

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AVIDBOTS CORP. and AVIDBOTS USA CORP.,
Petitioners,

v.

BRAIN CORPORATION,
Patent Owner.

Case No. IPR2025-01604
U.S. Patent No. 10,728,436

Petition for *Inter Partes* Review of U.S. Patent No. 10,728,436

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PETITIONERS' EXHIBIT LIST

Exhibit	Description
1001	U.S. Patent No. 10,728,436
1002	File History for U.S. Patent No. 10,728,436 (Appl. No. 15/845,891)
1003	Declaration of Dr. Lina Karam
1004	WO 2011/146259 A2 (“Rosenstein”)
1005	John Canny, <i>A Computational Approach to Edge Detection</i> , IEEE Transactions on Pattern Analysis and Machine Intelligence (“Canny”)
1006	Qian Xu, <i>A Distributed Canny Edge Detector and its Implementation on FPGA</i> , Proceedings of the IEEE Digital Signal Processing Workshop (“Xu”)
1007	U.S. Patent No. 5,793,900 (“Nourbakhsh”)
1008	U.S. Patent No. 9,076,214 (“Tsutsumi”)
1009	Declaration of Dr. Mary K. Bolin
1010	Dr. Lina J. Karam, <i>Curriculum Vitae</i>

TABLE OF ABBREVIATIONS

Abbreviation	Term
'891 Application	U.S. Patent Application No. 15/845,891
'436 Patent	U.S. Patent No. 10,728,436
Board	Patent Trial and Appeal Board
Challenged Claims	Claims 1–18 of U.S. Patent No. 10,728,436
Commission	United States International Trade Commission
Ex.	Exhibit
Fig.	Figure
IPR	<i>inter partes</i> review
Patent Office	United States Patent and Trademark Office
Petitioners or Avidbots	Avidbots Corp. and Avidbots USA Corp.
POSITA	person of ordinary skill in the art

MANDATORY NOTICES

A. Real Parties-in-Interest [37 C.F.R. § 42.8(b)(1)]

The real parties-in-interest are Petitioners Avidbots Corp. and Avidbots USA Corp. (collectively, “Petitioners” or “Avidbots”). No entity not named above is funding, controlling, or directing this Petition, or otherwise has had an opportunity to control or direct this Petition or Petitioners’ participation in any resulting IPR.

B. Related Matters [37 C.F.R. § 42.8(b)(2)]

The ’436 Patent that is the subject of this IPR is also the subject of a patent litigation suit brought by Patent Owner Brain Corporation entitled *Brain Corp. v. Avidbots Corp. et al.*, Case No. 1:24-cv-12569 (N.D. Ill.).

C. Lead and Back-Up Counsel [37 C.F.R. § 42.8(b)(3)]

Pursuant to 37 C.F.R. §§ 42.8(b)(3), 42.8(b)(4), and 42.10(a), Petitioners provide the following designation of counsel:

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A Power of Attorney accompanies this Petition in accordance with 37 C.F.R. § 42.10(b).

D. Service Information [37 C.F.R. § 42.8(b)(4)]

Service via hand delivery or postal mail may be made at the addresses of the lead and back-up counsel above. Petitioners hereby consent to electronic service, and service by electronic mail may be made at the following email address:

- GDC-AvidbotsIPR@gibsondunn.com

I. INTRODUCTION

Pursuant to 35 U.S.C. § 311, Petitioners hereby petition for IPR of U.S. Patent No. 10,728,436 (Ex1001) and seek cancellation of claims 1–18 as unpatentable under 35 U.S.C. §§ 102 and 103.

The Challenged Claims of the '436 Patent add nothing to the prior art. The patent claims methods and computer instructions for detecting the presence of an object in an image, and for navigating an apparatus (e.g., a robot) based on the detection of an object. Neither concept was new at the time of filing. Further, the specific object detection techniques used by the '436 Patent—including comparing a contrast parameter to a threshold and using that comparison to detect in-focus objects—were well-known in the art many years before the patent issued (*e.g.*, Ex1005).

The allowance of the '436 Patent reflects clear error during examination. To overcome prior art objections, the applicant amended the claims to recite a specific way of determining the presence of an object: doing so “based on comparing a contrast parameter of the at least one image to a threshold, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value, and the threshold being dynamically configured based on one or more parameters.” Ex1002, 295–300. The Examiner apparently accepted these amendments as distinguishing the claims from the prior art and allowed the claims. *Id.*, 305. However, as illustrated below, the claimed contrast parameter

technique is well-known and used in multiple different approaches to object detection including (1) by detecting edges in an image, as disclosed in Canny and Xu, and (2) by identifying in-focus objects, as disclosed in Nourbakhsh and Tsutsumi. None of these references were before the Examiner during prosecution, and the Examiner's failure to consider these well-known approaches resulted in an erroneous allowance.

Petitioners respectfully submit that it is appropriate for the Board to institute IPR to invalidate this patent that never should have issued.

II. REQUIREMENTS OF *INTER PARTES* REVIEW

A. Standing

Pursuant to 37 C.F.R. § 42.104(a), Petitioners certify that the '436 Patent is available for IPR and that Petitioners are not barred or estopped from requesting an IPR on the grounds identified herein. Because more than nine months have passed since issuance, the '436 Patent is eligible for IPR. 35 U.S.C. § 311(c)(1).

B. Identification of Challenge and Relief Requested

Pursuant to 37 C.F.R. § 42.104(b), Petitioners request that the Board institute IPR of claims 1–18 of the '436 Patent under post-AIA 35 U.S.C. §§ 102 and 103.

The '436 Patent issued from U.S. Patent Application No. 14/321,736. Petitioners do not challenge whether the Challenged Claims are entitled to a priority date of July 1, 2014.

The precise relief requested by Petitioners is that claims 1–18 be canceled

based on the grounds below:

Ground	Claims	Basis for Rejection ¹
1	1-18	Obviousness in view of Rosenstein, Xu, and Canny
2	1-2, 6-7, 11, 13-14, 16-17	Obviousness in view of Nourbakhsh and Tsutsumi

The above challenges are made in view of the following prior art references:

1. WO 2011/146259 A2 (“Rosenstein”) (Ex1004)

International Publication No. WO 2011/146259 A2, titled “Mobile Human Interface Robot” issued on November 24, 2011, from International Application No. PCT/US2011/035488 filed on May 6, 2011. Rosenstein qualifies as prior art to the ’436 Patent under post-AIA 35 U.S.C. § 102(a). Rosenstein was not of record during prosecution of the ’436 Patent.

2. John Canny, *A Computational Approach to Edge Detection*, IEEE Transactions on Pattern Analysis and Machine Intelligence, (November 1986) (“Canny”) (Ex1005)

Canny was published in print in volume 6 of the IEEE journal, *Transactions on Pattern Analysis and Machine Intelligence*, in November 1986. Ex1009, ¶¶30-34. It was also published on the well-known online database IEEE Xplore in September 2008. *Id.* Canny would have been located by a POSITA exercising reasonable diligence as of at least September 2008, including by searching on IEEE

¹ All obviousness grounds include the knowledge of a POSITA.

Xplore for terms such as “edge detection,” “image processing,” and “machine vision,” which are terms synonymous and/or closely related to the concepts underlying the ’436 Patent. *Id.* ¶36; Ex1003, ¶63. Canny therefore qualifies as prior art to the ’436 Patent under post-AIA 35 U.S.C. § 102(a). Canny was not of record during prosecution of the ’436 Patent.

3. Qian Xu, et. al., *A Distributed Canny Edge Detector and its Implementation on FPGA*, Proceedings of the IEEE Digital Signal Processing Workshop, January 2011, (“Xu”) (Ex1006)

Xu was published in the well-known IEEE Xplore database in March 2011. Ex1009, ¶¶22-23. Xu would have been located by a POSITA exercising reasonable diligence as of at least March 2011, including by searching on IEEE Xplore for terms such as “edge detection,” “object recognition,” and “image processing,” which are terms synonymous and/or closely related to the concepts underlying the ’436 Patent. *Id.* ¶25; Ex1003, ¶63. Xu therefore qualifies as prior art to the ’436 Patent under post-AIA 35 U.S.C. § 102(a). Xu was not of record during prosecution of the ’436 Patent.

4. U.S. Patent No. 5,793,900 (“Nourbakhsh”) (Ex1007)

U.S. Patent No. 5,793,900, titled “Generating Categorical Depth Maps Using Passive Defocus Sensing,” issued on August 11, 1998 from a U.S. patent application filed on December 29, 1995. Nourbakhsh qualifies as prior art to the ’436 Patent

under post-AIA 35 U.S.C. § 102(a)(1). Nourbakhsh was not of record during prosecution of the '436 Patent.

