or more images.” *Id.*, 4:60-62. After capturing a video, called a camera initialization event, device

230 “transmits a camera initialization event to a camera initialization service 232.”

Id., 5:13-15. The camera initialization service 232 then “detects lane and horizon lines in the video using a predictive model.” *Id.*, 5:25-28. The ’580 patent defines a predictive model as “a deep learning or other AI model” or “a CNN [convolutional neural network] or other type of deep learning model.” *Id.* The ’580 patent then describes “if process 206 can detect at least two lanes..., process 206 can further include computing camera parameters for the device 230 that recorded the video.” *Id.*, 5:38-41. The process can predict “camera height, viewing angle, and road plane normal.” *Id.*, 5:45-47. The process then “overlays the computed lane and horizon lines on the original video file, generating an overlaid video file.” *Id.*, 5:48-50. The overlaid video is then sent to an annotator device 234. *Id.*, 5:54-56

The annotator device 234 is described as merely “a workstation or web-based application allowing for human review of automatically detected horizon and lane lines.” EX1001, 5:65-67. After receiving the overlaid video, the annotator device 234 “presents the overlaid video file to the human annotator” and “requests that the human annotator confirm the lane lines (if present) and horizon in the overlaid video file.” *Id.*, 6:01-05. “If the annotator confirms the overlaid lines, the annotator can accept the lines and transmit its acceptance back to the camera initialization service 232....” *Id.*, 6:05-08. If the annotator does not confirm the overlaid lines, the annotator can “manually add a horizon line and/or lane lines.”

Id., 6:29-33. The annotator then transmits the overlaid video to initialization service 236, which may use “a deep learning or AI model” to predict camera parameters based on the overlaid video. *Id.*, 6:44-46.

B. Prosecution History

The prosecution history of the '580 patent consists of only a single office action and response before allowance, with no claim amendments.

In the single office action, the Examiner rejected claims 1-3, 5, 8-12, and 14-15 over prior art and objected to claims 4, 6-7, 13, and 17-20 for being dependent upon the rejected base claims. EX1002, 0129. The cited prior art included: (1) U.S. Publication No. 2019/0034740 A1 to Kwant et al. (EX1057, “Kwant1”) and (2) U.S. Publication No. 2019/0102674 A1 to Kwant et al. (EX1058, “Kwant2”). EX1002, 0131.

In response to the rejections, the Applicant submitted five arguments without amending the claims. First, the Applicant argued that Kwant1 did not disclose “a predictive model, the one or more lines including a horizon line” (claim 1) or “predicting a horizon line using the lane or horizon prediction head” (claim 8). EX1002, 0145. According to the Applicant, Kwant1 did not disclose a predictive model to detect a *horizon* line, but instead predicted *lane* lines and then used a geometric approach to identify the horizon line. *Id.*, 0145-46.

Second, the Applicant argued that neither Kwant1 nor Kwant2 disclose “at least one camera parameter” (claims 1 and 8). EX1002, 0146-47. According to the Applicant, the parameters in Kwant1 and Kwant2 “have no relation to the camera used to generate the image but rather describe the lines—they are a pure mathematical representation of a line.” *Id.* In the response, “Applicant note[d] that the specification is clear that a camera parameter is a property of the camera itself ((e.g., height, viewing angle, road plane normal, etc.), ¶ 5, and 6–7) and not a property of a lane line.” EX1002, 0146.

Third, the Applicant argued that Kwant1 did not disclose overlaying lines on a video to generate an overlaid video as recited in claim 1. EX1002, 0147-48. According to the Applicant, “while the figure in Kwant1 may arguably illustrate an image with polylines overlaid (a point not conceded), Kwant1 does not describe a method step for doing this (i.e., the explicit step of ‘overlaying’ as claimed).” EX1002, 0147. According to the Applicant, the alleged overlay image “[wa]s a construction of the patent attorney or agent and not of a process.” *Id.* To satisfy the claim element, the Applicant noted that the reference “must describe a *process* for generating an *image* and the failure to do so renders Kwant1 deficient.” *Id.*

Fourth, the Applicant argued that Kwant1 did not disclose transmitting an overlaid video to an “annotator device for manual review” as claim 1 recites. According to the Applicant, even if Kwant1 displayed an image with overlaid

lines, “the ultimate recipient in Kwant1 is a driver, not an ‘annotator device’ as claimed.” EX1002, 0148.

Finally, the Applicant argued that the cited prior art failed to describe a “confirmation” from an “annotator device for manual review” as claim 1 recites. EX1002, 0147-48. The Applicant explained:

The Office Action cites a ‘learner module’ of KWANT2 as meeting this element. However, this learning module is not part of a “manual review.” Instead, it is an automated machine learning technique to adjust weights of a model based on a loss function. This is a fundamentally different process than using manual review to confirm the accuracy of a horizon detection.

EX1002, 0148.

The Examiner subsequently allowed all claims.

In the Notice of Allowance, it is unclear which of the five arguments the Examiner found persuasive. The Examiner merely quoted the majority of claim 1. EX1002, 0171. Of the limitations the Examiner found allowable, the Examiner also found that the prior art disclosed “identifying one or more lines in the video using a predictive model, the one or more lines including a horizon line,” “receiving a confirmation from the annotator device, the confirmation indicating that the one or more lines are accurate,” and “transmitting data representing the at least one camera parameter to the camera device.” EX1002, 0169-71. Accordingly,

the Examiner *may* have determined that the prior art failed to disclose “computing at least one camera parameter based on the one or more lines,” “overlaying the one or more lines on the video to generate an overlaid video,” and/or “transmitting the overlaid video to an annotator device for manual review.”¹ But it is unclear.

As this Petition explains, Choe, Khan, Ali, Workman, and Westmacot disclose the elements that led to allowance. *Infra* Section XII.A. None of these references were applied during prosecution, and only Westmacot was considered as being cited in an Information Disclosure Statement.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art (“POSA”) at the time of the alleged invention would have had a Bachelor’s in Computer Science with a focus on computer/machine vision, and at least two years of experience with each of: (1) machine learning (including neural network) methods as applied to machine/computer vision and (2) classical machine/computer vision algorithms (e.g., edge detection, line identification, computation of camera parameters from

¹ It is completely unclear what led to the allowance of claims 8-20, which do not include these limitations about computing camera parameters and generating an overlaid video for manual review.

horizon line, etc.). EX1003, ¶77. Additional education could serve as a substitute for the experience requirement. *Id.*

D. Claim Construction

Samsara has construed the terms according to their ordinary and customary meanings as understood by a POSA in view of the specification. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-13 (Fed. Cir. 2005). No term needs an explicit construction to resolve the controversy between the parties. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).

III. IDENTIFICATION OF THE CHALLENGE (37 C.F.R. § 42.104(B))

A. Prior Art

The Grounds in this Petition rely on the following prior-art references:

Reference	Exhibit(s)	Date	Prior Art
Choe (and its Patent Center filed drawings presented merely for enhanced clarity)	EX1005 EX1006	Published Dec. 31, 2020	§102(a)(1)-(2)
Khan	EX1007	Published At Least By May 14, 2020	§102(a)(1)
Ali	EX1008	Published At Least By May 14, 2020	§102(a)(1)
Westmacot	EX1010	Published Sept. 19, 2019	§102(a)(1)-(2)
Workman	EX1011	Published At Least By Aug. 16, 2016	§102(a)(1)

Petitioner has submitted a declaration from Dr. Hall-Ellis—a librarian with over forty years of experience—to verify the dates of Khan, Ali, and Workman. *See* EX1016 (citing EX1007-EX1009, EX1011, EX1018-EX1052).

Khan and Ali were published and publicly available at the IEEE Workshop on Applications of Computer Vision (WACV) in March 2020. EX1016, ¶¶50-56, 65-71; *see also* EX1053-EX1056 (paper presentations published on YouTube on March 14, 2020). After the workshop, both Khan and Ali were also published and publicly available at IEEE Xplore on May 14, 2020 and other locations such as arXiv. EX1016, ¶¶50-56, 65-71. Khan and Ali include the '580 patent inventors as authors, but the papers were not made by the same inventive entity. Regardless, even if Khan and Ali were made by the inventors or by another who obtained the subject matter from the inventors, the exceptions under §102(b) still do not apply because both Khan and Ali were published more than one year before the effective filing date of the '580 patent (Oct. 4, 2021).

Workman is also prior art because it was published and publicly available at arXiv on August 16, 2016 and then presented at the 27th British Machine Vision Conference in September 2016. EX1016, ¶¶72-78.

B. Grounds

Ground	Basis	Reference(s)	Claims
1	§103	Choe (Publication + Patent Center Figures)	1-4
2	§103	Choe, Khan, and Ali	1-5
3	§103	Choe and Workman	1-4
4	§103	Choe and Westmacot	5-7
5	§103	Choe, Westmacot, Khan, and Ali	1-7
6	§103	Choe, Westmacot, and Workman	1-7

IV. OVERVIEW OF THE PRIOR ART

As the following prior art establishes, manually calibrating a camera to detect traffic lanes was well known. EX1003, ¶¶36-64. As part of the calibration process, it was known how to overlay video frames with a horizon line, and then use that horizon line or an adjusted horizon line to calculate the camera's pitch, yaw, and roll. EX1003, ¶¶29-64. Using certain predictive models during the calibration process was also known. EX1003, ¶¶29-64.

A. Choe

Choe is directed towards “calibrating a sensor system of an autonomous driving vehicle.” EX1005, [0001]. As Choe explains, sensors in autonomous

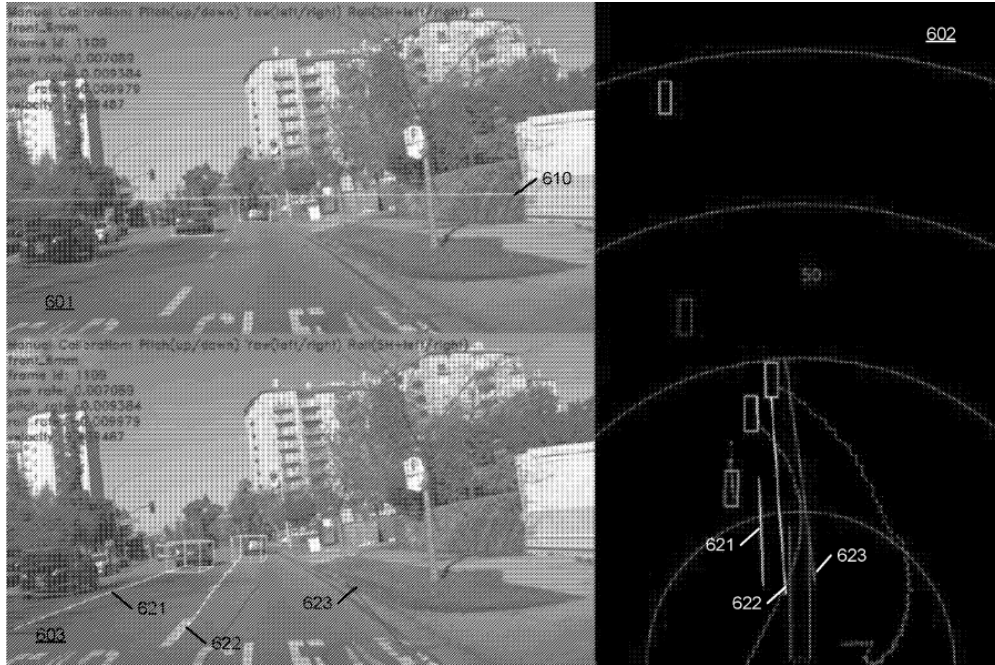
vehicles need to be periodically calibrated to ensure that they accurately detect and recognize objects and lane configuration of the driving environment. *Id.*, [0003].

At the time of Choe's invention, however, there was "a lack of efficient sensor calibration systems." *Id.*

One part of Choe's sensor calibration system involves calibrating a camera for lane detection. For this calibration, Choe describes processing logic that receives images from the camera over a network. EX1005, ¶[0018]. The camera is described as "still cameras and/or video cameras." *Id.*, ¶[0022]. When using a video camera, the "images" are video frames, as Figures 6A and 6B show:



EX1005, FIG. 6A.



EX1005, FIG. 6B.

After receiving the video frames, Choe predicts the horizon line and lane lines. EX1005, ¶¶[0015]-[0016]. “[A] horizon line is determined based on the camera’s hardware settings.” *Id.*, ¶[0015]. Additionally, “[o]ne or more lane lines are determined on the first image via a perception process performed on the first image.” *Id.*; see also EX1005, ¶¶[0056], [0059], FIG. 7.

Choe further describes superimposing lines for the horizon line and lane lines on the frames of the video. EX1005, ¶¶[0016], [0050]. After determining the horizon line within a video frame, the horizon line is superimposed on the frame. *Id.*, ¶[0050]. Then, “a second image is rendered” and “includes the lane lines superimposed thereon.” *Id.*



EX1006, FIG. 6A (excerpt, annotated); EX1005, FIG. 6A.

After superimposing the lines, Choe sends the video to a user to review the predicted lines. EX1005, ¶¶[0014]-[0016]. Choe describes having a “visualizer” which “includes a user interface to visually display a two-dimensional (2D) image captured by a camera.” *Id.*, ¶[0014]. On this visualizer, a user views the lines and manually lines them up with the real lane lines and horizon line. *Id.*, ¶¶[0055]-[0057]. A user may do this manual correction using an “input device (e.g., a keyboard, joystick, voice interactive command).” *Id.*, ¶[0015]. “In response to a first input signal (e.g., an up or down arrow key) received from an input device (e.g., keyboard, joystick, voice interactive command) ... a position of at least one of the lane lines is updated based on the updated horizon line.” *Id.* The user manipulates the lines until they are satisfied with the results. *Id.*, ¶[0014].

Based on determining the lines, Choe then predicts camera parameters, such as the pitch angle of the camera. EX1005, ¶[0015]. For example, “[a] first calibration factor or first correction value is determined for calibrating a pitch angle of the camera based on a difference between the initial horizon line and the updated horizon line.” *Id.*, ¶[0015]. Choe also specifies that the system uses the visualizer to manually calibrate other camera parameters, including the camera’s “yaw angle, and/or a roll angle.” *Id.*, ¶[0014].

Once the user is satisfied with the line placement, Choe transmits updated camera parameters back to the vehicle’s camera. EX1005, ¶¶[0014]-[0016]. After a user has moved the horizon line, “[a] first calibration factor or first correction value is determined for calibrating a pitch angle of the camera based on a difference between the initial horizon line and the updated horizon line.” *Id.*, ¶[0015]. “Similarly, the yaw angle and the roll angle of a camera can also be calibrated using the techniques as described above.” *Id.*, ¶[0057].

B. Khan

Khan also uses predictive models to identify the horizon line and line lines. Khan discloses “a lane boundary marker network to detect keypoints along the lane boundaries.” EX1007, 1823. Khan explains how lane detection for autonomous vehicles is “of critical importance” and current solutions “suffer[ed] from the problem of occlusion and struggle[d] to detect lanes with low or no evidence on

the road.” *Id.* At the time, Khan’s solution outperformed other predictive models in the industry. *Id.*, 1828-30 (showing detailed results).

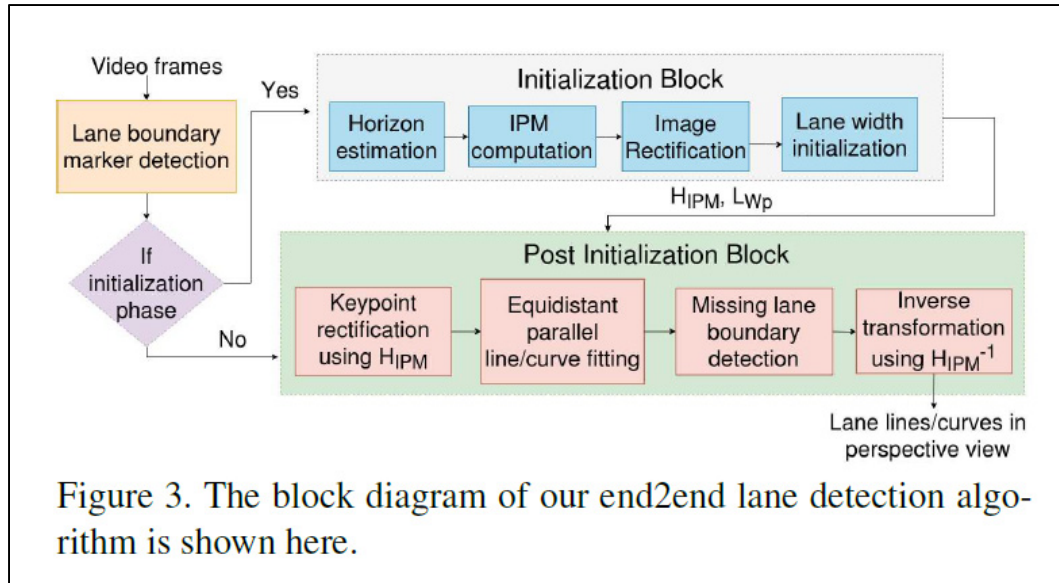
Khan discloses predictive models to identify the horizon and lane lines in images and overlay those lines onto the images.



EX1007, FIG. 1.

Khan uses a predictive model called “Mask-RCNN” to identify the lane lines. EX1007, 1825 (citing EX1009). Khan and the other authors did not invent this model. EX1003, ¶46. Rather, Mask-RCNN was a well-known model developed at Facebook AI Research that has “(i) the convolutional backbone architecture used for feature extraction” and “(ii) the network head for bounding-box recognition.” *Id.* Khan merely repurposed the Mask-RCNN to “predict [] lane markers.” EX1007, 1825; EX1003, ¶46.

Khan’s lane detection algorithm is shown in Figure 3 (below).



EX1007, 1825.

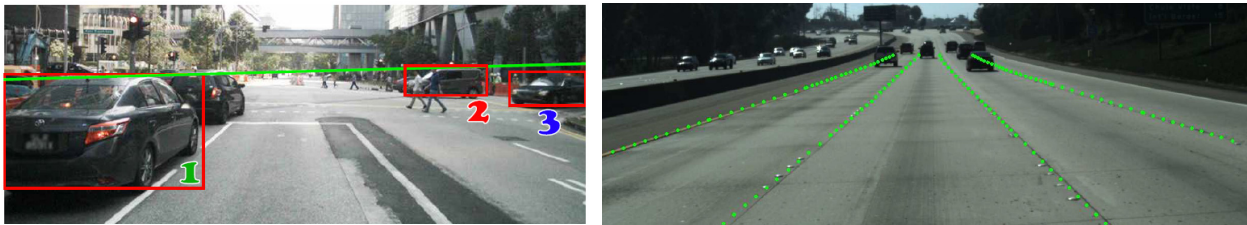
Shown above, if the camera is being initialized (i.e., calibrated), the algorithm estimates the horizon line after the lanes are predicted (shown above in the top left blue box). EX1007, 1826-27. Khan explains that the horizon is detected based on the lane lines and states that the horizon prediction algorithm is further disclosed in a companion paper. *Id.*, 1827 (citing EX1008).

The next step of Khan's algorithm is called Inverse Perspective Mapping (IPM) computation. EX1007, 1825. Using the predicted lane and horizon lines, the IPM computation "use[s] road geometry to find camera pose." *Id.*, 1826. Camera pose includes the camera tilt, pan angle, and road plane normal. *Id.* Instead of using the camera's known parameters to determine the road geometry, Khan uses "road geometry to find camera pose and in-turn find the IPM." *Id.* By using the

lane lines and horizon line, Khan “comput[es] plane normal $\hat{n}$ ” to determine how to rotate the camera view to “align its Z-axis with the road’s normal.” *Id.*, 1827.

C. Ali

Like Khan, Ali estimates lane lines and horizon lines for autonomous vehicles. EX1008, 1100. Specifically, Ali explains that “[d]istance estimation is required for advanced driver assistance systems” and that it “uses geometric ... road lane markings for distance estimation.” *Id.* Ali also uses a Mask-RCNN to predict lane lines and the horizon line. *Id.*, 1100, 1102.



EX1008, 1100, 1103.

Ali cites to Khan to describe how it estimates lane lines. EX1008, 1102. Then, Ali describes how it uses the lane lines to estimate a horizon line. *Id.* Ali provides pseudocode for how its algorithm estimates the best fitting horizon (l_h).

Algorithm 1: Best fitting Horizon (l_h) estimation

Input: Detected markers by lane detector
Output: Estimated Horizon line

```

1 Find forward and lateral VP for each frame in a video:
2 initialize;
3 for  $i \leq \text{num\_frames in video}$  do
4     Fit lines to keypoints ( $B = \text{num\_lines}$ );
5     if  $B \geq 2$  then
6         for  $j \leq {}^B C_2$  do
7             forward_vpij = crossprod(line_1, line_2)
8         end
9     end
10    if  $B \geq 3$  then
11        for  $k \leq {}^B C_3$  do
12            Get lateral_vpik using cross ratios as described
13            in Section 3.2.2
14        end
15    end
16 RANSAC for best fitting horizon across video:
17 initialize;
18 s = random_int between 1 to num_forward_vps;
19 t = random_int between 1 to num_lateral_vps;
20 while iterations  $\leq t$  OR num_inliers  $\leq \text{max\_inliers}$  do
21     Fit line  $l_h$  to forward_vp(s) and lateral_vp(t);
22     if  $\text{dist}(l_h, \text{forward\_vp}(s)) \leq \text{threshold}_s$  &
23         $\text{dist}(l_h, \text{lateral\_vp}(t)) \leq \text{threshold}_t$  then
24         record and count inlier points
25     end
26 end

```

EX1008, 1104.

Using the horizon line, Ali “find[s] camera height and road plane normal.”

EX1008, 1105. As Ali describes determining the camera height, Ali also describes “comput[ing] [the camera’s] viewing angle α alpha.” *Id.* Once the viewing angle is determined, Ali explains that the “camera height h_c is given by:

$$h_c = \frac{\frac{Lw_r}{2}}{\tan\left(\frac{\alpha}{2}\right)} \quad (3)$$

EX1008, 1105.

Using the camera height, road plane normal, and horizon line, Ali then determines the distance between the camera and a car in front of it. EX1008, 1105.

D. Workman

Workman shows that the inventors were far from the first to use a predictive model to identify the horizon line in cityscape and road images / video frames.

Workman uses convolutional neural networks (CNNs) to predict horizon lines without requiring any use of geometric constraints or spatial cues. EX1011, Abstract. Workman acknowledges that CNNs had been used to predict horizon lines many times prior for “a wide variety of applications.” *Id.*, 1-2. One of these applications was “pedestrian and vehicle detection.” *Id.*, 1.

Workman provides a “CNN-based approach for directly estimating the horizon line.” EX1011, 2. As part of this approach, Workman determines a horizon line by “manually validat[ing] a global horizon line for each model, and then project[ing] the horizon line back into each image.” *Id.*, 4.

Figure 5 of Workman shows the ground truth horizon line (dash green) and the predicted horizon line (magenta) for each image:



EX1011, 9.

E. Westmacot

Westmacot is directed towards “image annotation,” specifically for “the creation of annotated street road images which can be used (among other things) for training a machine learning road detection component.” EX1010, 1:5-7. As Westmacot explains, “[convolutional neural networks] require large numbers of training images.” *Id.*, 1:29. At the time of Westmacot, however, “[t]he conventional technique for creating the annotated training images is to have humans manually hand annotate the images.” *Id.*, 2:6-7. Westmacot describes a process for “automatic or semi-automatic image annotation technology” to “allow[] large numbers of training images to be generated more efficiently and quickly.” *Id.*, 3:1-6.

Westmacot describes how it annotates the road images to show the “road structure.” EX1010, 3:15-24. The road structure is the “real-world structure, such as road or lane structure, e.g., which part of the image is road surface, which part of the image makes up lanes on the road, etc.” *Id.*, 1:22-26.

After determining lane lines, a horizon line, and camera parameters, a manual reviewer may adjust the lines, *add* new lines, and change the camera parameters (e.g., camera height). *Id.*, 34:5-16. Westmacot describes this as the “human fixer” stage. *Id.*, 19:17-18.

Westmacot uses Figures 18 to 24 to illustrate “an annotation tool user interface for annotating images based on the techniques disclosed herein.” EX1010, 17:23-24. “[T]he annotator is provided with controls to manipulate currently rendered lanes (narrow, widen, move to the left or right, move the boundaries of the lane etc.) and add new lanes.” *Id.*, 34:7-9. Further, “the annotator is provided with means to adjust the camera height, to match the reconstruction to the road surface, and the crop height, to exclude the vehicle[’]s dash or bonnet.” *Id.*, 34:9-11. Examples of the user interface are shown below.



Fig. 18

EX1010, FIG. 18.

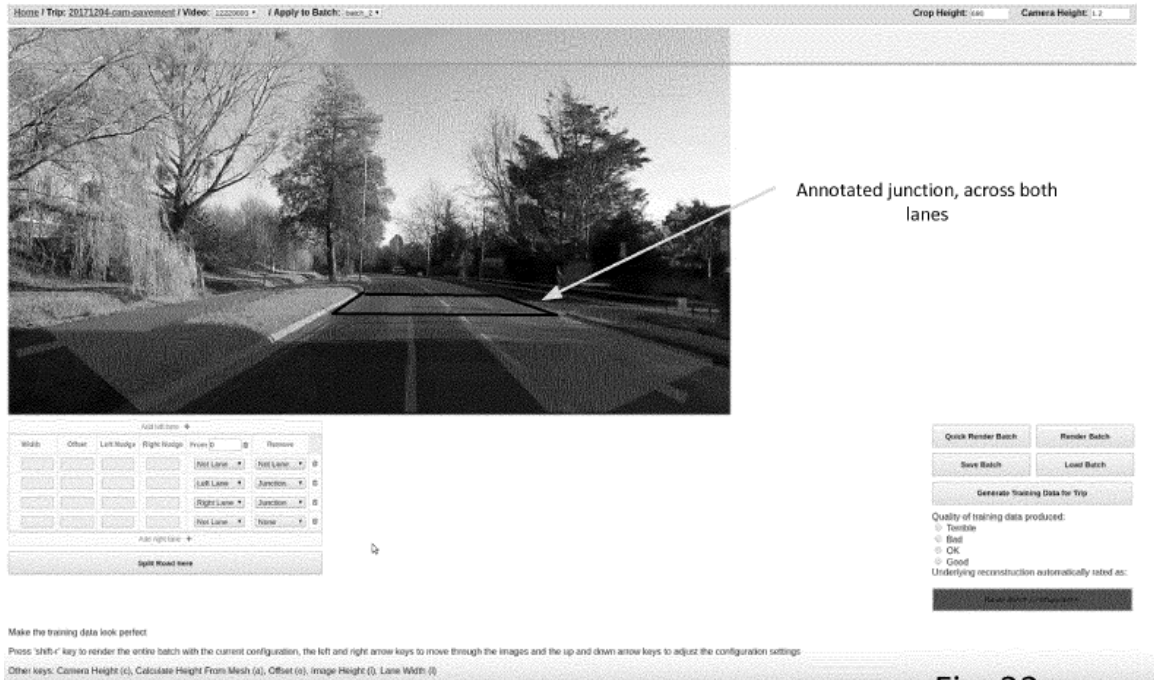


Fig. 22

EX1010, FIG. 22.

Westmacot determines camera parameters from the image. EX1010, 3:26-34, 6:10-11, 7:3-4. Westmacot explains that “one or more parameters of the image capture device ... may be derived from (only) the image data captured by the image capture device.” *Id.*, 3:31-34. For example, “[t]he expected road structure may be determined based on *a road normal vector*.” EX1010, 5:1.² The road normal vector *n* is “the surface normal of the road relative to the camera,” EX1010, 25:1-2, and may be estimated from the image as:

² All emphasis added unless stated otherwise.

$$n = \frac{1}{\sum_{i=2}^{N-2} \|n_i\|} \sum_{i=2}^{N-2} n_i$$

$$n_i = R_i^{-1}(m_{i-1,i} \otimes m_{i,i+1}),$$

EX1010, 5:2-4; *see also* EX1010, 24:1-6, 26:9-27:5, 39:31-40:2, FIGs. 8-9, 16, 27 (additional details on the road plane normal).

Westmacot's Figure 26, shown below, illustrates the camera height (h) and road normal (n) in relation to the determined lane lines.

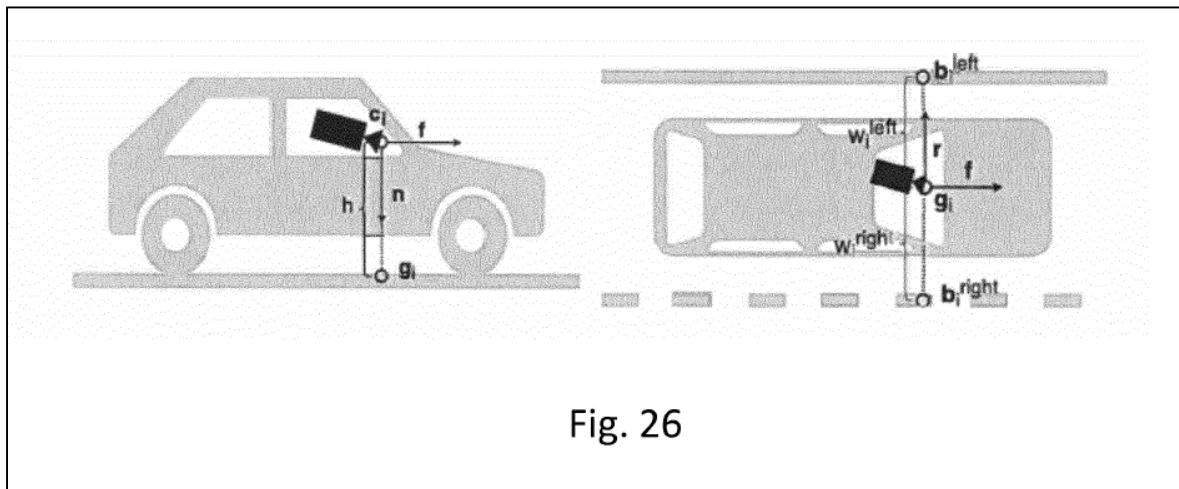


Fig. 26

EX1010, FIG. 26.

V. GROUND 1: CHOE RENDERS OBVIOUS CLAIMS 1-4.

Choe discloses all the features of claims 1-4.³ EX1003, ¶¶79-119. In the event PO argues that “video” or “overlaid video” is not explicit in Choe, these features are at least obvious in view of Choe’s teachings about predicting the horizon and lane lines on video “frames” / “images.” EX1003, ¶79.

A. Independent Claim 1

1. [1Pre] “A method comprising”

Choe discloses this element because it describes “processes or *methods* ... [that] may be performed by processing logic that comprises hardware (e.g., circuitry, dedicated logic, etc.), software (e.g., embodied on a non-transitory computer readable medium), or a combination of both.” EX1005, ¶[0064].

2. [1A] “receiving, over a network from a camera device, a video comprising a set of image frames”

Choe discloses this element. EX1003, ¶¶84-89.

³ “[A] disclosure that anticipates under § 102, also renders the claim invalid under § 103, for ‘anticipation is the epitome of obviousness.’” *Connell v. Sears, Roebuck Co.*, 722 F.2d 1542, 1548 (Fed. Cir. 1983) (quoting *In re Fracalossi*, 681 F.2d 792, CCPA 1982)); *see also Cohesive Techs., Inc. v. Waters Corp.*, 543 F.3d 1351, 1363-64 (Fed. Cir. 2008) (reaffirming this principle of the law).