5. U.S. Patent No. 9,076,214 (“Tsutsumi”) (Ex1008)

U.S. Patent No. 9,076,214, titled “Image Acquisition Apparatus and Image Processing Apparatus Using Selected In-Focus Image Data,” issued on July 7, 2015 from a U.S. patent application filed on August 6, 2012. Tsutsumi qualifies as prior art to the '436 Patent under post-AIA 35 U.S.C. § 102(a)(2). Tsutsumi was not of record during prosecution of the '436 Patent.

C. How the Challenged Claims Are To Be Construed Under 37 C.F.R. § 42.104(b)(3)

A claim subject to IPR shall be construed using the same standard as in a civil action. 37 C.F.R. § 42.100(b). The Board need only construe terms “to the extent necessary to resolve the controversy.” *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). Petitioners submit that no construction of any claim term is necessary for the Board to resolve, and that the Challenged Claims would have been anticipated and/or obvious under any reasonable construction.

D. How the Challenged Claims Are Unpatentable Under 37 C.F.R. § 42.104(b)(4)

An explanation of how the Challenged Claims are unpatentable under the statutory grounds identified above, including the identification of where each

element of the claim is found in the prior art patents or printed publications, is provided below.

E. Supporting Evidence Under 37 C.F.R. § 42.104(b)(5)

The exhibit numbers of the supporting evidence relied upon and the relevance of the evidence to the Challenged Claims, including an identification of specific portions of the evidence that support the challenge, are provided below. A list of exhibits with the exhibit number and a brief description of each exhibit is also included in this Petition pursuant to 37 C.F.R. § 42.63(e). The technical information and grounds for rejection explained in this Petition are further supported by the Declaration of Lina Karam, Ph.D. (Ex. 1003).

F. Payment of Fees

Pursuant to 37 C.F.R. §§ 42.103 and 42.15(a), the required fee is being submitted herewith. The Office is authorized to charge any fee deficiency, or credit overpayment, to deposit account no. 50-1408, including additional fees due in connection with this Petition.

III. TECHNICAL BACKGROUND

A. Alleged Invention of the '436 Patent

In the Background, the '436 Patent inventors acknowledge that “[a] variety of object detection apparatus (such as IR-based, ultrasonic, and lidar) currently exist.” Ex. 1001, 1:34–36. However, the inventors claimed that these preexisting systems suffered from “various disabilities” such as being unreliable outdoors or being costly

and heavy. *Id.*, 1:34–45.

The '436 Patent purports to provide an improved object detection sensor apparatus and associated methods where the improved detection sensors apparatus is “small sized, inexpensive, reliable, lightweight, power efficient, and/or capable of effective use outdoors.” *Id.*, 1:46-60. Claim 1 of the '436 Patent is directed to a robot that, *inter alia*, (1) obtains an image associated with surroundings of the robot and (2) determines the presence of an object in the image by (a) calculating the contrast parameter of the image, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value and (b) comparing the contrast parameter to a threshold, the threshold being dynamically configured based on one or more parameters. *Id.*, cl. 1.

The robot may comprise an image sensor located behind a lens. *Id.* 7:36–39. Depending on the distance between the object and the lens, the object may be in-focus or out-of-focus. *Id.* 6:55-63. “In-focus representations may be characterized by a greater contrast parameter than out-of-focus representations.” *Id.* 6:63-65. As the robot approaches an object, the image may gradually become sharper; the robot detects the presence of an object by the contrast or sharpness exceeding a threshold, indicating that the object is “within the range of focus in front of the lens.” *Id.* 7:4-10.

As illustrated in figure 4A below, the image sensor is configured at an angle

with respect to a lens, allowing the robot “to detect objects at multiple locations” based on a contrast parameter. *Id.*, 10:2–19, 19:9–20, 20:9–31.

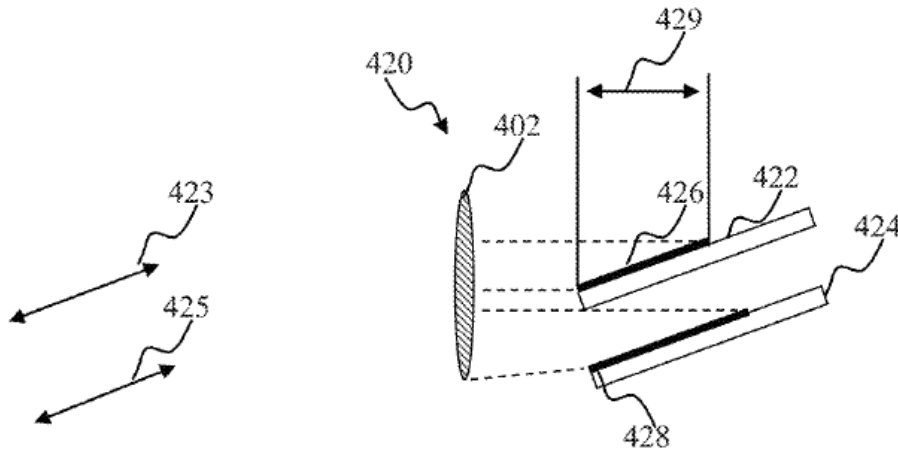
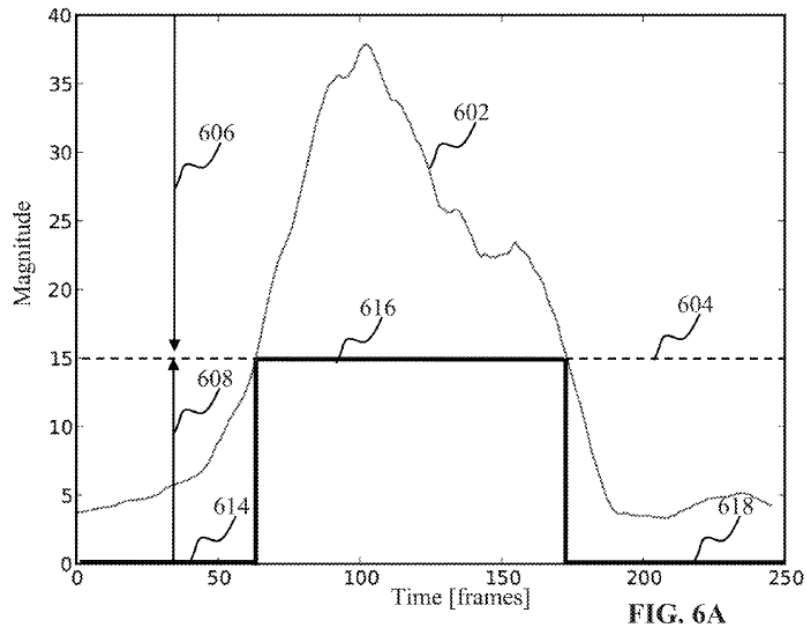


FIG. 4A

Ex1001, Fig. 4A.

As illustrated in Figure 6A, the contrast parameter for a given image is compared to a threshold in order to determine the presence of an object. *Id.* 14:55–58.



Ex1001, Fig. 6A.

B. Prosecution History of the '436 Patent

The '436 Patent is a continuation of U.S. Patent Application No. 14/321,736, now U.S. Patent No. 9,848,112, filed July 1, 2014. During prosecution, on August 21, 2019, the examiner rejected what were then claims 25–26 and 29 as anticipated by U.S. Patent No. 9,150,220 (“Clarke”) because Clarke discloses, *e.g.*, a method of navigating an apparatus comprising obtaining at least one image associated with surrounding of the apparatus using a sensor, the apparatus comprising a controller, an actuator and the sensor, analyzing the at least one image to detect a presence of an object in the at least one image, determining whether the object comprises one of either a target or an obstacle, and causing the controller to selectively activate the actuator based on the determination. Ex1002, 204–205.

The Examiner also rejected what were then claims 30-32 and 35 under 35 U.S.C. § 103 as being unpatentable over Clarke in view of U.S. Patent No. 8,542,875 (“Eswara”). The Examiner found that Eswara is “analogous art” to Clarke and that it disclosed “the use of image analysis to determine a contrast parameter criterion comprising a deviation parameter, a reference value, and/or threshold associated with object detection . . . wherein the detection of the presence is based on the contrast meeting or exceeding a predetermined threshold.” *Id.* at 207.

In response, the applicant amended the claims. *Id.* 295–300. For example, the patentee removed the language, “determining whether the object comprises one of either a target or an obstacle” with “determining the presence of the object based on comparing a contrast parameter of the at least one image to a threshold, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference vale [*sic*], and the threshold being dynamically configured based on one or more parameters.” *Id.* at 295. The patentee also argued that, in view of the above-amended language, the Examiner’s rejection in view of Clarke and Eswara was rendered moot. *Id.* at 302–03.

The Examiner allowed the claims on March 6, 2020. *Id.* at 305.

C. Person of Ordinary Skill in the Art

The ’436 Patent relates to the field of detection of objects or targets using processing of optical data. Ex1001, 1:23–25. A person of ordinary skill in the art at

the time of the earliest effective filing date of the '436 Patent would have had a Bachelor's degree or higher in electrical, computer, or mechanical engineering or computer science (or equivalent discipline) and at least two years' experience in research, design and/or development of autonomous robotics and/or robotic mapping/navigation and/or a related field. Additional education could substitute for experience, and vice versa. Ex1003, ¶25.