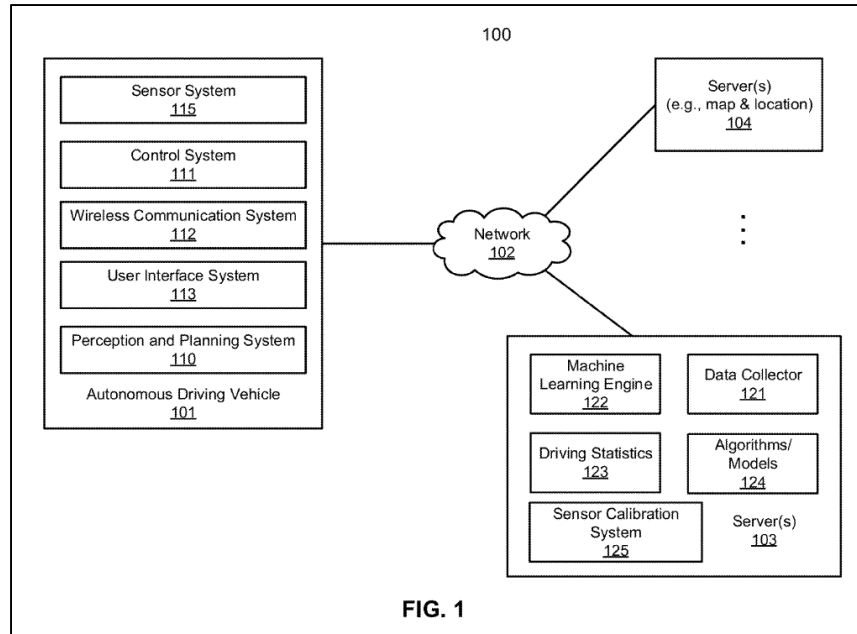
In Choe, an autonomous driving vehicle includes cameras 211. EX1005, ¶¶[0020]-[0022], FIGs. 1-2. “Cameras 211 may be still cameras *and/or video cameras*.” EX1005, ¶[0022]. As known in the art, the video captured by a video camera “compris[es] a set of image frames.” EX1003, ¶86.

Choe’s Figures 6A and 6B show the video frames used in its process. *Id.* Figure 6A (below) shows “frame id: 1110.” Figure 6B shows the prior frame, “frame id: 1109.” EX1005, FIG. 6B; EX1006, FIG. 6B.



EX1006, FIG. 6A (excerpt, annotated); EX1005, FIG. 6A.

Choe also discloses that its system sends information “over a network.” EX1003, ¶87. “Referring to FIG. 1, network configuration 100 includes autonomous vehicle 101 that may be communicatively coupled to one or more servers 103-104 *over a network 102*.” EX1005, ¶[0018]. The video captured by the video camera—a sensor of sensor system 115—is received, over the network, by the sensor calibration system 125 on server(s) 103. EX1005, ¶[0031], FIG. 1.



EX1005, FIG. 1.

If PO alleges that Choe does not explicitly disclose sending “video” over the network because the server performs analysis on video “frames” and “images,” combining Choe’s video frames to form a video would have been obvious to a POSA. EX1003, ¶88. For example, a POSA would have sent the video frames collectively as a single, compressed video file to reduce the size of the data transmission. EX1003, ¶88. Moreover, the Applicant expressed during prosecution that it performed processing on *images*. EX1002, 0147. Accordingly, receiving video frames over a network satisfies this claim element. EX1003, ¶¶88-89.

3. [1B] “identifying one or more lines in the video using a predictive model, the one or more lines including a horizon line”

Choe discloses this element. EX1003, ¶¶90-97.

Choe's method "identif[ies] one or more lines ... including a horizon line."

EX1003, ¶91. Choe explains: "[I]n response to a first image captured by a camera of an ADV, *a horizon line is determined* based on the camera's hardware settings."

EX1005, ¶[0015]; *see also* EX1005, ¶¶[0045], [0048], [0055], [0059], FIG. 7.

Additionally, "[o]ne or more lane lines are determined based on the first image via a perception process performed on the first image." EX1005, ¶[0015]; *see also* EX1005, ¶¶[0056], [0059], FIG. 7.

In Choe, the images used to identify the horizon and lane lines are video frames because, as explained for [1A], Choe captures video. EX1005, FIGs. 6A-6B; EX1006, FIGs. 6A-6B (identifying horizon and lane lines on video frames). The identified lines would therefore be "in the video." EX1003, ¶92.

The initial horizon and lane lines are identified "using a predictive model." EX1003, ¶¶93-96. Choe states that it uses a "machine learning engine 122 [that] generates or trains a set of rules algorithms, *and/or predictive models 124* for a variety of purposes." EX1005, ¶[0030]. One of these purposes is camera calibration: "Algorithms 124 may further include sensor calibration algorithms...." EX1005, ¶[0030]; *see also* EX1005, FIG. 1 (showing algorithms/models 124 with the sensor calibration system 125). These sensor calibration algorithms/models predict the initial horizon line before manual calibration. EX1005, ¶¶[0015], [0059]; EX1003, ¶¶93-94. After the initial horizon line is predicted with a

predictive model 124, the result is then identified again and used by additional predictive models. EX1005, ¶[0045] (“The result of the perception processing can be utilized by other modules such as prediction module 303....”); EX1003, ¶94.

4. [1C] “computing at least one camera parameter based on the one or more lines”

Choe discloses this element. EX1003, ¶98.

Choe computes camera parameters (e.g., calibration factors or parameters for calibrating the camera’s pitch, yaw, and roll) based on the horizon line and/or the lane lines. EX1003, ¶98. Choe states: “[a] first calibration factor or first correction value is determined for calibrating a pitch angle of the camera based on a difference between the initial horizon line and the updated horizon line.”

EX1005, ¶[0015]. Choe also computes other parameters based on the lane lines.

EX1005, ¶[0014] (“A user can calibrate any of the sensors such as a pitch angle, a yaw angle, and/or a roll angle....”), [0049], [0052]-[0053], [0057], [0059], FIG. 7.

PO may allege that Choe computes these camera parameters *after* the manual calibration. Even if true, Choe still satisfies [1C] because the computation is nonetheless “based on the one or more lane lines.” EX1003, ¶98. And neither the claims themselves, nor the specification require a specific order for this element. *See Interactive Gift Express, Inc. v. Compuserve Inc.*, 256 F.3d 1323, 1342 (Fed. Cir. 2001) (“Unless the steps of a method [claim] actually recite an order, the steps are not ordinary construed to require one.”); EX1001, 4:35-38, 6:15-7:10, 18:38-

44, 19:55-60 (disclosing embodiments where steps are performed in different orders, including computing camera parameters after manual calibration).

5. [1D] “overlaying the one or more lines on the video to generate an overlaid video”

Choe discloses this element. EX1003, ¶¶99-103.

In Choe, the initial horizon line is superimposed on the image: “[T]he first image with the horizon line superimposed thereon....” EX1005, ¶[0016]; see also EX1005, ¶¶[0046], [0055]-[0057], FIGs. 6A-6B. Shown below, this image is a video frame with “frame id: 1110.” EX1005, FIG. 6A; EX1006, FIG. 6A.



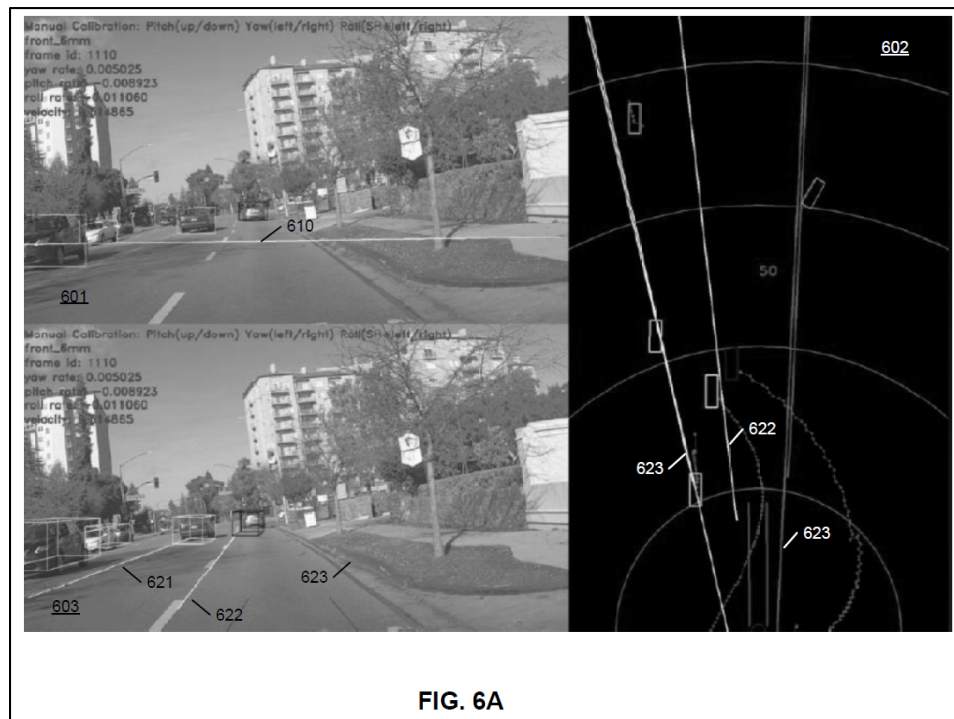
EX1006, FIG. 6A (excerpt, annotated); EX1005, FIG. 6A.

The PO may allege Choe does not explicitly disclose an overlaid “video.” Even if not explicit, a POSA would have found it obvious that a collection of video frames having the horizon line superimposed thereon is an overlaid “video.” EX1003, ¶103.

6. [1E] “transmitting the overlaid video to an annotator device for manual review”

Choe discloses this element. EX1003, ¶¶104-07.

Choe discloses “an annotator device for manual review” because a user uses an input device 404 (e.g., a computer station with a keyboard) to review, annotate, and reposition the overlaid lines manually on display 405. EX1005, ¶¶[0045]-[0054]; EX1003, ¶¶105-06. Figure 6A shows screenshots from the annotation device’s graphical user interface (GUI). EX1005, ¶¶[0010], [0046], [0055]-[0058].

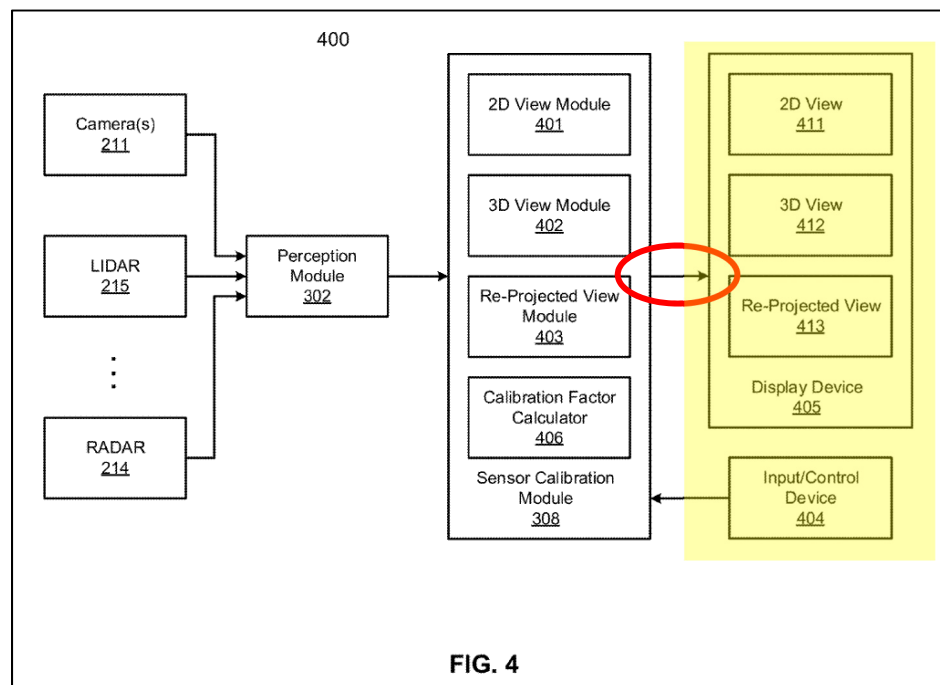


EX1006, FIG. 6A; EX1005, FIGs. 6A.

Figure 6A and related text show the GUI on display 405 instructs the user how to perform manual calibration with a keyboard: “Manual Calibration: Pitch (up/down) Yaw (left/right) Roll (SH+left/right).” EX1006, FIG. 6A; EX1005, FIG.

6A. “[I]n response to a first input signal (e.g., an up or down arrow key) received from an input device (e.g., keyboard, joystick, voice interactive command), a position of at least one of the lane lines is updated based on the updated horizon line.” EX1005, ¶[0015]; *see also* EX1005, ¶¶[0016]-[0017], [0047], [0049], [0052], [0055]-[0057], FIGs. 6A-6B (explaining and showing how a user manually adjusts the horizon and lane lines).

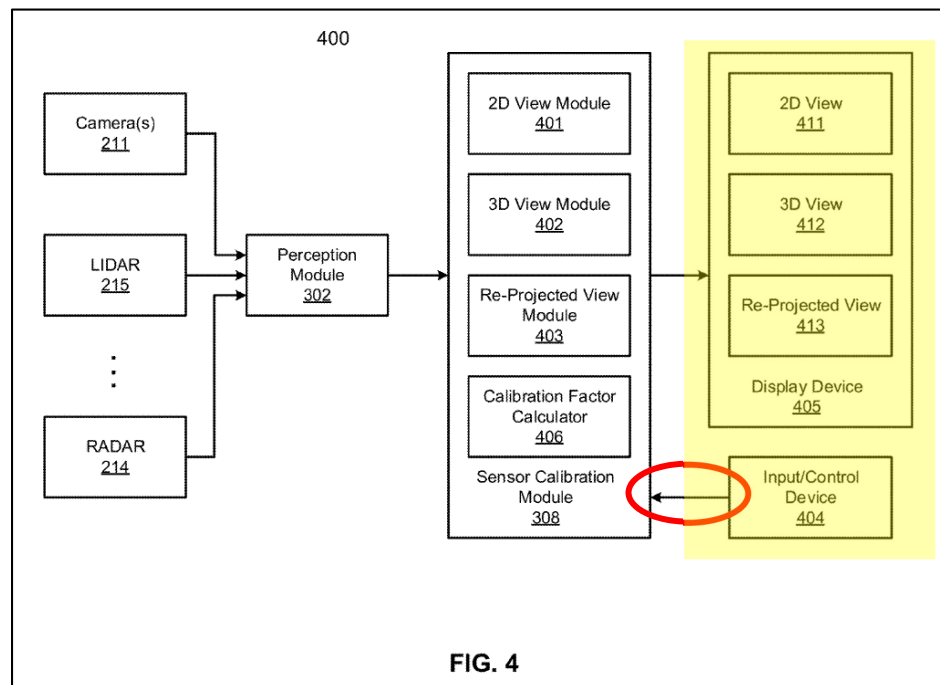
In Choe, the captured video with the initial overlaid horizon and lane lines is first transmitted to the sensor calibration module 308. EX1005, ¶[0048]. The video is then transmitted (shown below with the red arrow) to the annotator device, e.g., elements 404, 405, 411, 412, and/or 413 (highlighted below in yellow). EX1005, ¶¶[0045]-[0054]; EX1003, ¶105.



EX1005, FIG. 4 (annotated); *see also* EX1005, ¶¶[0046]-[0047].

7. [1F] “receiving a confirmation from the annotator device, the confirmation indicating that the one or more lines are accurate”

Choe discloses this element. EX1003, ¶¶108-09. Once the annotator device, e.g., elements 404, 405, 411, 412, and/or 413 (highlighted below in yellow), receives the video with overlaid image frames, the reviewer either adjusts the lines or confirms that they are accurate. EX1005, ¶[0047]; EX1003, ¶109. Shown below in Figure 4, the annotator device’s input/control device 404 sends confirmation indicating that the lines and camera parameters are accurate. EX1003, 109; EX1005, ¶[0047] (“[T]he user can calibrate the sensors until the calibration results as shown on display device 405 are satisfied.”). The sensor calibration module 308 then receives this confirmation. EX1003, ¶109; EX1005, FIG. 4.



EX1005, FIG. 4 (annotated).

8. [1G] “transmitting data representing the at least one camera parameter to the camera device”

Choe discloses this element. EX1003, ¶¶110-12.

In Choe, after the manual calibration, the data representing at least one camera parameter (e.g., calibration factors or parameters for calibrating the pitch, yaw, and roll of camera 211) is transmitted to the camera 211. EX1003, ¶¶111-12. Choe states: “The calibration parameters can then be uploaded to the corresponding vehicles and utilized by autonomous driving software to calibrate and compensate the corresponding sensors.” EX1005, ¶[0031]. Specifically, the camera parameters are transmitted to software modules of the camera 211 to “perform proper adjustment at the software level to compensate the hardware settings of the sensors.” EX1005, ¶[0047]; *see also* EX1005, ¶[0044].