IV. GROUNDS OF UNPATENTABILITY

A. Ground 1: Rosenstein in view of Canny and Xu Render Obvious Claims 1-18

Rosenstein's mobile human interface robot, combined with Canny and Xu's methods for object detection disclose all elements of the Challenged Claims (Ground 1) and render the Challenged Claims obvious.

1. Overview of Ground and Prior Art

a. Summary of Rosenstein

Rosenstein discloses a mobile human interface robot with a drive system, a controller in communication with the drive system, and an imaging device. Ex1004, Title, Abstract; Ex1003, ¶66. The controller "receives [] signals from the imaging device and issues drive commands to the drive system." Ex1004, Abstract. The robot also includes "one or more types of sensors," including "obstacle detection obstacle avoidance (ODOA) sensors, communication sensors, navigation sensors, etc." *Id.*, [00137]. The "sensor system 400 includes a set or an array of proximity

sensors 410, 420 . . . and/or imaging sensors (e.g., 3D depth and image sensors) that provide a signal to the controller 500 when an object is within a given range of the robot 100.” *Id.*, [00139]. The “robot 100 may include first and second 3-D image sensors 450a, 450b” and the “first 3-D image sensors 450a is mounted on the torso 140 and pointed downward at a fixed angle to the ground G.” *Id.*, [00162]. Additionally, the robot “may tilt the second 3-D image sensor 450b downward slightly to increase a total or combined field of view of both 3-D image sensors 450a, 450b, [] to avoid an obstacle.” *Id.*

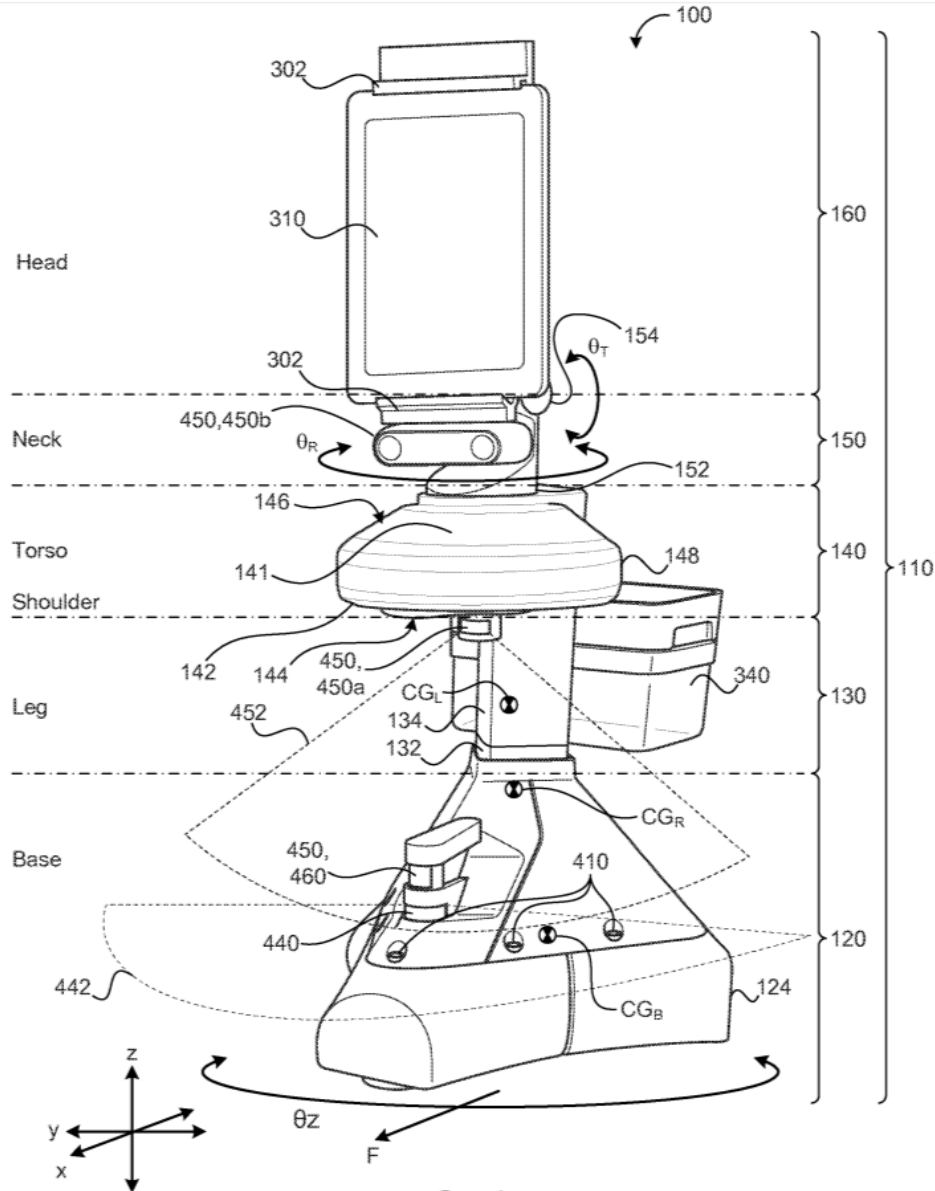


FIG. 1

Ex1004, Fig. 1.

The 3-D imaging sensor 450 includes a camera that can include a “complementary metal oxide semiconductor (CMOS) sensor 1520 (or charge-coupled device (CCD)), a lens 1530, and control logic or a camera controller 1540 having processing resources (and/or the robot controller 599).” *Id.*, [00182]. “The

CMOS sensors 1520 may include an array of pixel detectors 1522, or other arrangement of pixel detectors.” *Id.*

The mobile human interface robot also contains “reasoning software” that “processes the data collected from the sensor system 400 and outputs data for making navigational decisions on where the robot 100 can move without colliding with an obstacle.” *Id.* [00165].

Further, Rosenstein recognizes that “[p]roperly sensing objects 12 using the imaging sensor 450, despite ambient light conditions[,] can be important.” *Id.* [00189]. The “imaging sensor 450 can be used for identifying and resolving people and objects 12 in all situations with relatively little impact from ambient light conditions (e.g., ambient light rejection).” *Id.*

b. Summary of Canny

Canny discloses a well-known method for edge detection. Ex1005; Ex1003, ¶69. Canny’s paper describes a “computational approach to edge detection.” Ex1005, Abstract. Canny’s approach discloses “deriv[ing] a single operator shape which is optimal at any scale” and which “has a simple approximate implementation in which edges are marked at maxima in gradient magnitude of a Gaussian-smoothed image.” *Id.*

c. Summary of Xu

Xu teaches that “[e]dge detection is one of the key stages in image processing and object recognition.” Ex1006, pg. 500; Ex1003, ¶71. Xu also teaches that “the Canny edge detector is one of the most widely-used edge detection algorithms due to its good performance” and that “[t]he Canny edge detector is predominantly used in many real-world applications due to its ability to extract significant edges with good detection and good localization performance.” Ex1006, Abstract. According to Xu, the Canny edge detector algorithm consists of the following steps: (1) “Smoothing the input image by Gaussian mask. The output smoothed image is denoted as $I(x, y)$.”; (2) “Calculating the horizontal gradient $G_x(x, y)$ and vertical gradient $G_y(x, y)$ at each pixel location by convolving the image $I(x, y)$ with partial derivatives of a 2D Gaussian function”; (3) Computing the gradient magnitude $G(x, y)$ and direction $\theta(x, y)$ at each pixel location.”; (4) “Applying non-maximum suppression (NMS) to thin edges.”; (5) “Computing the hysteresis high and low thresholds based on the histogram of the magnitudes of the gradients of the entire image.”; and (6) “Performing hysteresis threshold to determine the edge map.” *Id.*, 501.

Xu presents a “distributed Canny edge detection algorithm that results in significantly reduced memory requirements, decreased latency and increased throughput with no loss in edge detection performance as compared to the original Canny algorithm.” *Id.*

Specifically, while Steps 1 to 4 and Step 6 of Xu's distributed Canny edge detection algorithm "are the same as in the original Canny [edge detection] algorithm," the steps are "applied at the block level." *Id.* 501. That is, while Canny's edge detection algorithm "operates on the whole image," Xu's distributed Canny edge detection algorithm divides the input image into $m \times m$ blocks and "removes the inherent dependency between the various blocks so that the image can be divided into blocks and each block can be processed in parallel." *Id.* Xu's block-level NMS, shown in Figure 9 below, then identifies the local maximum gradient magnitude in each block. *Id.* Xu goes on to disclose that thresholding is performed based on a threshold value that is dynamically adapted based on the local characteristics of each image block. *Id.*, 501–502, Fig. 4.