Choe discloses (or at least suggests) every element of claim 1. EX1003, ¶¶81-112. Accordingly, Choe renders obvious claim 1.

B. Claim 2

Choe discloses claim 2. EX1003, ¶¶113-14.

Claim 2 depends from claim 1 and further recites “wherein the one or more lines includes at least one lane line of a roadway.” Choe discloses this element because, as shown below, the lines 621, 622, 623 superimposed on the video frames are lane lines of a roadway. EX1003, ¶¶113-14; EX1005, ¶¶[0015]-[0017], [0048]-[0053], [0056]-[0057], [0059], FIGs. 6B, 7.



EX1006, FIG. 6A (excerpt, annotated); EX1005, FIG. 6A.

C. Claim 3

Choe discloses claim 3. EX1003, ¶¶115-17.

Claim 3 depends from claim 1 and further recites “wherein computing the at least one camera parameter comprises predicting the at least one camera parameter using the predictive model.”

Choe discloses this element because the camera parameters (e.g., for calibrating the camera’s pitch, yaw, and roll) are predicted “using [a] predictive model.” EX1003, ¶116. Choe states that it uses a “machine learning engine 122 [that] generates or trains a set of rules algorithms, *and/or predictive models 124* for a variety of purposes.” EX1005, ¶[0030]. One of these purposes is camera calibration: “Algorithms 124 may further include sensor calibration algorithms....” EX1005, ¶[0030]; *see also* EX1005, FIG. 1 (showing algorithms/models 124 with the sensor calibration system 125). These sensor calibration algorithms/models

predict initial camera parameters and updated camera parameters. EX1005,

¶¶[0015], [0017], [0047], [0049], [0052]-[0054], [0059].

D. Claim 4

Choe discloses claim 4. EX1003, ¶¶118-19.

Claim 4 depends from claim 1 and further recites “wherein computing the at least one camera parameter comprises predicting the at least one camera parameter using a second predictive model.”

As explained for [1B], Choe discloses a predictive model for identifying a horizon line in a video frame (a first predictive model). And as explained for claim 3, Choe discloses a predictive model for predicting a camera parameter (a second predictive model). Indeed, Choe states that it uses *multiple* predictive models: “machine learning engine 122 generates or trains a set of rules algorithms, *and/or predictive models 124* [(plural)] for a variety of purposes.” EX1005, ¶[0030].

* * *

For at least these reasons, Choe discloses (or at least suggests) every element of claims 1-4. Accordingly, these claims would have been obvious to a POSA.

VI. GROUND 2: CHOE IN VIEW OF KHAN AND FURTHER IN VIEW OF ALI RENDERS OBVIOUS CLAIMS 1-5.

Choe in view of Khan, further in view of Ali renders obvious claims 1-5.

A. A POSA would have been motivated to combine Choe with Khan, and Choe and Khan with Ali.

1. Choe

As Ground 1 explains, Choe discloses a “machine learning engine 122 [that] generates or trains a set of rules, algorithms, and/or predictive models,” including for its sensor calibration algorithms. EX1005, ¶[0030].

PO may allege that Choe does not explicitly disclose which predictive models it uses. A POSA would have therefore searched for references that use predictive models for horizon and lane detection. EX1003, ¶121. This would have led to Khan and Ali, which disclose predictive models for horizon and lane detection. EX1003, ¶121.

2. Khan

A POSA would have been motivated to use Khan’s predictive models in Choe’s camera calibration system because they provide “a robust and efficient lane detection algorithm.” EX1007, 1830. And once combined, a POSA would have had an expectation of success of the combination. EX1003, ¶123. Khan’s predictive models also outperformed other predictive models in the industry for this use case. EX1003, ¶123. Specifically, “[t]he results show a significant improvement of +7.8%, +6.8% and +1.2% of F1 scores over the state-of-the-art on CU-Lane, Caltech and TuSimple datasets, respectively.” EX1007, 1823; *see also* EX1007, 1828-30 (detailed results). Khan’s predictive models also improved

results for occluded and missing lanes. EX1007, 1823; *see also* EX1007, 1824 (“Our approach significantly improved the results on public datasets, specifically for crowded or missing lane scenarios.”), 1826 (“This pipeline greatly improves the lane detection accuracy....”).

A POSA would have also been motivated to use Khan’s predictive models for Choe’s camera calibration because both use similar methods. EX1003, ¶124. For example, during calibration, Choe manually sets the horizon line to maintain the parallelism of the lane lines. EX1005, ¶[0057]. Similarly, Khan relies on the parallelism of the lane lines when calibrating the camera. EX1007, 3-4. And, like Choe’s use of a top-down view, EX1005, ¶[0057], to visualize the parallel property of lane lines, Khan’s model also “synthetically rotates the camera into a top (bird’s eye) view thus rendering the intersecting lines as parallel; the way they actually are in the real world.” EX1007, 1826. Given these similarities, a POSA would have understood that Khan’s predictive models would have been compatible with Choe’s camera calibration and annotation software. EX1003, ¶124. Additionally, because predictive models were so well known, a POSA would have had a reasonable expectation of success when combining Khan’s predictive models with Choe’s system. EX1003, ¶124.

3. Ali

A POSA would have also been motivated to use Ali's horizon estimation algorithm in the Choe-Khan combination because Khan states that "we use [Ali's] horizon estimation algorithm to find the best fitting horizon l_h ." EX1007, 1827; EX1003, ¶125. Ali discloses this algorithm, which uses a predictive model using RANSAC and predicted keypoints for each video frame:

Algorithm 1: Best fitting Horizon (l_h) estimation	
	Input: Detected markers by lane detector
	Output: Estimated Horizon line
1	Find forward and lateral VP for each frame in a video:
2	<u>initialize;</u>
3	for $i \leq \text{num_frames in video}$ do
4	Fit lines to keypoints ($B = \text{num_lines}$);
5	if $B \geq 2$ then
6	for $j \leq {}^B C_2$ do
7	forward_vpi _j = crossprod(line_1, line_2)
8	end
9	end
10	if $B \geq 3$ then
11	for $k \leq {}^B C_3$ do
12	Get lateral_vpi _k using cross ratios as described in Section 3.2.2
13	end
14	end
15	end
16	RANSAC for best fitting horizon across video:
17	<u>initialize;</u>
18	s = random_int between 1 to num_forward_vps;
19	t = random_int between 1 to num_lateral_vps;
20	while iterations $\leq t$ OR num_inliers $\leq \text{max_inliers}$ do
21	Fit line l_h to forward_vp(s) and lateral_vp(t);
22	if dist(l_h , forward_vp(s)) $\leq \text{threshold}_s$ & dist(l_h , lateral_vp(t)) $\leq \text{threshold}_l$ then
23	record and count inlier points
24	end
25	end

EX1008, 1104.

A POSA would have been motivated to use Ali's horizon estimation with Khan's predictive models because the algorithm in Ali could efficiently predict the horizon line. EX1008, 1106-07 (detailed results); EX1003, ¶127. It was "computationally inexpensive and is data-domain invariant." EX1008, 1100. It was "well suited" for autonomous high-way driving. EX1008, 1101. And it was "simple, intuitive, independent of data and performs almost equally on all the tested datasets..." EX1008, 1107. A POSA would have therefore had a reasonable expectation of success when using Ali's horizon prediction algorithm in the Choe-Khan system. EX1003, ¶127.

4. KSR Rationales

Using predictive models for Choe's lane and horizon prediction would have combined known elements according to known methods to yield predictable results. EX1003, ¶128. Predictive models, including convolutional neural networks (CNNs) and region-based CNNs (R-CNNs), were known and were already being used to predict lane lines and horizon lines in traffic images and cityscapes. EX1007, 1825-26; EX1008, 1102; EX1009, 9. Implementing these known mathematical models in Choe's calibration system, according to their known functions, would have yielded predictable results. EX1003, ¶128. Indeed, Choe is already designed to implement predictive models. EX1005, ¶¶[0030], [0037]. And Khan's predictive model is "simple." EX1007, 1824.

Using predictive models for Choe's lane and horizon prediction would have used a known technique (predictive models) to improve similar devices in the same way. EX1003, ¶129. Choe and Khan/Ali identify and annotate video frames with lane lines. EX1005, ¶[0057], FIG. 6B; EX1007, 1823, 4; EX1008, 1102-03. Both Choe and Khan/Ali compute and annotate the horizon line. EX1005, ¶[0055], FIG. 6A; EX1007, 1823, 1826-27; EX1008, 1100, 1103-04. And they determine camera parameters based on those lines. EX1005, ¶¶[0014], [0015], [0049]; EX1007, 1826; EX1008, 1103. Applying Khan/Ali's predictive models to determine the lane and horizon lines—something Choe is already intended to do—would improve Choe in the same way. EX1003, ¶129.

Using predictive models for Choe's lane and horizon prediction would have also applied a known technique (predictive models) to a known device (a manual annotator device) ready for improvement. EX1003, ¶130. As just explained, Khan/Ali's predictive models and Choe's manual calibration system were known. Choe was also ready for improvement. EX1003, ¶130. Choe states: "It will be evident that *various modifications may be made* thereto without departing from the broader spirit and scope of the disclosure...." EX1005, ¶[0066].

For all these reasons, a POSA would have been motivated to combine Choe and Khan/Ali to identify lane and horizon lines with predictive models, and the combination would have been successful. EX1003, ¶¶121-31.

B. Claims 1-4

1. Choe

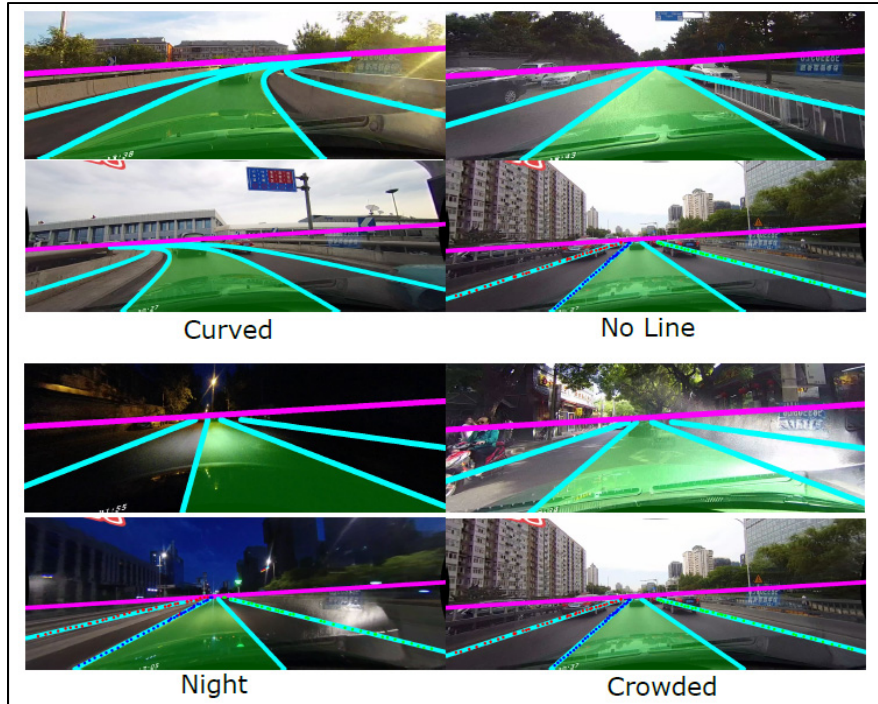
As Ground 1 explains, Choe discloses (or at least suggests) every element of claims 1-4. However, if PO alleges that Choe fails to explicitly describe its “predictive models,” Khan in view of Ali provide this teaching. EX1003, ¶132.

2. Khan in view of Ali

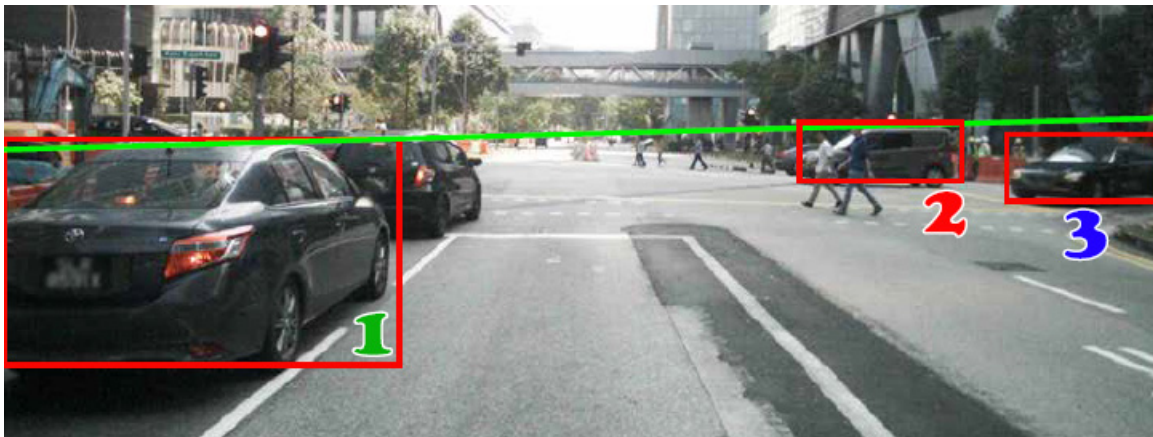
Khan in view of Ali “identif[ies] one or more lines in the video using a predictive model, the one or more lines including a horizon line” as recited in [1B]. EX1003, ¶133. In Khan, the predictive model used to identify lane and horizon lines is called a “Mask-RCNN.” EX1007, 1825; EX1003, ¶133. As known by a POSA, a Mask-RCNN is the same predictive model used in the ’580 patent. EX1003, ¶133 (Mask-RCNN uses a backbone network and a network head).

Khan in view of Ali uses this predictive model to identify lane lines and horizon lines. EX1003, ¶134. Specifically, the Mask-RCNN predicts lane boundary markers and then fit lines to the predicted keypoints. EX1007, 1825-26 (“We fit lines to predicted keypoints....”), 1828 (Algorithm 1). After lane lines are fit to the detected markers, Khan uses RANSAC (a predictive model) to predict the horizon line. EX1007, 1826-27. This predictive model for the horizon is described more fully in Ali. EX1008, 1104; *see also* EX1007, 1827 (citing EX1008).

Once Khan in view of Ali identifies the horizon and lane lines, it overlays the horizon line and/or lane lines on the video, as shown in the screenshots below.



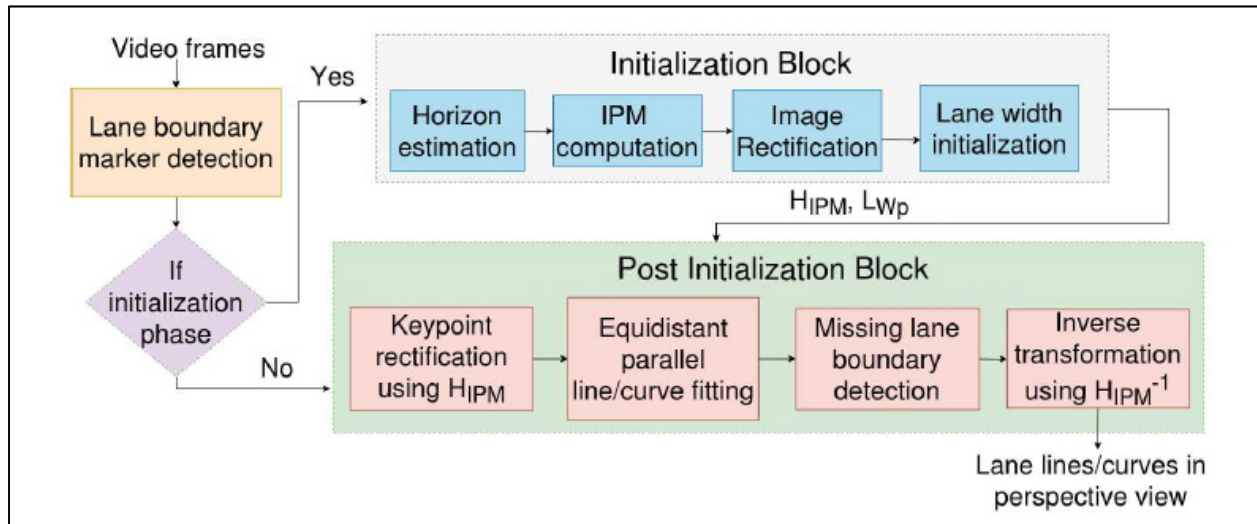
EX1007, 1823; *see also* EX1007, 1824, 1828-29 (additional figures).