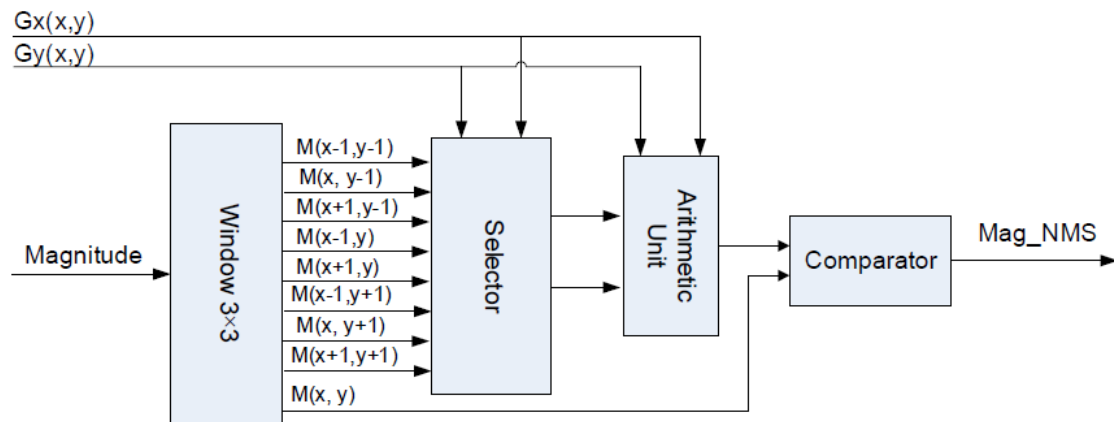


Fig. 9. Directional Non Maximum Suppression Unit.

Ex1006, Fig. 9.

d. Motivation to Combine Rosenstein, Canny, and Xu

A POSITA reviewing Xu and Canny would have been motivated to combine their teachings with the autonomous mobile human interface robot of Rosenstein. Ex1003, ¶85–86. As an initial point, the '436 Patent contemplates edge detection. *See* Ex1001, 5:65-6:3 (“As used herein the term feature may refer to a representation of an object edge, determined by change in color, luminance, brightness, transparency, texture, and/or curvature. The object features may comprise, inter alia, individual edges, intersections of edges (such as corners), orifices, and/or curvature.”). Rosenstein discloses that “[t]hresholds may be recognized by edge detection” and that the “controller 500 may receive imaging data from the cliff detecting proximity sensors 420 (or another imaging sensor on the robot 100), execute an edge detection routine, and issue a drive command based on results of the edge detection routine.” Ex1004, [00146]. A POSITA would have looked to well-known methods of edge detection in order to perform Rosenstein’s “edge detection routine.” Ex1003, ¶88. A POSITA would have reasonably expected success in looking to the edge detection disclosed by Canny given that the “Canny edge detector is one of the most widely used edge detection algorithms [.]” Ex1006, 501. It would also have been obvious for a POSITA to look to Xu, which discloses an improvement of the well-known Canny method, one “that results in significantly reduced memory requirements, decreased latency and increased throughput with no

loss in edge detection performance as compared to the original Canny algorithm.”

Ex1006, pg. 501.

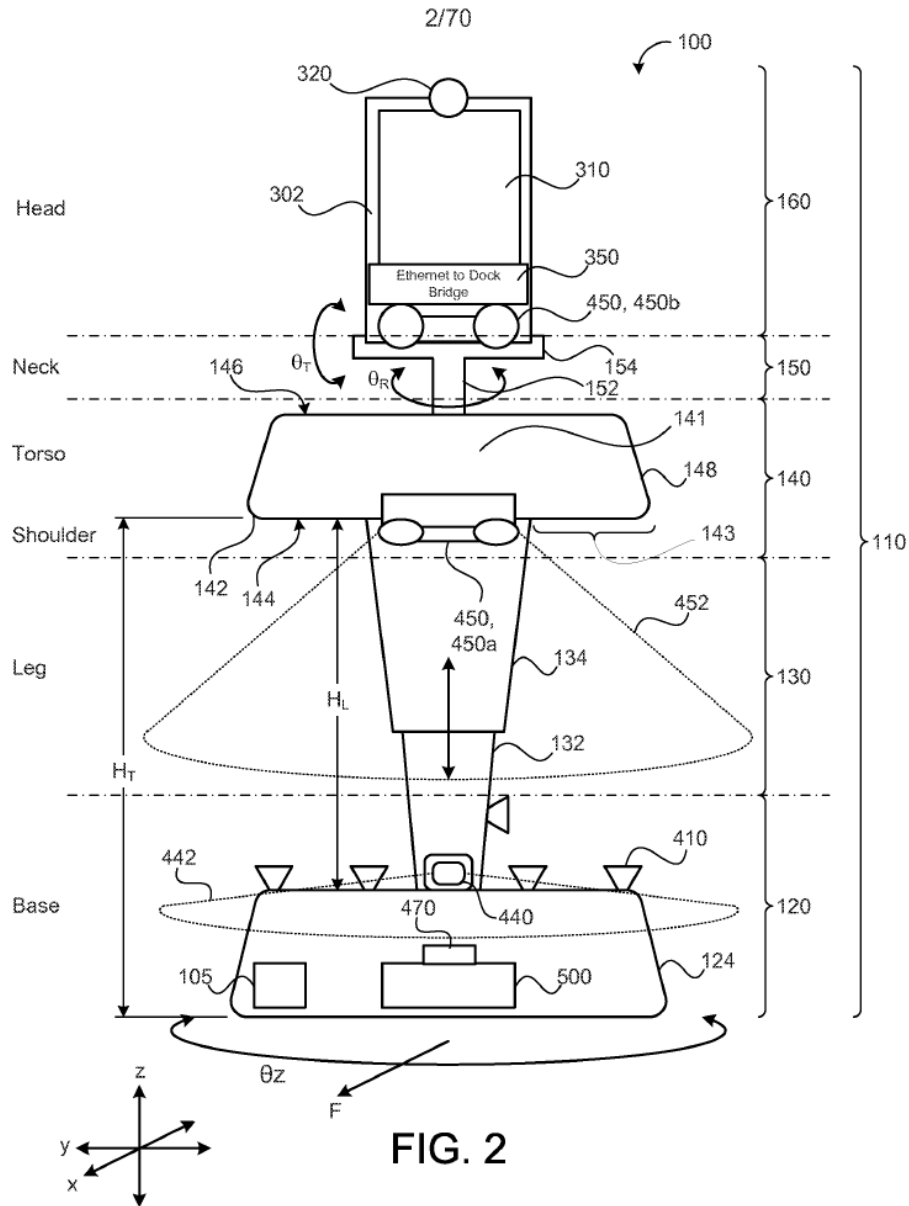
2. Detailed Analysis of Ground 1

As supported by the Declaration of Dr. Lina Karam, the combination Rosenstein, Canny, and Xu teaches all elements of claims 1–18 of the ’436 Patent and also renders all of those claims obvious. Ex1003, ¶85.

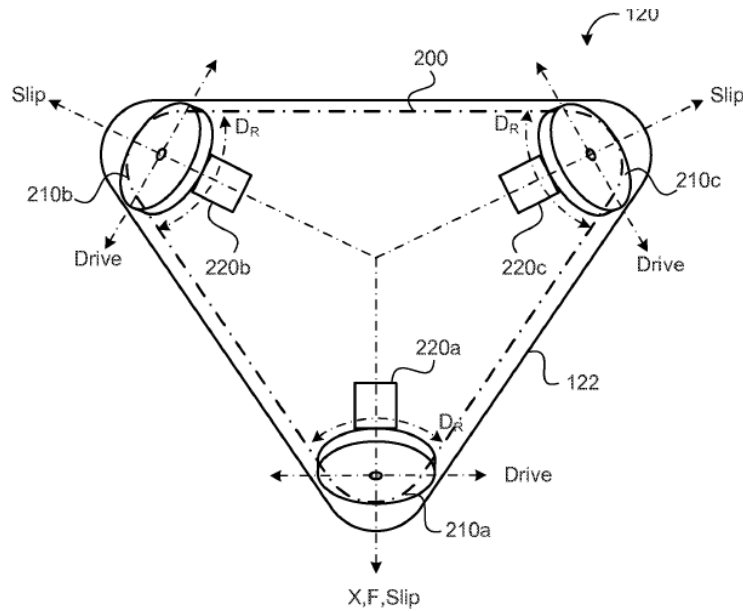
a. Element 1[pre]

“A method of navigating an apparatus, comprising:”

To the extent the preamble is limiting, the Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶91. Rosenstein discloses a mobile robot 100 with a drive system 200 and a controller 500 that is in communication with the drive system. Ex1004, [00121]; Ex1003, ¶91.



Ex1004, Fig.2.



Ex1004, Fig. 5B.

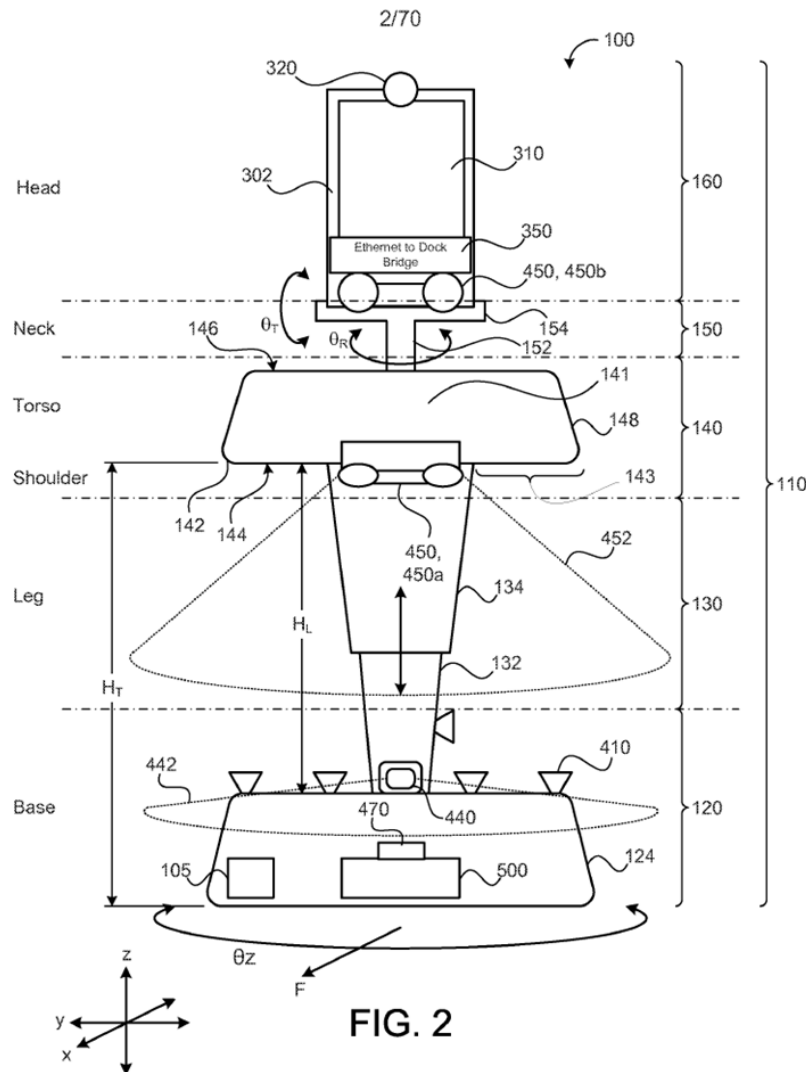
Rosentein's mobile robot 100 corresponds to the claimed "apparatus." Ex1003, ¶92. Rosenstein also discloses methods through which the controller "issues drive commands to the drive system to maneuver the robot in the scene..." *id.* [0010], which is a method for "navigating an apparatus." Ex1003, ¶92.

b. Element 1[a]

"obtaining at least one image associated with surroundings of the apparatus using a sensor, the apparatus comprising a controller, an actuator and the sensor;"

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶93. As discussed, Rosenstein discloses that its mobile robot 100 "includes a drive system 200," and a "sensor system 400," all in "communication with a controller

500[.]” Ex1004, [00121]. It is Rosenstein’s drive system that “maneuver[s] the robot in the scene,” and discloses the claimed “actuator.” *Id.*, [0010]; Ex1003, ¶94. Rosenstein’s “imaging sensor may” also “capture image of the scene along a drive direction of the robot.” *Id.*, [0010]. Rosenstein’s captured image corresponds to the claimed “image associated with surroundings of the apparatus.” Ex1003, ¶93.



Ex1004, Fig. 2.

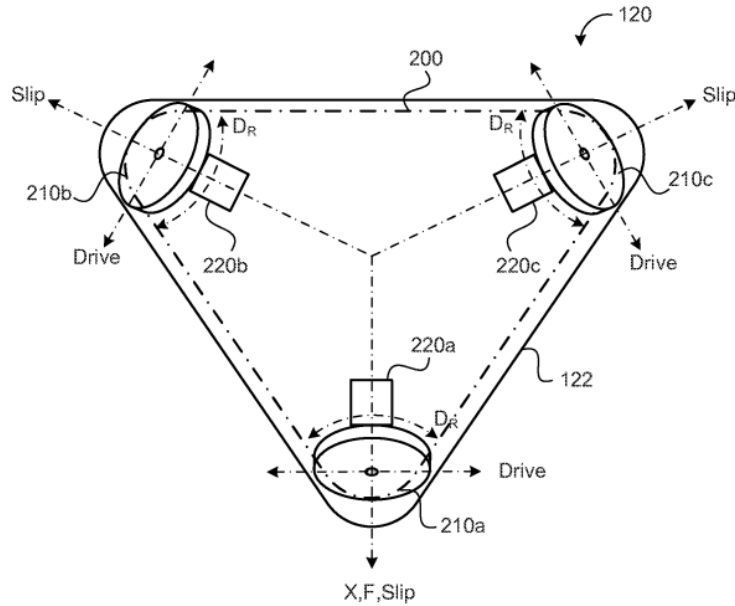


FIG. 5B

Ex1004, Fig.5B.

c. Element 1[b]

“analyzing the at least one image to detect a presence of an object in the at least one image;”

The Rosenstein/Canny/Xu combination discloses this element. Ex1003, ¶95. As discussed in Section IV.A.2.b, (Element 1[a]), Rosenstein discloses a sensor system 400 which captures an “image of the scene along a drive direction of the robot.” Ex1004, [0010]. Then, “based on” an “image comparison,” the “controller determines a location of an object in the scene.” *Id.* Rosenstein’s “image comparison” to “determine a location of an object in the scene” corresponds to “analyzing the at least one image to detect a presence of an object in the at least one image.” Ex1003, ¶95.

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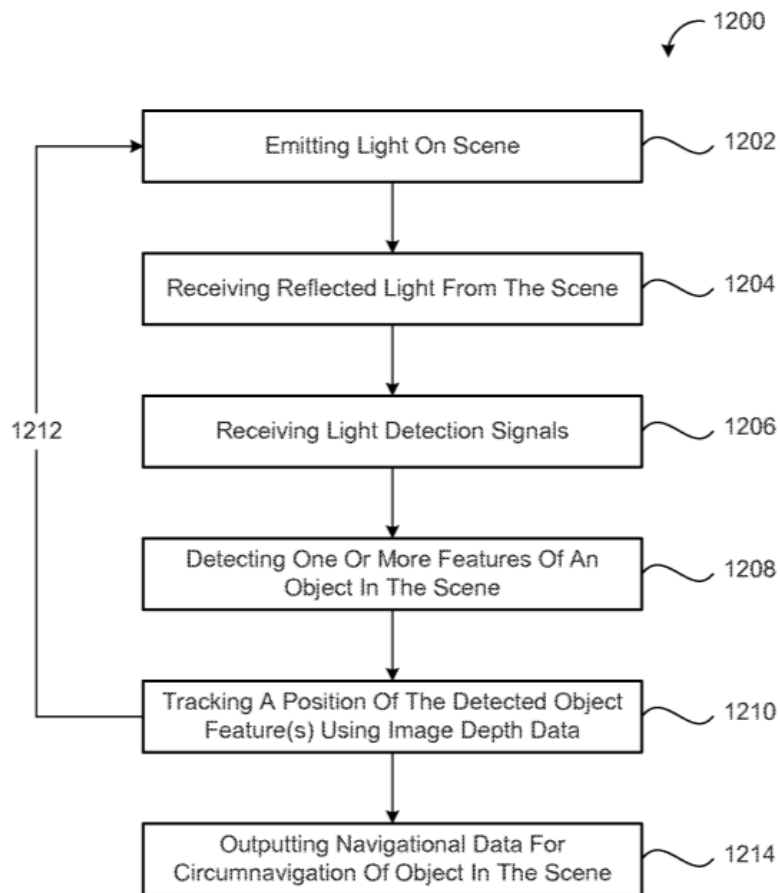


FIG. 12

Ex1004, Fig. 12.

d. Element 1[c]

“determining the presence of the object based on comparing a contrast parameter of the at least one image to a threshold, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value, and the threshold being dynamically configured based on one or more parameters; and”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶96.

To the extent Rosenstein is found not to disclose this limitation, Xu discloses it. Ex1003, ¶97.

First, Xu discloses a Canny edge detection algorithm, which is described in Figure 1 illustrated below. Ex1003, ¶98.