EX1008, 1100; *see also* EX1008, 1103-06 (additional figures).

Using these lines, Khan in view of Ali then “predict[s] the at least one camera parameter ... using a predictive model.” EX1003, ¶137. In Khan and Ali, camera parameters are predicted during its Inverse Perspective Mapping (IPM) computation step. EX1007, 1826; EX1008, 1103. The ’580 patent likewise uses

IPM computation. *E.g.*, EX1001, 6:44-46, 14:15-16. As Khan states: “We instead use road geometry to *find camera pose* and in-turn find the IPM.” EX1007, 1826. Other camera parameters such as camera height are also predicted during the IPM computation step. EX1007, 1827; EX1008, 1105.



EX1007, 1825.

If the entire end2end lane detection algorithm (e.g., EX1007, FIG. 3) is “the predictive model,” the IPM computation is part of “the predictive model,” as recited in claim 3 of the ’580 patent EX1003, ¶138. One could also view the lane boundary marker detection, the horizon estimation, and IPM computation as different predictive models—all three use well-known models to predict different features. EX1003, ¶138. With understanding, the lines are predicted with a first predictive model and the camera parameters are predicted with “a second predictive model” as recited in claim 4. EX1003, ¶138.

3. Motivation to Combine

For these reasons, using the predictive models in Khan in view of Ali for Choe's camera calibration system would have disclosed every element of claims 1-4. Because a POSA would have been motivated to combine Choe, Khan, and Ali in a manner that satisfied every element of claims 1-4, these claims were obvious.

Supra Section VI.A; EX1003, ¶¶132-39.

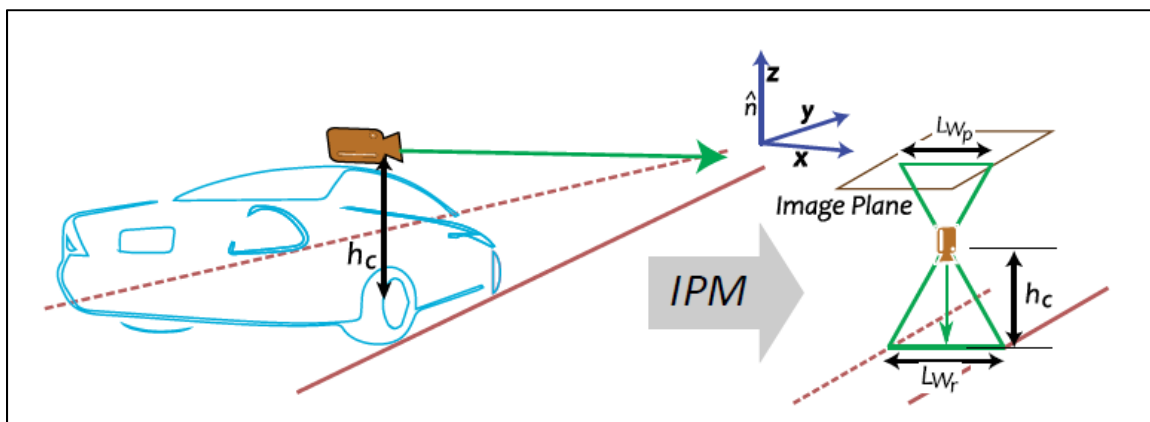
C. Claim 5

Choe in view of Khan, further view of Ali discloses claim 5. EX1003, ¶¶140-44. Claim 5 depends from claim 1 and further recites "wherein the at least one camera parameter comprises a camera height and road plane normal." To the extent Choe does not expressly compute the camera height and/or the road plane normal, Khan in view of Ali provides this teaching. EX1003, ¶140.

A POSA would have been motivated to use the predictive models in Khan in view of Ali for Choe's camera calibration. *Supra* Section VI.A. These predictive models compute "a camera height" and "road plane normal" based on the lane and horizon lines. EX1003, ¶¶141-43.

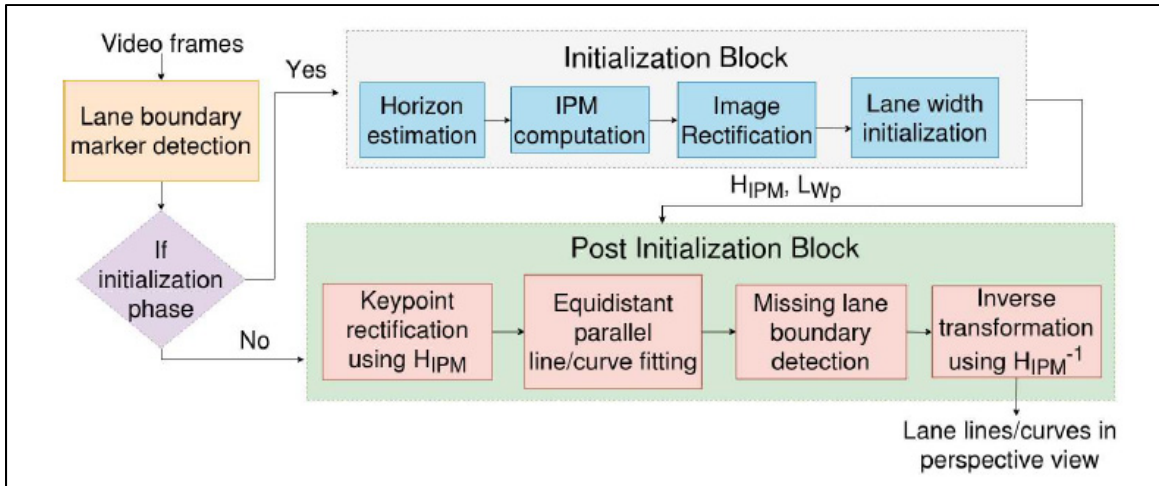
The predictive model predicts the camera height (h_c) based on a lane line and the lane width. EX1003, ¶141; EX1007, 1826 (" h_c is the camera height"); EX1008, 1100 ("[I]t determines an Inverse Perspective Mapping (IPM) and camera height from a known lane width and the detected horizon."), 1105 (additional detail on

how to calculate camera height). Also shown below, the predictive models predict the road plane normal ($\hat{n}$) based on the lines. EX1007, 1826. Khan explains: “After estimating horizon, we compute plane normal $\hat{n}$ using camera intrinsic matrix K and horizon l_h [11] by $\hat{n} = K^T l_h$.” EX1007, 1827; *see also* EX1008, 1103 (“Camera initialization involves finding camera height and road plane normal.”). “The road plane normal $\hat{n}$ was along the Z-axis (upwards)....” EX1008, 1103.



EX1007, 1826; *see also* EX1008, 1103 (similar figure).

Shown above with the arrow labeled “IPM” (Inverse Perspective Mapping), these parameters are calculated as part of Khan’s predictive model. EX1003, ¶142. They are also calculated based on one or more of the lines because, as shown in the figure above and the figure below, the camera parameters are calculated during the IPM computation *after*, and based on, the lane boundary marker detection and horizon estimation. EX1003, ¶142; EX1007, 1826-27; EX1008, 1103-04 (using lane and horizon lines to determine camera parameters).



EX1007, 1825.

A POSA would have been motivated to use Khan's predictive models, which predict these camera parameters. *Supra* Section VI.A. Additionally, a POSA would have been motivated to calculate the camera height and road plane normal based on the lines, as taught by Khan in view of Ali, to compensate for variability in the vehicle height, the camera height relative to the dashboard, and the camera's pitch, yaw, and roll. EX1003, ¶143. As a POSA would have appreciated, calculating these camera parameters and using them to calibrate the camera would have improved consistency of lane detection. EX1003, ¶143.

Because a POSA would have been motivated to combine Choe, Khan, and Ali in a manner that satisfied every element of claim 5, this claim is also obvious. *Supra* Section VI.A; EX1003, ¶¶140-44.

VII. GROUND 3: CHOE IN VIEW OF WORKMAN RENDERS OBVIOUS CLAIMS 1-4

As Ground 2 explains, a POSA would have been motivated to use a predictive model in Choe’s camera calibration system to identify the horizon line and lane lines. Khan and Ali show that predictive models were already used to identify these lines. These publications include the ’580 patent inventors as authors. However, the inventors were not the first to use predictive models for horizon and lane detection. Far from it. As Workman shows, predictive models (e.g., CNNs) were used to identify the horizon line years prior. EX1003, ¶145.

A. Motivation to Combine Choe with Workman

As Ground 1 explains, Choe discloses a “machine learning engine 122 [that] generates or trains a set of rules, algorithms, and/or predictive models,” including for its sensor calibration algorithms. EX1005, ¶[0030]. However, if PO alleges that Choe does not explicitly disclose which predictive models it uses or whether it uses predictive models to identify the horizon line, a POSA would have searched for references that use predictive models and how such models were used. EX1003, ¶146. This would have led to Workman, which discloses predictive models to identify the horizon line. EX1003, ¶146.

A POSA would have known *how* and *why* to use Workman’s predictive models to identify the horizon lines in Choe with an expectation of success because the combination achieved state-of-the-art results:

An extensive evaluation shows that using our CNNs, either in isolation or in conjunction with a previous geometric approach, *we achieve state-of-the-art results* on the challenging HLW dataset and two existing benchmark datasets.

EX1011, 1; *see also* EX1003, ¶147; EX1011, 2 (reporting “significantly improve[d] performance for vanishing point based horizon line estimation”), 8-10 (experiment results showing “state-of-the-art results on all datasets”).

A POSA would have known *how* and *why* to use Workman’s predictive models to identify the horizon lines in Choe with an expectation of success also because it identifies the horizon line faster than other models:

The resulting network implicitly combines both geometric and semantic cues, makes no explicit assumptions about the contents of the underlying scene, and is *several orders of magnitude faster than current state-of-the-art methods* which focus on vanishing points.

EX1011, 1; *see also* EX1003, ¶148-50; EX1011, 2 (“requiring only milliseconds per image”), 10 (“outperforming all existing methods”). It was also designed and intended to be used “as input to other methods.” EX1011, 10.

Using Workman’s predictive model to identify the horizon line would also have merely been combining known elements (CNNs and annotation for camera calibration) according to known methods to yield predictable results and used

known techniques (CNNs) to improve similar devices in the same way. EX1003, ¶150. Additionally, because these predictive models had been so well known, a POSA would have had a reasonable expectation of success. EX1003, ¶150.

B. Claims 1-4

1. Choe

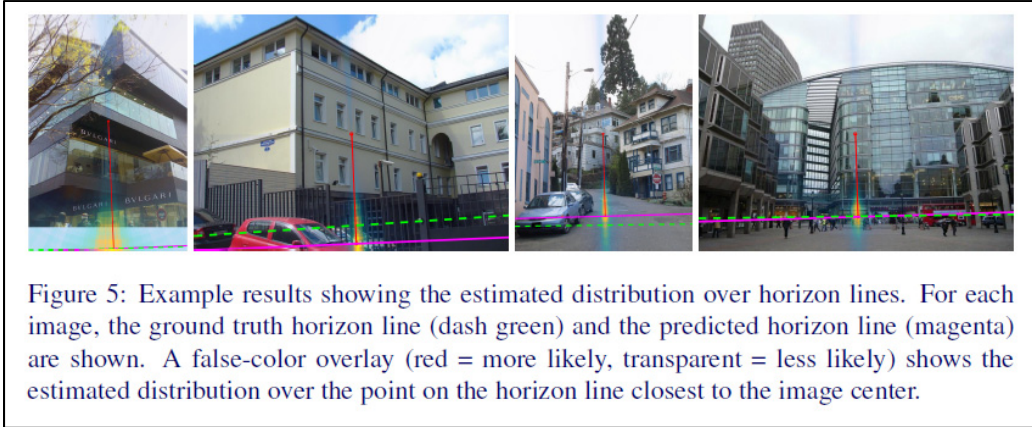
As Ground 1 explains, Choe discloses (or at least suggests) every element of claims 1-4. However, if PO alleges that Choe fails to explicitly describe the “predictive model,” Workman provides this teaching. EX1003, ¶¶151-53.

2. Workman

Workman “identif[ies] one or more lines in the video using a predictive model, the one or more lines including a horizon line” as recited in [1B]. EX1003, ¶¶151-53. Workman uses a CNN to directly estimate the horizon line:

We introduce a large, realistic evaluation dataset, Horizon Lines in the Wild (HLW), containing natural images with labeled horizon lines. Using this dataset, we investigate the application of *convolutional neural networks for directly estimating the horizon line*, without requiring any explicit geometric constraints or other special cues.

EX1011, 1 (original emphasis removed and new emphasis added); *see also* EX1011, 1 (“directly estimate the horizon line”), 6 (“(CNNs) to estimate the location of the horizon line from raw pixel intensities.”), 10 (“directly estimating the horizon line using convolutional networks”).



EX1011, 9.

3. Motivation to Combine

When Choe uses Workman’s predictive model to identify the horizon line, the combination also identifies the lane lines as recited in claim 2 because the lane lines are identified based on the identified horizon line. EX1003, ¶153. For example, Choe states that “lane lines 621-23 [are] positioned based on the position of horizon line 610.” EX1005, ¶[0056]; *see also* EX1005, ¶¶[0015]-[0016], [0048]-[0053], [0059]. When using Workman’s predictive model, the lane lines would therefore also be identified “using a predictive model.” EX1003, ¶¶153-54.

Choe in view of Workman also discloses “predicting the at least one camera parameter using a predictive model” as recited in claim 3. *Id.*, ¶155. As explained for Ground 1, Choe uses the predicted horizon line to predict camera parameters. The Choe-Workman combination likewise performs this step. *Id.*, ¶155.

If Workman's algorithm and Choe's camera parameter prediction are collectively "the predictive model," the camera parameter prediction is part of "the predictive model," as recited in claim 3 of the '580 patent. EX1003, ¶156.

One could also view the horizon line prediction and the camera parameter prediction as different predictive models because each predict different features. *Id.*, ¶156. With this understanding, the lines are predicted with a first predictive model and the camera parameters are predicted with "a second predictive model" as recited in claim 4. *Id.*, ¶156.

For these reasons, using Workman's predictive model in Choe's camera calibration system would have disclosed (or at least suggested) every element of claims 1-4 of the '580 patent. *Id.*, ¶¶151-57. Claims 1-4 are therefore obvious. *Supra* Section VII.A.