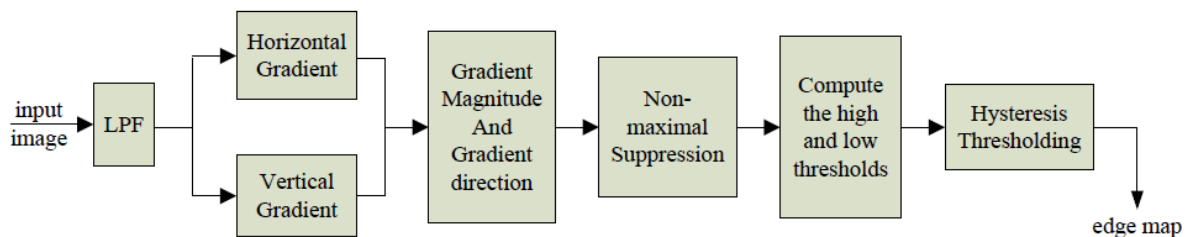


Fig. 1. Block diagram of the Canny edge detection algorithm.

Ex1006, Fig. 1.

Xu teaches that the Canny edge detection algorithm is “one of the key stages in image processing and object recognition,” Ex1006, 500, *i.e.*, the claimed “determining the presence of the object.” Steps 1 to 4 and Step 6 of Xu’s distributed Canny algorithm are the same as in the original Canny algorithm, disclosed by Canny, “except that they are now applied at the block level.” *Id.*, 501. Step 3 involves “computing the gradient magnitude $G(x, y)$ and direction” at “each pixel location.” *Id.*, 501, Fig. 1. Step 4 then consists of “[a]pplying non-maximal suppression (NMS)” along the gradient direction (directional non-maximal

suppression or directional NMS) at each pixel location to retain only the maximum gradient magnitude in each pixel's neighborhood, *i.e.*, local maximum gradient magnitudes are retained while any "non local maximum gradient magnitude is eliminated." *Id.*, 501, 503–504, Fig. 1, Fig. 9.

A POSITA would have understood that Xu's disclosed "maximum gradient magnitude" corresponds to the claimed contrast parameter. Ex1003, ¶99. That's because "applying non-maximum suppression (NMS) to thin edges" ensures that the computed contrast parameter corresponds, as claimed, to a maximum absolute deviation of pixels within the at least one image from a reference value. Ex1003, ¶100. That is, and as reflected in Figure 9 of Xu, for a given pixel, NMS checks if the computed gradient magnitude, denoted $M(x,y)$, at that pixel's location is a maximum by comparing it with the gradient magnitude value at one or more neighboring pixels along the computed gradient direction. Ex1006, 504; Ex1003, ¶100. If the pixel's computed gradient magnitude is not the maximum, then that pixel "is eliminated." Ex1006, 504. A POSITA would have understood that the gradient magnitude value of the one or more neighboring pixels corresponds to the claimed "reference value," meaning the non-eliminated pixel's computed gradient magnitude corresponds to a maximum absolute deviation from that reference value, as laid out in the claim. Ex1003, ¶100.

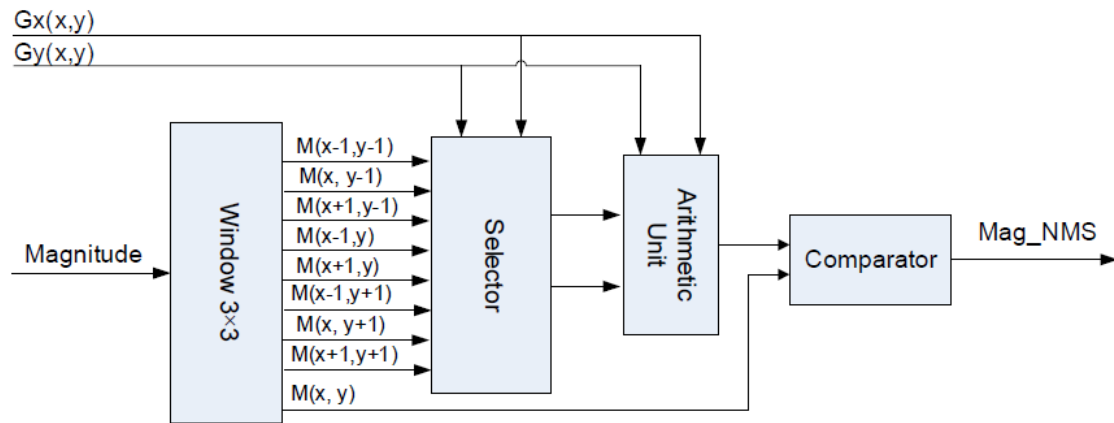


Fig. 9. Directional Non Maximum Suppression Unit.

Ex. 1006, Fig. 9.

Xu goes on to disclose that the computed local maximum gradient magnitude (contrast parameter) is compared to a threshold by performing hysteresis thresholding (which is Step 6 of the Canny edge detection algorithm). Ex1006, 501-502, 504. Thresholding is performed because “the output of the non maximum suppression unit contains some spurious edges.” *Id.*, 504.

Further, Xu discloses “the threshold being dynamically configured based on one or more parameters,” as laid out in the claim. Ex1003, ¶102. Xu teaches that “[i]t is known that the original Canny edge detection algorithm needs two adaptive image-dependent high and low thresholds to remove false edges.” Ex1006, 500. A POSITA would have understood that the threshold is dynamically configured because, as Xu discloses, the original Canny edge detection algorithm requires

“computing the hysteresis high and low thresholds based on the histogram of the magnitudes of the gradients (after NMS is applied) of the entire image.” *Id.*, 501; *see also id.*, 500; Ex1003, ¶102.

Xu also discloses that the threshold is dynamically configured, this time based on the local characteristics of image blocks by “propos[ing] a new threshold selection algorithm based on the distribution of pixel gradients in a block of pixels to overcome the dependency between the blocks.” *Id.*, 501–502, 504, Fig. 4; Ex1003, ¶103.

e. Element 1[d]

“causing the controller to selectively activate the actuator based on the determination that the object is within the range of the apparatus.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶104. As discussed, Rosenstein discloses a “controller 500” and an actuator in the form of a “drive system 200.” Ex1004, [0010], [00121], [00169], [00171]. Rosenstein also discloses the “controller 500 . . . detecting 1208 one or more features of an object 12 in the scene 10 using image data derived from the light detection signals” and then performing a set of “operations.” Ex1004, [00169]. The operations that are performed by the controller consist, in part, of “outputting 1214 navigation data for circumventing the object 12 in the scene 10.” *Id.*, [00171]. In “some implementations, the controller 500 uses the outputted navigation data to

issue drive commands to the drive system 200 to move the robot 100 in a manner that avoids collision with the object 12.” *Id.*

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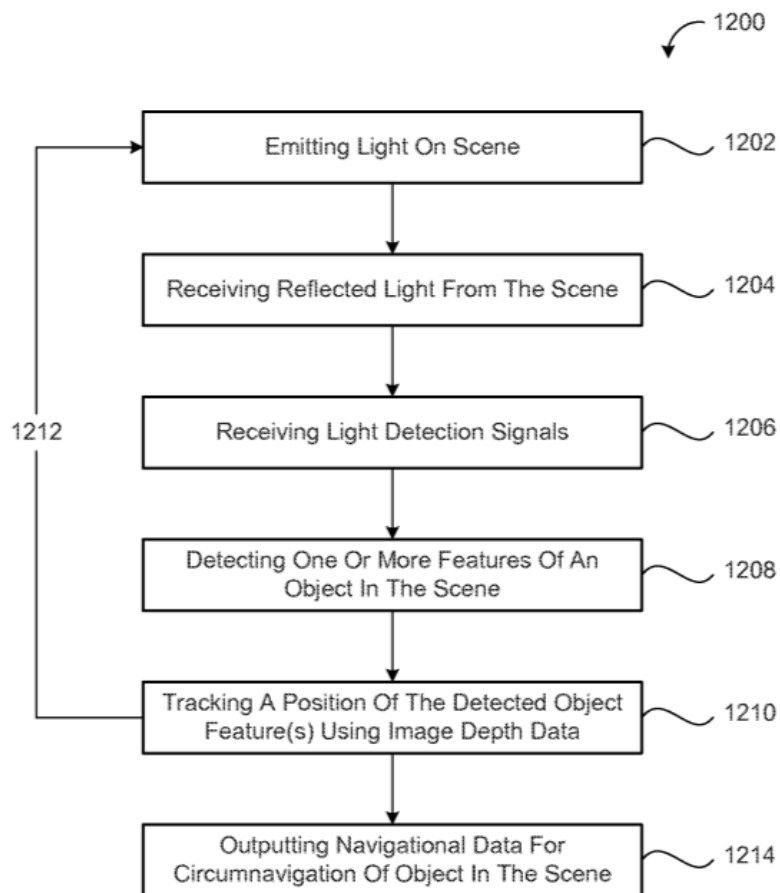


FIG. 12

Ex1004, Fig. 12.

A POSITA would have understood that Rosenstein’s “controller 500” is what activates the “drive system 200,” *e.g.*, the claimed actuator, once it detects an object

that is nearby or sufficiency close in the scene, subsequently issuing “drive commands” so as to “avoid[] collision with the object,” Ex1004, [00171], which corresponds to the claimed “based on the determination that the object is within the range of the apparatus.” Ex1003, ¶106.

f. Claim 2

“The method of claim 1, further comprising: adapting movement of the apparatus as the object is detected in the surroundings of the apparatus.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶107.

Petitioner incorporates by reference the disclosures provided under Claim 1. As discussed, (*supra*, IV.A.2.e), Rosenstein discloses the “controller 500” issuing “drive commands” to the “drive system 200” to move the robot 100, *e.g.*, the apparatus, in order to “avoid[] collision with the object,” which corresponds to the claimed “adapting movement of the apparatus as the object is detected in the surroundings of the apparatus.” Ex1004, [00171]; Ex1003, ¶108. Rosenstein also discloses an “obstacle detection obstacle avoidance (ODOA) navigation strategy for the control system 510” which “may include either accepting or rejecting potential robot positions that would result from commands.” Ex1004, [00234]. For each “robot position 2120 in the robot path 2110,” the ODOA executes “a method for object detection and obstacle avoidance that includes identifying each cell in the grid

2100 that is in a bounding box around a corresponding position of the robot 100, receiving a classification of each cell.” *Id.* For each “cell classified as an obstacle or unknown,” a “grid point corresponding to the cell” is then retrieved and, if the “grid point is within [a] collision circle,” about a location of the robot 100, “the method further includes executing a triangle test of whether the grid point is within the collision triangle.” *Id.* If the “grid point” is “within the collision circle,” then the method further includes “rejecting the grid point.” *Id.* A POSITA would understand this ODOA navigation strategy as also corresponding to the claimed “adapting movement of the apparatus as the object is detected in the surroundings of the apparatus.” Ex1003, ¶109.

g. Claim 3

“The method of claim 1, wherein the contrast parameter corresponds to partitioning of the at least one image into a low spatial frequency portion and a high spatial frequency portion.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶110.

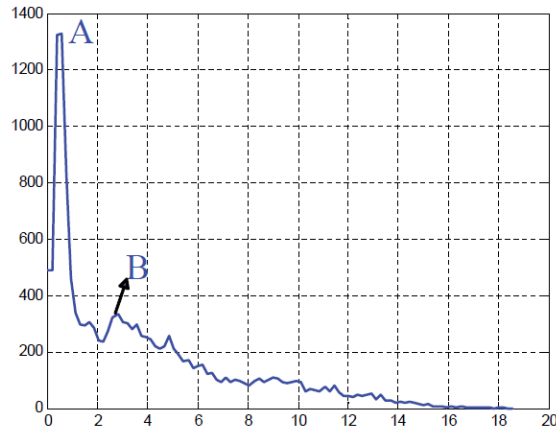
To the extent Rosenstein is found not to disclose this limitation, Xu discloses it. Ex1003, ¶111.

Petitioner incorporates by reference the disclosures provided under Claim 1. As discussed, (*supra* IV.A.2.d), Xu’s local maximum gradient magnitude corresponds to the claimed contrast parameter. Ex1003, ¶112. Xu also discloses

that “the largest peak in the gradient magnitude histograms after NMS of the Gaussian smoothed natural images occurs near the origin and corresponds to low-frequency content, while edge pixels form a series of smaller peaks where each peak corresponds to a class of edges having similar gradient magnitudes.” Ex1006, 501. The “high threshold should be selected between the largest peak and the second largest edge peak.” *Id.* Figure 2(b) of Xu, displayed below, shows a sample gradient magnitude histogram. The low-frequency portion corresponds to “A,” and the high frequency region corresponds to “B.” Ex1003, ¶112.



(a)



(b)

Fig. 2. (a) Original 512×512 House image; (b) Histogram of the gradient magnitude after non-maximal suppression of the House image.

Ex1006, Fig. 2. Therefore, a POSITA would have understood that the local maximum gradient magnitude (which is the gradient magnitude after NMS), in other words, the contrast parameter, corresponds to the claimed partitioning of the image into a low spatial frequency portion, A, and a high spatial frequency portion, B. Ex1003, ¶112.

Xu additionally discloses, as discussed, a distributed Canny edge detection algorithm where “the image can be divided into blocks.” Ex1006, 501. Further, Xu discloses that the local maximum gradient (gradient magnitude after NMS), *e.g.*, the contrast parameter, is used to partition the image blocks into “blurred,” “moderately-edged,” or “high-detailed” blocks as described in Xu’s Fig. 4, reproduced below. *Id.*

```
Let  $G_t$ : set of pixels with gradient magnitudes greater
      than a threshold  $t$ 
 $N_{G4}$ : the number of elements in the set  $G_t$ 

Step 1: Determine  $G_t$  for  $t = 2, 4$ , and  $6$  and  $N_{G_t}$  for  $t = 2, 4, 6$ 
Step 2: If ( $N_{G4} > 0.25 * \text{Total\_block\_pels}$ )
           $C = 6$  /*High-detailed*/
      else If ( $N_{G4} > 0.05 * \text{Total\_block\_pels}$ )
           $C = 4$  /*moderately-edged*/
      else If ( $N_{G2} < 0.25 * \text{Total\_block\_pels}$ )
           $C = 2$  /*blurred*/
      Else
          Exit; /*textured*/
Step 3: Compute the 8-bin non-uniform gradient magnitude
      histogram of  $G_c$  and the corresponding cumulative
      distribution function  $F(G_c)$ .
Step 4: Compute High_threshold as  $F(\text{High\_threshold}) = 0.8$ 
Step 5: Compute Low_threshold =  $0.4 * \text{High\_threshold}$ 
```

Ex1006, Fig. 4. A POSITA would have understood that partitioning the image into blocks that are blurred corresponds to the claimed “partitioning of the image into a low spatial frequency portion” and into blocks that are moderately-edged or high-detailed corresponds to the claimed “partitioning of the image into a high-spatial frequency portion.” Ex1003, ¶113.

h. Claim 4

“The method of claim 1, wherein the partitioning is configured by selecting a first area and a second area within the at least one image, the first area corresponds to region around zero frequency, and the second area corresponds to the remaining portion of the

spectrum.”

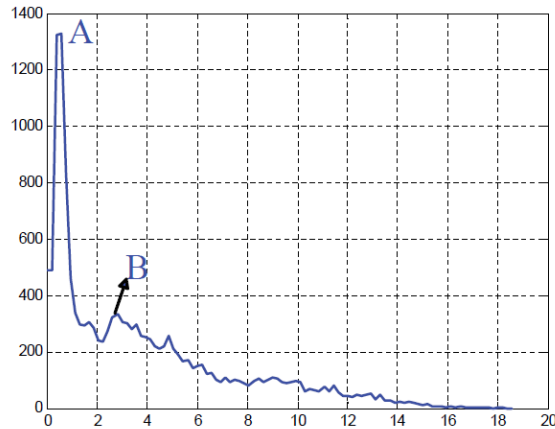
The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶114.

To the extent Rosenstein is found not to disclose this limitation, Xu discloses it. Ex1003, ¶115.

Petitioner incorporates by reference the disclosures provided under Claim 1. As discussed, (*supra*, IV.A.2.g) with respect to Xu’s Figure 2(b), Xu discloses partitioning of the image into a low spatial frequency portion, A, and a high spatial frequency portion, B. Ex1003, ¶116. Xu further discloses that, as claimed, the first area corresponds to a region around zero frequency (*see* “A” in Figure 2(b) below) and the second area corresponds to the remaining portion of the spectrum. *Id.*



(a)



(b)

Fig. 2. (a) Original 512×512 House image; (b) Histogram of the gradient magnitude after non-maximal suppression of the House image.

Ex. 1006, Fig. 2.

i. Claim 5

“The method of claim 1, wherein the one or more parameters include ambient light conditions surrounding the apparatus and time of day.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶117.

Petitioner incorporates by reference the disclosures provided under Claim 1. Rosenstein recognizes that “[p]roperly sensing objects 12 using the imaging sensor 450, despite ambient light conditions can be important.” Ex1006, [00189]. Rosenstein also teaches that “in many environments the lighting conditions cover a broad range from direct sunlight to bright fluorescent lighting to dim shadows, and

can result in large variations in surface texture and basic reflectance of objects 12.

Lighting can vary within a given location and from scene 10 to scene 10 as well.”

Id. The “imaging sensor 450” disclosed in Rosenstein is what can “used for identifying and resolving people and objects 12 in all situations and with relatively little impact from ambient light conditions (e.g., ambient light rejection).” *Id.* Also, in Rosenstein, the “3-D imaging sensor 450 [can] provide[] three types of information,” including “ambient light intensity at each pixel detector location,” which corresponds to “[t]he ambient light image [resulting from] ambient light reflected off of the target object 12” and is meant to “provide additional robustness, particularly when lighting conditions are poor (e.g., too dark or excessive ambient lighting).” *Id.*, [00185]. It would have been obvious to a POSITA to utilize Xu’s edge detection, where the threshold is dynamically adapted based on the ambient lighting conditions by means of analyzing local image statistics, and to pair it with Rosenstein’s “imaging sensor 450” in order to achieve Rosenstein’s goal of allowing its “imaging sensor 450” to be used in “identifying and resolving people and objects 12 in all situations and with relatively little impact from ambient light conditions.” Ex1004, [00189]; Ex1006, 501–502, Fig. 4; Ex1003, ¶118.

j. Element 6[a]

“The method of claim 1, further comprising: detecting the object at multiple locations from the apparatus based on the sensor being at a slanted angle; and”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶119.