VIII. GROUND 4: CHOE IN VIEW OF WESTMACOT RENDERS OBVIOUS CLAIMS 5-7

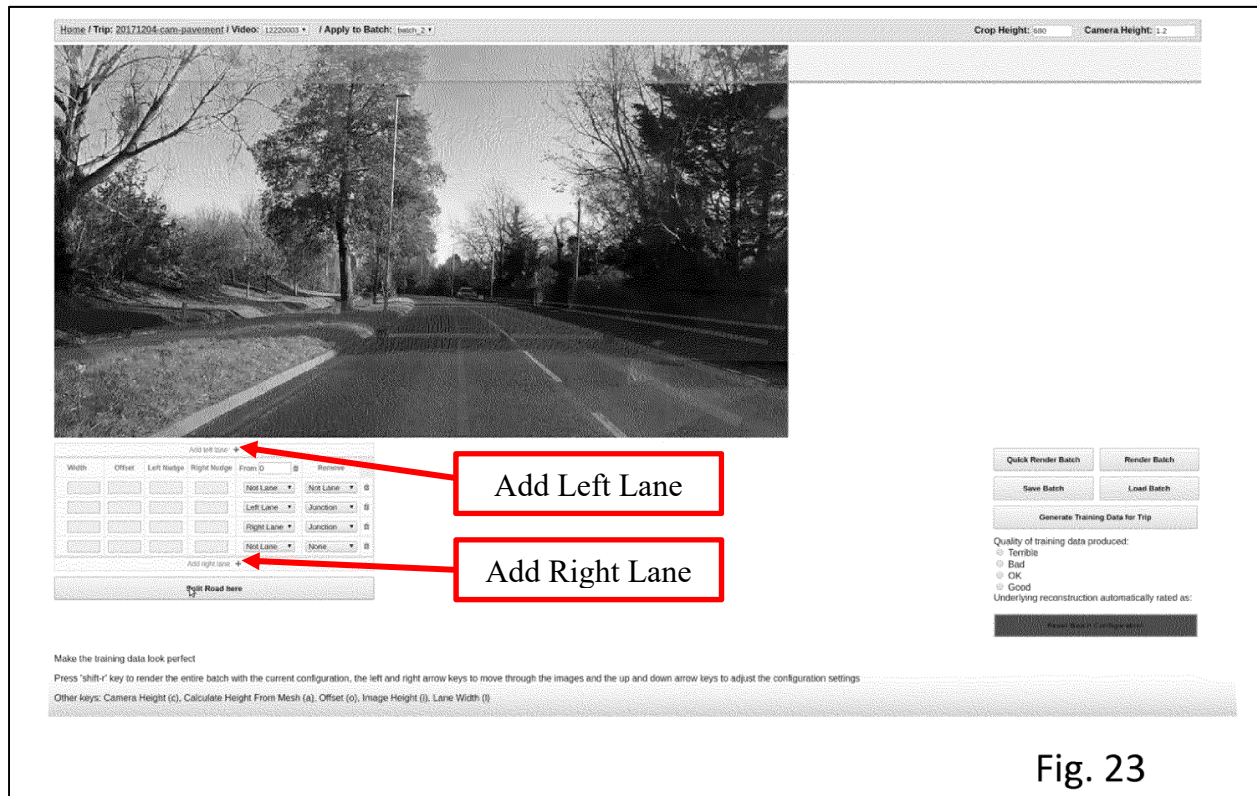
A. Choe

As explained for Ground 1, Choe discloses a camera calibration system that predicts the horizon and lane lines and an annotator that allows users to modify these lines. EX1005, ¶¶[0015], [0057]. However, to the extent Choe does not expressly disclose the mathematics for predicting these lane lines or allow an annotator to *add* lane lines, a POSA would have looked for references in the prior

art. EX1003, ¶¶160, 169-70. This would have led to Westmacot, which likewise predicts lane lines and has an annotator. *Id.*

B. Westmacot

Westmacot discloses “[a] method of annotating road images....” EX1010, Abstract. Shown in the figure below, “[i]n the bottom-left, the annotator is provided with controls to manipulate currently rendered lanes (narrow, widen, move to the left or right, move the boundaries of the lane etc.) *and add new lanes.*” *Id.*, 34:7-9. Additionally, “the annotator is provided with means to adjust the camera height....” *Id.*, 34:9-11.



EX1010, FIG. 23 (annotated).

C. Motivation to combine Choe with Westmacot.

A POSA would have found it obvious *why* and *how* to combine the teachings of Westmacot with the teaching of Choe, and once combined, would have found there was a reasonable expectation of success that the combination would continue to operate as intended. EX1003, ¶¶159-74.

A POSA would have found it obvious to combine the references for at least two reasons. First, a POSA would have been motivated to compute and calibrate the camera height and road plane normal in Choe's camera calibration system. EX1003, ¶159. Second, a POSA would have been motivated to allow the user add lane lines during Choe's manual calibration. EX1003, ¶159. Each reason is explained in detail below.

1. *How and Why* it would have been obvious to compute and calibrate the camera height and the road plane normal

In Choe's camera calibration system, a POSA would have been motivated to calculate a camera height and road plane normal because the left and right lane lines are derived from equations that require the camera height (h) and the road plane normal (n). EX1003, ¶161; EX1010, 36:26-37:9, 65:1-4. For example, the ground point g_i on the road below the camera at frame i can be calculated with the following equation, where h is the height of the camera above the road and n is the surface normal of the road relative to the camera. EX1010, 24:24-25:2.

$$g_i = c_i + hR_i n$$

Id., 24:26. The ground point g_i is then used to determine the left and right lane borders, as Westmacot's equation shows:

$$\begin{aligned} b_i^{\text{left}} &= g_i + w_i^{\text{left}} R_i r \\ b_i^{\text{right}} &= g_i + w_i^{\text{right}} R_i r \end{aligned}$$

Id., 25:2-4.

Additionally, a POSA would have been motivated to compute the camera height and the road plane normal because these parameters are used to determine the rotational orientation of the camera. *Id.*, 9:19-22; EX1003, ¶162. Since Choe's camera calibration requires calculating the camera's rotational orientation (pitch, yaw, and roll), a POSA would have understood that the system would need to compute these camera parameters. EX1003, ¶162.

A POSA would have also been motivated to enable the user to manually adjust the camera height during calibration to correct errors. *Id.*, ¶163. For example, Westmacot states that the initially computed camera height "may not be exactly correct." EX1010, 47:24. These errors "can be fixed up with very little effort by a human annotator." *Id.*, 47:21-22. For example, "[i]n Figure 1[8], the

annotator is provided with means to adjust the camera height....” *Id.*, 34:9-10.⁴

This “means” is a “simple” user interface, *id.*, 48:6-7, that has an option on the upper right (shown below) that allows the user to adjust the camera height.

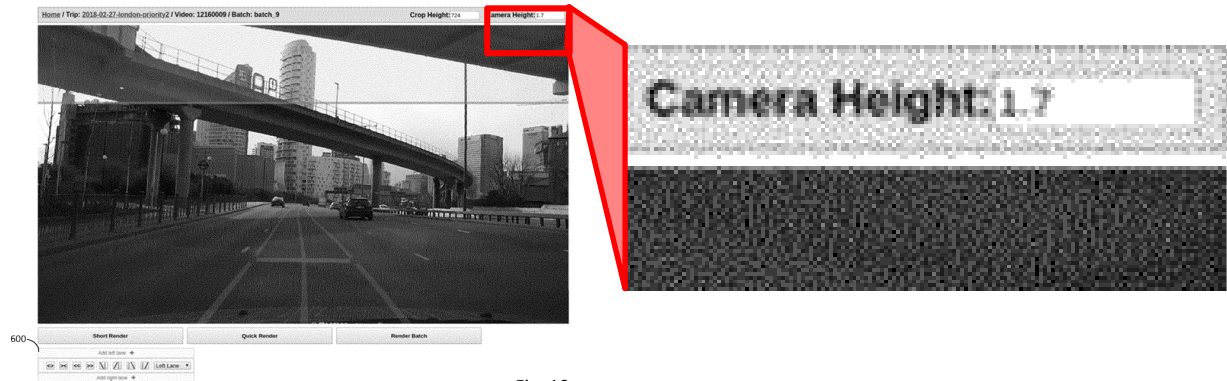


Fig. 18

EX1010, FIG. 18 (excerpted and annotated).

Computing and calibrating the camera height and the road plane normal would have combined known elements according to known methods to yield predictable results. EX1003, ¶165. Specifically, the camera height and road plane normal were known calculations or measurements that used known methods (e.g., multiplication and division). EX1010, 5:2-4 (equation for the road plane normal), 26:4 (“The camera height above the road ft is *easy* to measure”), FIGS. 3, 3A, 26; EX1008, 5 (computing road plane normal) 6 (equation for camera height).

Performing known mathematical calculations in Choe’s calibration system would have yielded predictable results because, given a set of rules and known variables,

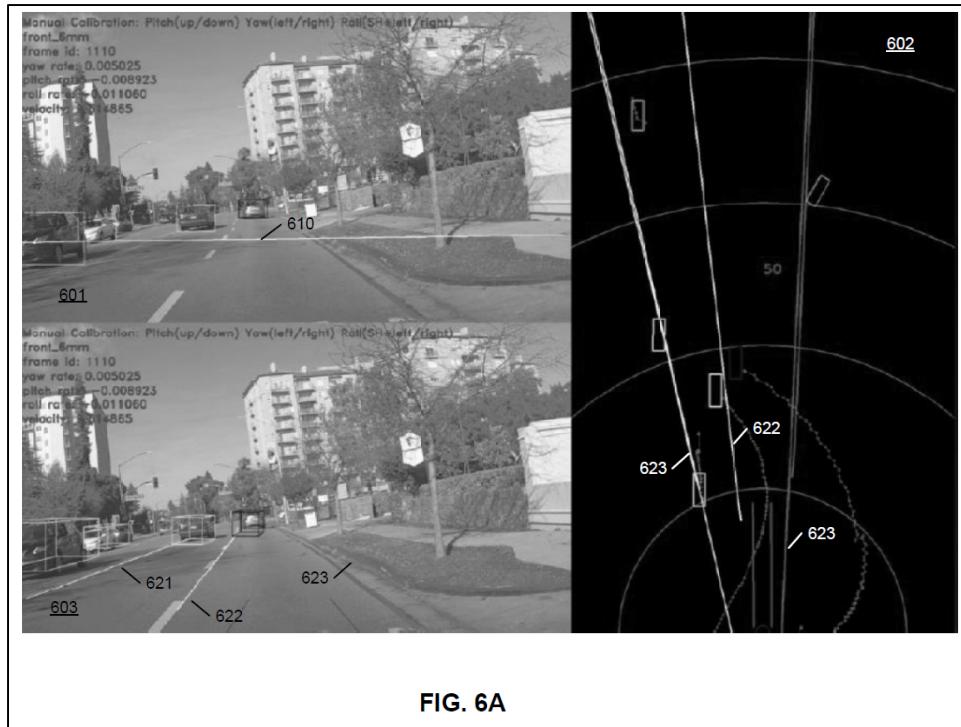
⁴ The figures make clear that Westmacot meant to cite Figure 18 (not 19).

a POSA could consistently calculate the camera height and the road plane normal. EX1003, ¶165. Accordingly, a POSA would have had a reasonable expectation of success when computing the road plane normal and camera height in Choe's camera calibration system. EX1003, ¶165.

Computing and calibrating the camera height and road plane normal would have used a known technique to improve similar devices in the same way. *Id.*, ¶166. Choe and Westmacot are both annotator devices. EX1005, ¶[0055], FIG. 6A; EX1010, 33:20-25, 34:5-11. Both rely on manual annotations. EX1005, ¶¶[0014], [0057]; EX1010, 33:18-34:16. Both annotate video frames with lane lines. EX1005, ¶[0057], FIG. 6B; EX1010, 34:5-9. And both compute and annotate the horizon line. EX1005, ¶[0055], FIG. 6A; EX1010, 37:3-4, 44:14-18. Applying Westmacot's option to adjust the camera height during its manual calibration would have improved Choe's annotator in the same way—by increasing the accuracy of the annotated lane lines. EX1003, ¶166.

2. *How and why it would have been obvious to enable a user to add lane lines during manual calibration*

As Ground 1 explains, Choe discloses an annotator device that enables a user to manually adjust lane lines. Figure 6A shows screenshots from the annotation device's graphical user interface (GUI). EX1005, ¶¶[0010], [0055].

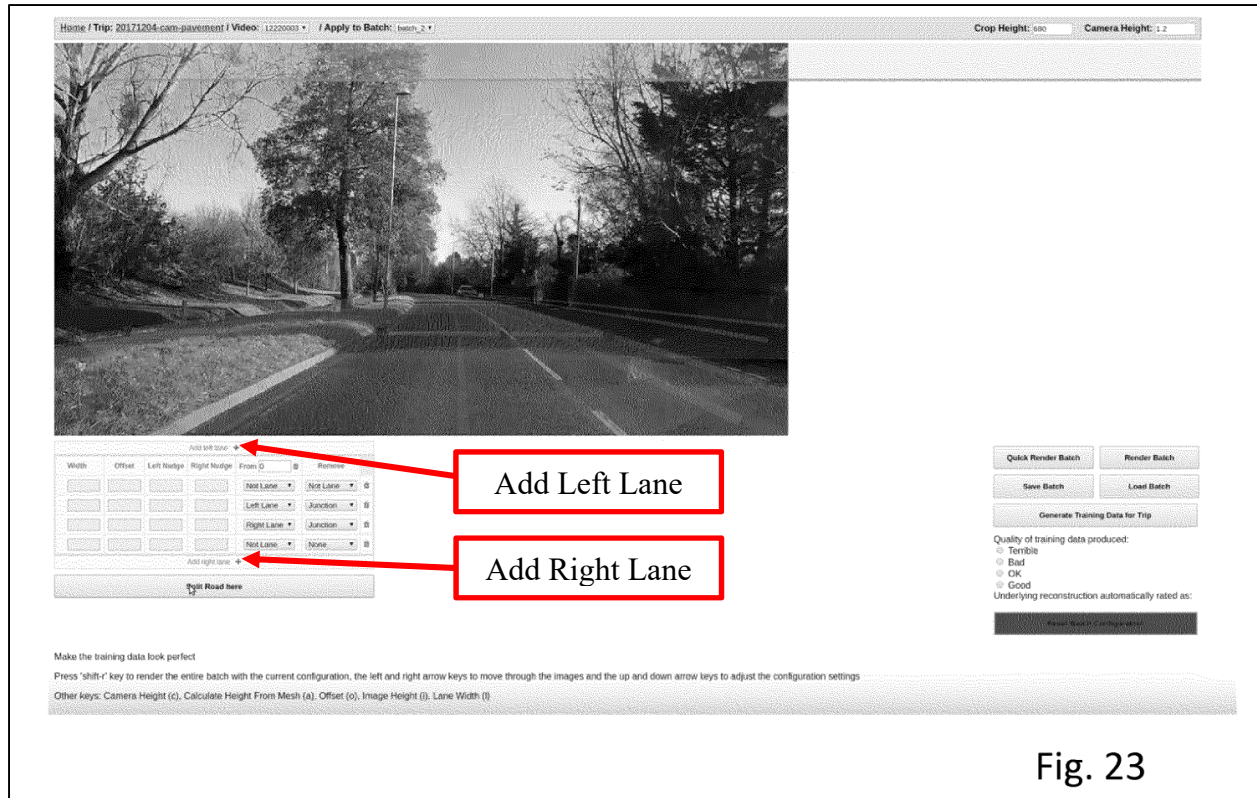


EX1006, FIG. 6A; *see also* EX1005, FIGS. 6A-6B; EX1006, FIG. 6B.

Shown above, the GUI instructs users how to perform manual calibration with a keyboard: “Manual Calibration: Pitch (up/down) Yaw (left/right) Roll (SH+left/right).” EX1006, FIG. 6A; EX1005, FIG. 6A. “[I]n response to a first input signal (e.g., an up or down arrow key) received from an input device (e.g., keyboard, joystick, voice interactive command), ... a position of at least one of the lane lines is updated based on the updated horizon line.” EX1005, ¶[0015]; *see also* EX1005, ¶¶[0016]-[0017], [0047], [0049], [0052], [0055]-[0057], FIGS. 6A-6B. Although Choe expressly discloses manual calibration to adjust lane lines, PO may allege that Choe does not explicitly allow users to *add* lane lines.

Adding lane lines would have been obvious. In Choe, a POSA would have understood that lane prediction models would not identify all the lane lines that exist in the real world. EX1003, ¶169; EX1007, 1837-28. For example, some lane lines may be faded and others may not have lane markings at all. EX1003, ¶169; EX1007, 1824 (“fading color of the lane boundary over time ... is quite common”). Without sufficient lane markings, Choe’s the lane detection algorithm, in certain circumstances, would be unable to detect lane features. EX1003, ¶169.

A POSA would have therefore searched for references that disclose how to remedy the problem of missing lane lines. *Id.*, ¶170. This would have led the POSA to Westmacot, which discloses an annotator that allows users to add missing lane lines. *Id.*, ¶170. Westmacot states: “In the bottom-left, the annotator is provided with controls to ... add new lanes.” EX1010, 34:7-9.



EX1010, FIG. 23 (annotated).

A POSA would have been motivated to have Choe's annotator device to add lane lines, as taught in Westmacot. EX1003, ¶172. Not only does it solve the problem of faded and/or missing lane lines, Westmacot's annotation is quick and efficient. *Id.*, ¶172 (citing EX1010, 4:28-30, 19:17-24, 47:28-48:10, 55 (Table 1)). Indeed, Westmacot's annotation requires "100 times less human effort [than other annotation methods], as measured in terms of annotation time per image." EX1010, 19:17-24. And the feature of adding lane lines requires "very low effort to add but provide[s] significant benefit." EX1010, 47:28-30.

Adding lane lines during manual calibration would have combined known elements according to known methods to yield predictable results. EX1003, ¶173. Specifically, manually adding a lane line would have used known methods (e.g., an annotator and overlaid annotations). EX1005, ¶¶[0016], [0057], FIG. 6A; EX1010, 34:5-11, 49:2-5. Using this known annotation option (new lane lines) in Choe's system would have yielded predictable results because Choe is already configured to annotate images with lane lines. EX1003, ¶173. And Westmacot's annotations, which include adding lane lines, are "simple." EX1010, 48:6-7. Accordingly, a POSA would have had a reasonable expectation of success when combining Westmacot's option to add lane lines with Choe's system. EX1003, ¶173.

Adding lane lines during manual calibration would have used a known technique (a conventional graphical user interface with an option to add a line into a video frame) to improve similar devices (annotators) in the same way. EX1003, ¶174. Choe and Westmacot are both annotator devices. EX1005, ¶[0055], FIG. 6A; EX1010, 33:20-25, 34:5-11. Both rely on manual annotations. EX1005, ¶¶[0014], [0057]; EX1010, 33:18-34:16. And both annotate video frames with lane lines. EX1005, ¶[0057], FIG. 6B; EX1010, 34:5-9. Adding the option for the user to manually add lane lines would have improved Choe's annotator in the same way—e.g., by adding missing lane lines and/or adding bike/bus lanes. EX1003, ¶174.

D. Claim 5

Choe-Westmacot render obvious claim 5.

Claim 5 depends from claim 1 and further recites “wherein the at least one camera parameter comprises a camera height and road plane normal.”

1. Choe

Choe “comput[es] at least one camera parameter based on the one or more lines.” *Supra* Section V.A.4. To the extent PO alleges that Choe does not explicitly disclose which parameters are required for accurate calibration, Westmacot provides this teaching, disclosing that camera height (h) and the road plane normal (n) are among many parameters that are required. EX1003, ¶¶175-81.

2. Westmacot

Westmacot shows the camera height (h) and road plane normal (n) in Figure 26 (below) in relation to the left and right lane lines.

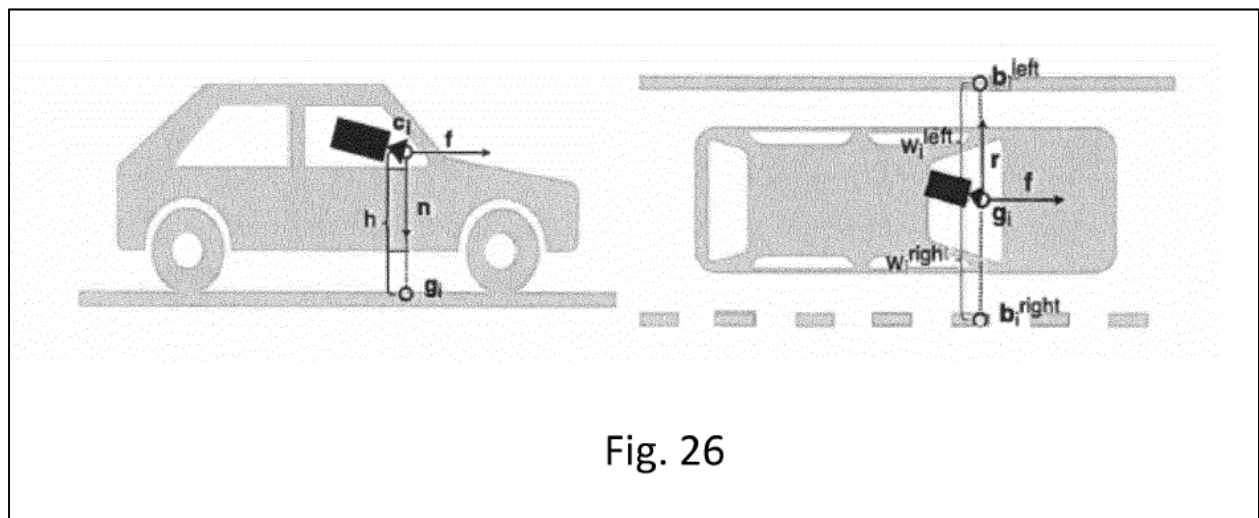


Fig. 26

EX1010, FIG. 26.

As Westmacot explains, “[t]he projection may be performed based on a *height of the image capture device* in the vehicle.” EX1010, 7:1-2; *see also* EX1010, 24:4 (“h is the height of the camera above the road”), 6:5-7, 26:4-8, 30:24-28, 45:20-31, FIGS. 3, 3A, 26 (additional details on the camera height).

Westmacot also discloses that the camera parameters include the road plane normal (n). EX1003, ¶179. Westmacot states: “The expected road structure may be determined based on a *road normal vector*.” EX1010, 5:1. The road normal vector n is “the surface normal of the road relative to the camera,” 25:1-2, and may be estimated from the image as:

$$\mathbf{n} = \frac{1}{\sum_{i=2}^{N-2} \|\mathbf{n}_i\|} \sum_{i=2}^{N-2} \mathbf{n}_i$$
$$\mathbf{n}_i = \mathbf{R}_i^{-1}(\mathbf{m}_{i-1,i} \otimes \mathbf{m}_{i,i+1}),$$

EX1010, 5:2-4; *see also id.*, 24:1-6, 26:9-27:5, 39:31-40:2, FIGS. 8-9, 16, 27 (additional details on the road plane normal).

Accordingly, Westmacot discloses that the camera parameters needed to determine the camera position include “a camera height and road plane normal.”

3. Motivation to Combine

Because a POSA would have been motivated to combine Choe and Westmacot in a manner that satisfied every element of claim 5, this claim is also obvious. *Supra* Section VIII.C; EX1003, ¶¶175-81.

E. Claim 6

Claim 6 depends from claim 1 and recites the following elements.

- 1. [6A] “receiving, over the network from the camera device, a second video comprising a second set of images”**

Choe discloses this element. EX1003, ¶¶183-85.

Choe’s sensor calibration system “receiv[es], over a network from a camera device, a video comprising a set of image frames.” *Supra* Section V.A.2. Choe performs the same step with “a second video comprising a second set of images” because it calibrates the camera multiple times. EX1003, ¶184.

Choe calibrates the camera multiple times because it states: “sensors require *periodically* calibrated [sic] to make sure the accuracy of the sensors, such that the perception system of an autonomous driving system can accurately detect and recognize the objects and lane configuration of the driving environment.” EX1005, ¶[0003]. Moreover, performing the same function (receiving a video, over a network, from the camera device) twice instead of once is not patentable. “It is well settled that the mere duplication of parts has no patentable significance unless a new and unexpected result is produced.” *Application of Harza*, 274 F.2d 669, 671 (C.C.P.A. 1960); M.P.E.P. § 2144.04.VI.B.

2. [6B] “transmitting the second video to the annotator device for manual review”

Choe discloses this element. EX1003, ¶¶186-88.

Choe’s sensor calibration system transmits video to an annotator device for manual review. *Supra* Section V.A.6. Choe performs the same step with “the second video” because it calibrates the camera multiple times. EX1003, ¶187.

Choe performs its process multiple times because the camera must be “periodically” calibrated. *Supra* Section VIII.E.1; EX1005, ¶[0003]. Moreover, performing the same function (transmitting video to an annotator device) twice instead of once is not patentable. “It is well settled that the mere duplication of parts has no patentable significance unless a new and unexpected result is produced.” *Harza*, 274 F.2d at 671; M.P.E.P. § 2144.04.VI.B.

3. [6C] “adding, by the annotator device, one or more lines to the second video to generate a second overlaid video”

Choe in view of Westmacot discloses this element. EX1003, ¶¶189-95.

(a) Choe

Choe discloses an “annotator device” that modifies or confirms lane and horizon lines in video frames of a video. *Supra* Section V.A.7. If PO alleges that Choe does not explicitly disclose “adding” a line to the video, Westmacot provides this teaching.

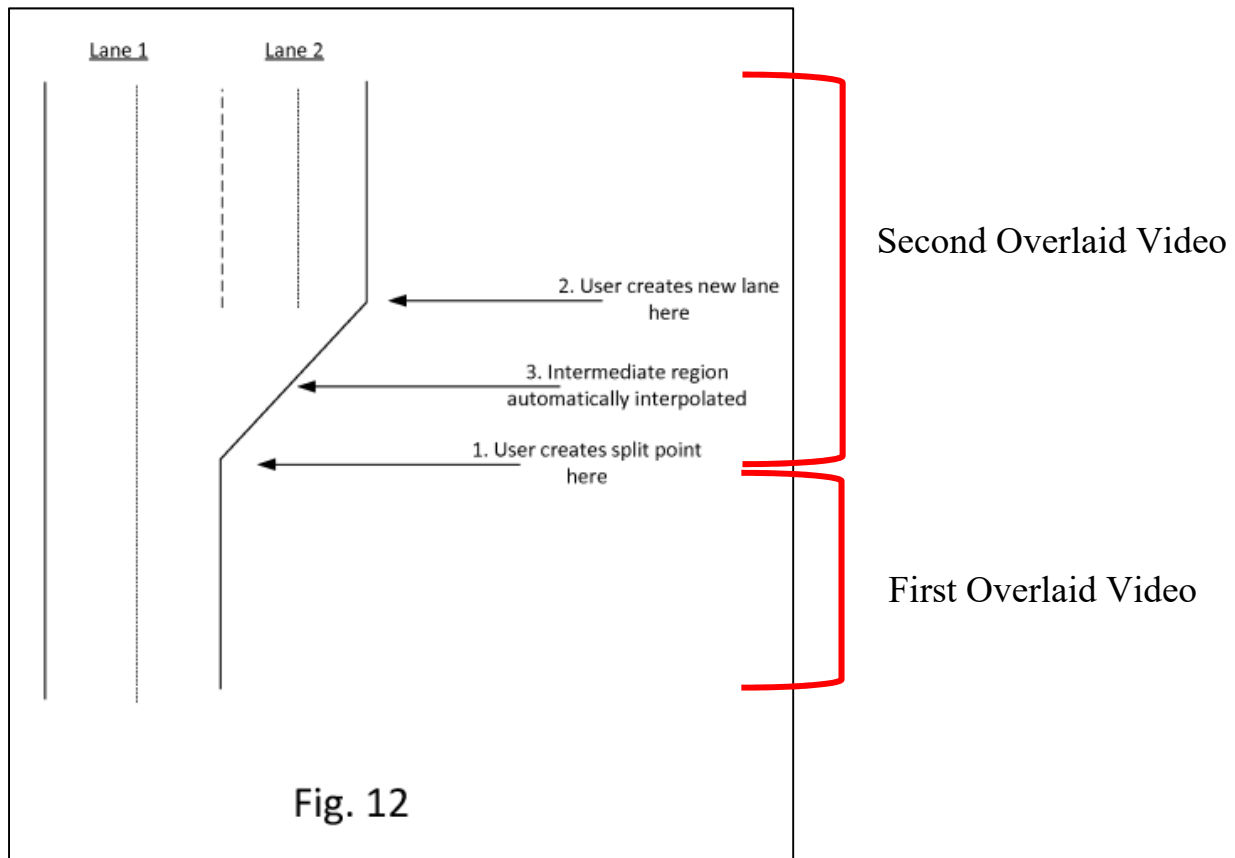
(b) Westmacot

Westmacot discloses an “annotator device” (e.g., a computer with an annotation interface) that adds lines to a video. EX1003, ¶191. Specifically, “[a]n annotation interface provides a human annotator with the ability to view the frames in a batch individually with the currently rendered lanes projected into the images.” EX1010, 33:20-23. These images are video frames. *Id.*, 19:26-28. The annotator device can then add lane lines: “In the bottom-left, the annotator is provided with controls to manipulate currently rendered lines ... *and add new lines.*” *Id.*, 34:7-9; *see also id.*, 51:25-30. The user can add lines for adjacent lanes (47:31-33), cycle lanes (52:18-21), and bus/taxi lanes (48:1-3).



EX1010, FIG. 23 (annotated).

Once added, Westmacot's annotator device generates "a second overlaid video." EX1003, ¶193. As Westmacot explains, a user can "split" the video at the junction where a second lane line is added. EX1010, 50:11-17, 51:18-52:4. A first overlaid video includes the frames before the split point and the second overlaid video includes the frames after the split point. EX1003, ¶193.



EX1010, FIG. 12 (annotated).

Even if PO alleges that the "split" video is not a "second overlaid video," Westmacot would still disclose a "second overlaid video" because it performs its process multiple times. EX1010, 19:26-20:4 (annotating "batches" of video frames), FIGS. 18, 22 (two different overlay videos). The second time Westmacot

performed its process would generate a “second” overlaid video. EX1003, ¶194; *see also Harza*, 274 F.2d at 671. Westmacot therefore “add[s], by the annotator device, one or more lines to the second video to generate a second overlaid video.” EX1003, ¶194.

(c) Motivation to Combine

Because a POSA would have combined Choe and Westmacot to enable Choe’s annotator device to add lines to the videos, the combination also discloses this element. *Supra* Section VIII.C.2; EX1003, ¶189-95.

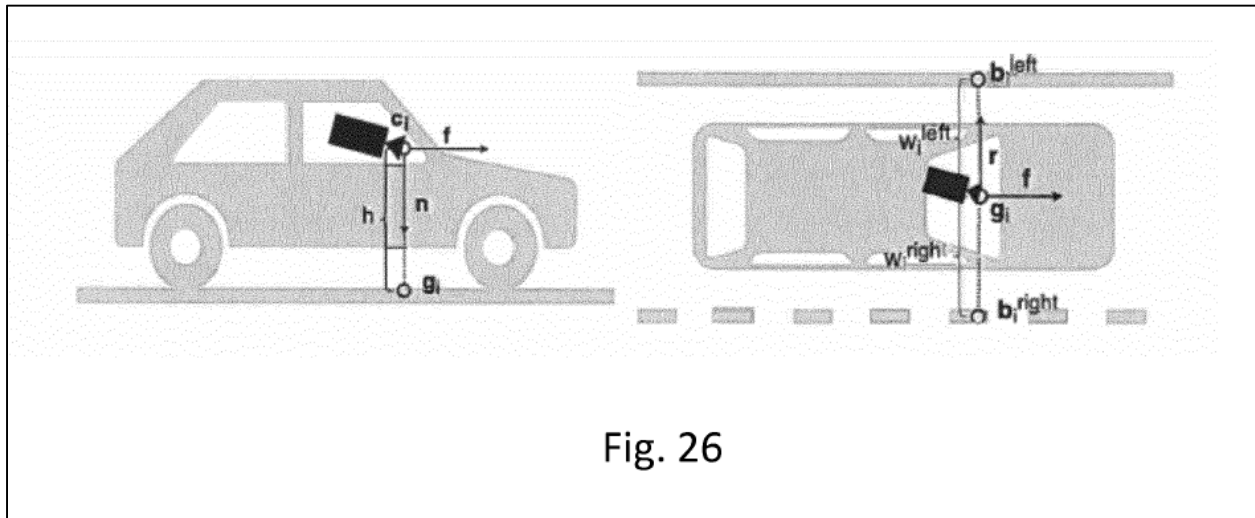
4. [6D] “predicting, using the one or more lines in the second overlaid video, at least one camera parameter”

Choe in view of Westmacot discloses this element. EX1003, ¶¶196-98.

Choe in view of Westmacot discloses a second overlaid video. *Supra* Section VIII.E.3. Both Choe and Westmacot predict camera parameters using the lines in the overlaid video. *Supra* Sections V.A.4 and VIII.D; EX1003, ¶196.

In Choe, “[a] first calibration factor or first correction value is determined for calibrating a pitch angle of the camera based on a difference between the initial horizon line and the updated horizon line.” EX1005, ¶[0015]. Choe also uses the lines to predict other camera parameters. *Id.*, ¶¶[0014] (“A user can calibrate any of the sensors such as a pitch angle, a yaw angle, and/or a roll angle....”), [0049], [0052]-[0053], [0057], [0059], FIG. 7.

Even if PO alleges that Choe does not predict camera parameters, Westmacot shows how a camera height (h) mathematically relates to the left and right lane lines. EX1010, 24:1-29:2.



EX1010, FIG. 26.

Accordingly, in the Choe-Westmacot combination, Choe would predict camera parameters (e.g., parameters for the camera's pitch, yaw, roll, and height) based on the annotated lines—including lines added during manual calibration, as taught in Westmacot. *Supra* Section VIII.C; EX1003, ¶198.

5. [6E] “transmitting the at least one camera parameter to the annotator device”

Choe in view of Westmacot discloses this element. EX1003, ¶¶199-202.

(a) Choe

Choe “transmit[s] the at least one camera parameter to the annotator device.”

Choe's sensor calibration module 308 "transmit[s] the overlaid video to an annotator device for manual review." *Supra* Section V.A.6. This transmission includes "the at least one camera parameter" because, as Choe shows, the GUI of the annotator device includes the camera parameters. EX1003, ¶1200.



EX1006, FIG. 6A (excerpt, annotated); *see also* EX1005, FIGS. 6A-6B.

(b) Westmacot

Even if Choe is alleged to be deficient, Westmacot transmits camera parameters to the annotator device because the annotator device's GUI includes camera height. EX1003, ¶1201.



Fig. 18

EX1010, FIG. 18 (excerpted and annotated).

(c) Motivation to Combine

Accordingly, Choe in view of Westmacot discloses transmitting the camera parameters to an annotator device, which receives and displays them to a user.

EX1003, ¶202. And the references would have been obvious to combine to meet this feature. *Supra* Section VIII.C; EX1003, ¶¶160-66.

F. Claim 7

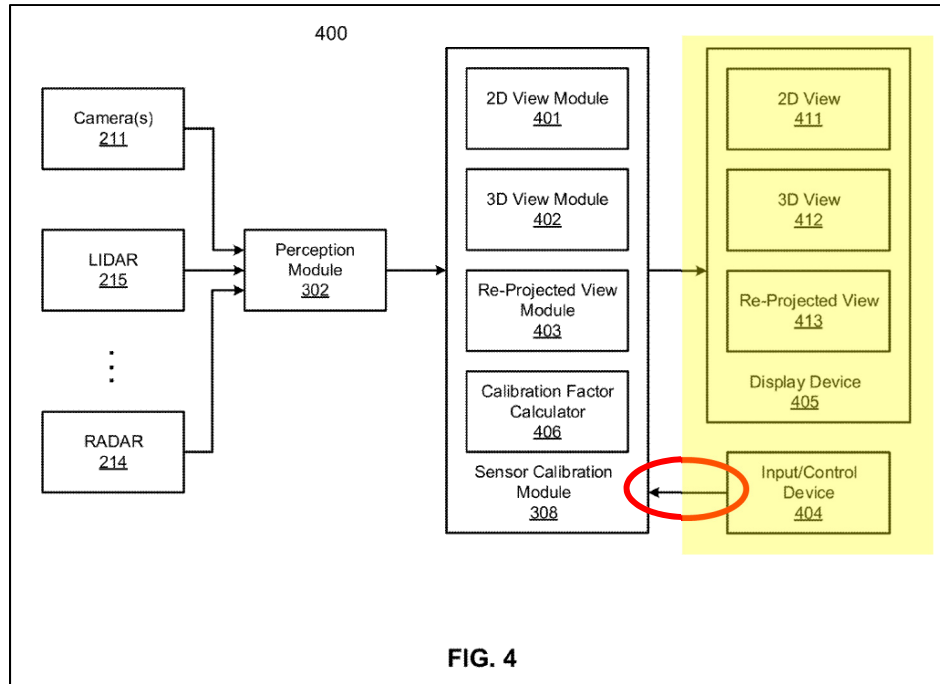
Claim 7 depends from claim 6 and recites the following elements.

1. **[7A] “receiving a second confirmation from the annotator device, the second confirmation indicating that the at least one camera parameter are accurate”**

Choe in view of Westmacot discloses this element. EX1003, ¶¶204-10.

(a) Choe

In Choe, once the annotator device receives the video with overlaid image frames, the reviewer either adjusts the lines or confirms that they are accurate. EX1005, ¶[0047]; EX1003, ¶205. The annotator device’s input/control device 404 sends confirmation indicating that the lines and camera parameters are accurate. EX1003, ¶205; EX1005, ¶[0047] (“[T]he user can calibrate the sensors until the calibration results as shown on display device 405 are satisfied.”). The sensor calibration module 308 receives this confirmation. EX1005, FIG. 4.



EX1005, FIG. 4 (annotated).

Choe therefore discloses this claim element. EX1003, ¶205.

If PO argues that claim 7 requires two *separate* confirmations: (1) a first confirmation that confirms that the *lines* are accurate and (2) a second, separate confirmation that confirms that a *camera parameter* is accurate, Choe in view of Westmacot discloses this element. EX1003, ¶206.

(b) Choe-Westmacot

As explained for [1F] (Section V.A.7), Choe discloses a first confirmation indicating that the lines are accurate. When combined with Westmacot to compute and calibrate camera height (Section VIII.C.1), the combination also separately confirms that a camera parameter is accurate. EX1003, ¶¶207-08. During manual

calibration, the user either adjusts the camera height or confirms that this parameter is accurate. EX1010, 34:9-11.



Fig. 18

EX1010, FIG. 18 (excerpted and annotated).

A POSA would have understood that this decision (either adjust or confirm) would likewise get transmitted to and received by Choe’s sensor calibration module 308 to calibrate the camera accordingly. EX1003, ¶209.

(c) Motivation to Combine

Because a POSA would have been motivated to combine Choe and Westmacot to compute and calibrate a camera height, Choe in view of Westmacot therefore also discloses [7A]. *Supra* Section VIII.C.1; EX1003, ¶¶204-10.

2. [7B] “transmitting data representing the one or more lines of the second video to the camera device”

Choe in view of Westmacot discloses this element. EX1003, ¶¶211-13.

In Choe, after the manual calibration, “[t]he calibration result can then be uploaded onto the vehicle to be utilized online during the image processing as a part of the perception process.” EX1005, ¶[0044]. In Choe-Westmacot, modifying

the perceived lane lines and adding new lane lines is part of the calibration result.

EX1003, ¶212; EX1005, ¶[0047]. The result (e.g., a new lane line) would therefore be transmitted to the camera's perception module. EX1003, ¶212; EX1005, FIG. 4 (showing perception module 302 associated with camera(s) 211). Indeed, this is consistent with Choe's disclosure, which uses the camera's perception software to identify lane features. EX1005, ¶[0035].

To the extent Choe does not expressly state that data representing a line is sent to the camera, doing so would have been obvious such that a passenger viewing the camera's video feed can "visually 'feel' the calibration result based on user feedback." EX1005, ¶¶[0014], [0047]; *see also* EX1005, ¶[0027] (the use can be a passenger); EX1003, ¶213.

* * *

For at least these reasons, Choe in view of Westmacot discloses (or at least suggests) every element of claims 5-7. These claims would have been obvious.

IX. GROUND 5: CHOE IN VIEW OF WESTMACOT, FURTHER IN VIEW OF KHAN AND ALI RENDERS OBVIOUS CLAIMS 1-7

As Ground 1 explains, Choe discloses (or at least suggests) every element in claims 1-4. And as Ground 4 explains, Choe in view of Westmacot discloses (or at least suggests) every element in claims 5-7. However, to the extent PO argues that Choe-Westmacot does not explicitly disclose the predictive models, Khan and Ali provide this teaching. EX1003, ¶215.

To the extent the Choe-Westmacot combination does not explicitly disclose which predictive models it uses, a POSA would have searched for references that use predictive models for horizon and lane detection. EX1003, ¶216. As Ground 2 explains, this would have led to Khan and Ali, which disclose predictive models for horizon and lane detection. *Supra* Section VI.A; EX1003, ¶216.

As Ground 2 explains, a POSA would have been motivated to use Khan and Ali's predictive models in Choe's system. *Supra* Section VI.A. The same motivations to combine apply equally here. EX1003, ¶217.

Ground 2 also explains why applying Khan and Ali's predictive models satisfy the claim elements. Indeed, Khan and Ali are publications from the '580 patent inventors (and other authors) disclosing to the public—over a year before the '580 patent was filed—the specific predictive models used in the '580 patent. *Id.*, ¶218. Accordingly, Choe in view of Westmacot, further in view of Khan and further in view of Ali render obvious claims 1-7.

X. GROUND 6: CHOE IN VIEW OF WESTMACOT, FURTHER IN VIEW OF WORKMAN RENDERS OBVIOUS CLAIMS 1-7

As Ground 1 explains, Choe discloses (or at least suggests) every element in claims 1-4. Ground 4 also explains why Choe in view of Westmacot discloses (or at least suggests) every element in claims 5-7. To the extent the Choe-Westmacot combination does not explicitly disclose which predictive models it uses, a POSA would have searched for references that use predictive models for horizon and lane

detection. EX1003, ¶220. As Ground 3 explains, this would have led to Workman, which discloses predictive models for horizon detection. *Id.*

As Ground 3 explains, a POSA would have been motivated to use Workman's predictive models in Choe's system. *Supra* Section VII.A. The same motivations to combine apply equally to the Choe-Westmacot combination with Workman. EX1003, ¶221.

Ground 3 also explains why applying Workman's predictive models satisfy the claim elements. Indeed, Workman shows that the inventors were far from the first people to use predictive models to identify the horizon line in an image/video. *Id.*, ¶222. Nor were they the first to use manual annotations to adjust the lines. *Id.*, ¶222. These functions were well known and used throughout the industry well before the inventors disclosed their methods to the public. *Id.*, ¶222.

XI. NO OBJECTIVE INDICIA OF PATENTABILITY

Petitioner is unaware of any objective indicia of non-obviousness. If PO alleges objective indicia in its POPR, Petitioner requests a response.

XII. DISCRETIONARY DENIAL IS NOT APPROPRIATE

A. *Advanced Bionics* strongly favors institution.

Applying the two-part framework from *Advanced Bionics* demonstrates that denial under §325(d) is not appropriate. *Advanced Bionics, LLC v. Med-El Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 at 8-9 (P.T.A.B. Feb. 13, 2020) (precedential). Under part one, the same or substantially the same art or

arguments were *not* previously presented to the Office, ending the inquiry in favor of institution. EX1003, ¶¶227-33. During prosecution, neither the patentee nor the examiner cited or applied Choe, Khan, Ali, or Workman. A U.S. counterpart to Westmacot was cited to the Office via an information disclosure form. EX1002, 0119. But the Office never applied Westmacot in any rejection. Nor was it mentioned in the reasons for allowance of the claims.

Choe, Khan, Ali, and Workman also disclose the five elements that the Applicant raised during prosecution, establishing that they are non-cumulative.

First, the Applicant argued that Kwant1 did not predict a horizon line but instead predicted *lane lines* and then used a geometric approach to identify the horizon line. EX1002, 0145. In contrast, the Grounds identify the horizon *directly* with a predictive model. EX1003, ¶228. Khan and Ali identify the horizon line using RANSAC, a predictive model. EX1008, 1104; EX1007, 1826-27. Workman also uses a CNN as a predictive model “to directly estimate the horizon line.” EX1011, 1.

Second, the Applicant argued that Kwant1 and Kwant2 did not compute a camera parameter because they did not compute a parameter “related to a camera.” EX1002, 0146. In contrast, Choe discloses calibration factors or parameters for calibrating the camera’s pitch, yaw, and roll. EX1005, ¶¶[0014], [0015], [0049], [0052]-[0053], [0057], [0059], FIG. 7. Westmacot describes how a camera height

(h) is determined. EX1010, 24:1-29:2. And Khan/Ali also compute camera pose and other parameters such as camera height. EX1007, 1826-27; EX1008, 1105.

Third, the Applicant argued that Kwant1 did not disclose “overlaying the one or more lines on the video” because the overlay was allegedly an annotation added by a patent attorney or agent. EX1002, 0147. In contrast, the horizon and lane lines are *actually* superimposed/overlayed on the video frames of Choe, Khan, Ali, Workman, and Westmacot. EX1005, ¶¶[0016]-[0017], FIGS. 6A-6B; EX1007, 1823; EX1008, FIGS. 1, 3; EX1011, FIG. 5; EX1010, FIGS. 13, 18-24.

Fourth, the Applicant argued that Kwant1 did not disclose “an annotator device for manual review.” EX1002, 0147-48. Both Choe and Westmacot disclose an annotator to manually adjust the predicted lane and horizon lines. *See, e.g.*, EX1005, ¶[0016], FIGS. 4, 6A-6B; EX1010, 33:20-25, FIGS. 18-24.

Finally, the Applicant argued that Kwant2 did not “receiv[e] a confirmation from the annotator device....” EX1002, 0148. Similar to their fourth argument, the Applicant argued that no manual reviewer confirmed that predicted lines were accurate. *See id.* In contrast, Choe and Westmacot do have manual calibration with confirmation. EX1005, ¶[0047], FIG. 4; EX1010, FIGS. 18, 22-24.

The “new, noncumulative prior art asserted in the Petition” strongly favors institution of this IPR. *Oticon Medical AB v. Cochlear Ltd.*, IPR2019-00975, Paper 15 at 20 (P.T.A.B. Oct. 16, 2019) (§§II.B and II.C precedential).

Even if the Board were to find that any of these references is substantially the same as those used in prosecution, the Office would have been in error in allowing the claims. As the Grounds explain, the prior art discloses every element of the claims. The strong grounds of unpatentability therefore favor institution. *Id.*

Should PO attempt to analogize any previously-considered art or arguments to those presented here, Petitioner reserves the right to respond.

B. *Fintiv* favors institution.

Fintiv favors institution because the district court case has been stayed, before invalidity contentions or claim construction. EX1060. A trial date is not scheduled, there is no indication that trial will occur before the projected statutory deadline for a final written decision, and the district court is not expected to issue substantive orders related to the '580 patent before institution. The *Fintiv* factors therefore favor institution. *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (P.T.A.B. Mar. 20, 2020) (precedential).

XIII. MANDATORY NOTICES

A. Real Party in Interest

Petitioner Samsara Inc. is the only real party-in-interest.

B. Related Matters

Motive asserted the '580 patent in the Northern District of California (Case No. 3:24-cv-00902). The district court case was filed on February 15, 2024. EX1059. The case was stayed on June 4, 2024 pending arbitration. EX1060.

C. Lead and Backup Counsel.

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XIV. GROUNDS FOR STANDING

Samsara certifies the '580 patent is available for IPR and that Samsara is not barred or estopped from requesting IPR of the '580 patent challenging the patent claims on the grounds identified in this Petition.

XV. CONCLUSION

As Grounds 1-6 explain, the named inventors did not invent a camera calibration system that used predictive models to identify the horizon line and lane lines. Nor were they first to use a human to annotate the predicted lines. These systems and methods were known for many years before the '580 patent. And even if the inventors were the first to use well-known predictive models in this manner, they disclosed their methods to the public over a year before filing their patent application. The Board should institute trial and cancel the challenged claims.

Respectfully submitted,

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**CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME
LIMITATION, TYPEFACE REQUIREMENTS, AND TYPE STYLE
REQUIREMENTS**

1. This Petition complies with the type-volume limitation of 14,000 words, comprising 13,238 words, excluding the parts exempted by 37 C.F.R. § 42.24(a).

2. This Petition complies with the general format requirements of 37 C.F.R. § 42.6(a) and has been prepared using Microsoft® Word 2016 in 14-point Times New Roman.

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CERTIFICATION OF SERVICE (37 C.F.R. §§ 42.6(e), 42.105(a))

The undersigned hereby certifies that the above-captioned **PETITION FOR**
***INTER PARTES* REVIEW OF U.S. PATENT NO. 11,875,580** and all
supporting exhibits were served via via FedEx Express® on February 14, 2025, in
their entirety on the following:

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