Petitioner incorporates by reference the disclosures provided under Claim 1. Ex1003, ¶120. As already discussed, Rosenstein discloses a mobile robot, which is the claimed apparatus. Rosenstein's robot may detect an "object" based on "first and second 3-D image sensors 450a, 450b (depth cameras)." Ex1004, [00162]. The "first 3-D image sensor 450a is mounted on the torso 140 and pointed downward at a fixed angle to the ground G." *Id.* This enables the robot to receive "dense sensor coverage in an area immediately forward or adjacent to the robot." *Id.* The "second 3-D image sensor 450b is mounted on the head 160, which can pan and tilt via the neck 150," and the "tilt and/or pan" allows the sensor "to see both close and distant objects." *Id.*, [00163]. Rosenstein further discloses that "the robot 100 may tilt the second 3-D image sensor 450b downward slightly to increase a total of combined field of view of both 3-D sensors 450a, 450b, and to give sufficient time for the robot 100 to avoid an obstacle." *Id.*

A POSITA would have understood that Rosenstein's "3-D image sensor[s]" one "pointed downward at a fixed angle" and the other which can "pan and tilt," enables the claimed "detecting the object at multiple locations from the apparatus," including the area "immediately forward or adjacent to the robot" and "distant objects." Ex1003, ¶121.

k. Element 6[b]

“determine, based on the detection of the object, whether the apparatus is approaching the object or the object is approaching the apparatus.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶122. As previously discussed, Rosenstein discloses a mobile robot, which is the claimed apparatus. Ex1003, ¶123. Rosenstein further teaches that the “robot 100 may include first and second 3-D image sensors 450a, 450b (depth cameras).” Ex1004, [00162]; Ex1003, ¶123. “During fast travel, the robot 100 may tilt the second 3-D image sensor 450b downward slightly to increase a total or combined field of view” and “to give sufficient time for the robot 100 to avoid an obstacle.” *Id.*, [00163]. At “slower speeds, the robot 100 may tilt the second 3-D image sensor 450b upward or substantially parallel to the ground G to track a person that the robot 100 is meant to follow.” *Id.* Rosenstein also discloses “[i]f the person [] approaches too close to the robot 100, the robot can optionally back away from the person [] to maintain a safe distance.” *Id.*, [00259]; *see also id.*, [0025], [00251]-[00252]. Also, Rosenstein discloses that the sensors “may repeatedly capture scene depth images for real-time decision making by the controller 500 to navigate the robot 100 about the scene without colliding into any objects in the scene.” *Id.*, [00167].

A POSITA would understand that Rosenstein’s sensors, which allow for “real-time decision making” in order to navigate the “robot” about the “scene” and

that additionally prevent the robot from “colliding into any objects in the scene,” “track the motion of the object(s),” and “maintain a safe distance” by backing away from an approaching object, disclose the claimed determination by the robot of whether it is approaching the object or the object is approaching the robot. Ex1003, ¶125.

I. Claim 7

“The method of claim 1, wherein the sensor comprising a linear array of photo sensitive elements.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶126.

Petitioner incorporates by reference the disclosures provided under Claim 1. Rosenstein teaches that its mobile robot includes a “sensor system 400” which “includes a set or an array of proximity sensors 410, 420 in communication with the controller 500 and arranged in one or more zones or portions of the robot 100.” Ex1004, [00139]. The “proximity sensors 410, 420” may be “imaging sensors.” *Id.* In some implementations, “the 3-D imaging sensors 450” include “an imager 1174 (e.g., an array of light-sensitive pixels 1174p) which captures reflected light from the scene.” Ex1004, [00168]. Rosenstein further discloses “an image sensor 1324 having an array of light detectors.” *Id.*, [00174]; *see also id.*, [0005] (disclosing “imager includes an array of light detecting pixels”), [0039] (disclosing “imager may include an array of light detecting pixels”), [00169] (disclosing “an imager (e.g.,

array of light-sensitive pixels)), [00182] (disclosing imaging sensor “may include an array of pixel detectors 1522, or other arrangement of pixel detectors 1522, where each pixel detector 1522 is capable of detecting the intensity and phase of photonic energy impinging on it”).

A POSITA would have understood Rosenstein’s disclosed image sensors (including “imager 1174” or “image sensor 1324”) as comprising the claimed linear array of photo sensitive elements. Ex1003, ¶128.

m. Claim 8

“The method of claim 7, wherein the linear array of photo sensitive elements disposed along axial direction of a lens.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶129.

Petitioner incorporates by reference the disclosures provided under Claim 7. Regarding Figure 11 in Rosenstein, reproduced below, the imaging sensor 450 includes “an imager 1174 (e.g., an array of light-sensitive pixels 1174p) which captures reflected light from the scene 10.” Ex1004, [00168]. As previously discussed, the “imager 1174” comprises the claimed array of photo sensitive elements (1174p in Fig. 11, reproduced below). Ex1003, ¶130. Rosenstein further discloses that the “imaging sensor 450” may also include “a light source lens 1176 and/or a detector lens 1178 for manipulating (e.g., speckling or focusing) the emitted

and received reflected light.” *Id.*

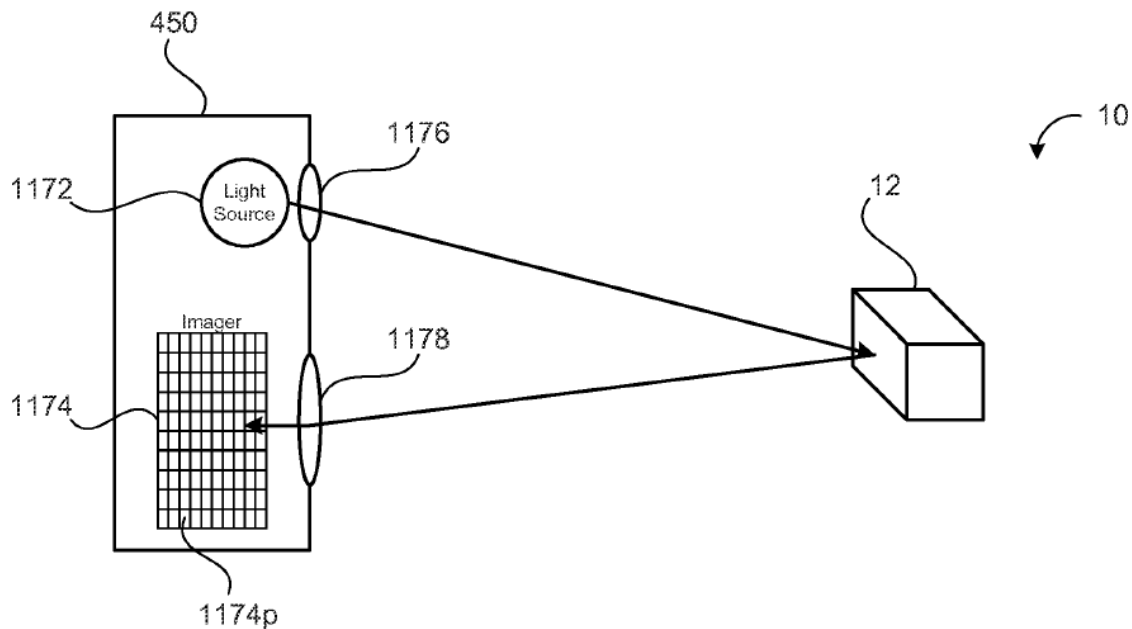


FIG. 11

Ex1004, Fig. 11. As seen in Fig. 11, Rosenstein’s array of photo sensitive elements (e.g., 1174p in Fig. 11), comprises a linear array of photo sensitive elements that are disposed along an axial direction of a lens, (lens 1178 in Fig. 11), as claimed.

Ex1003, ¶130.

n. Claim 9

“The method of claim 1, wherein the sensor comprises one or more sensing layers axially displaced from one another, each one of the one or more sensing layers comprise a plurality of photo sensitive elements.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003,

¶131.

Petitioner incorporates by reference the disclosures provided under Claim 1. As previously discussed (*supra*, IV.A.2.1-m), Rosenstein discloses a sensor 450 which comprises an imager 1174p made up of an array of photo sensitive elements, the claimed “sensing layers” “compris[ng] a plurality of photo sensitive elements.” Ex1003, ¶133. As seen in Fig. 11, reproduced below, the photo sensitive elements are arranged in sensing layers axially displaced from one another. Ex1003, ¶133.

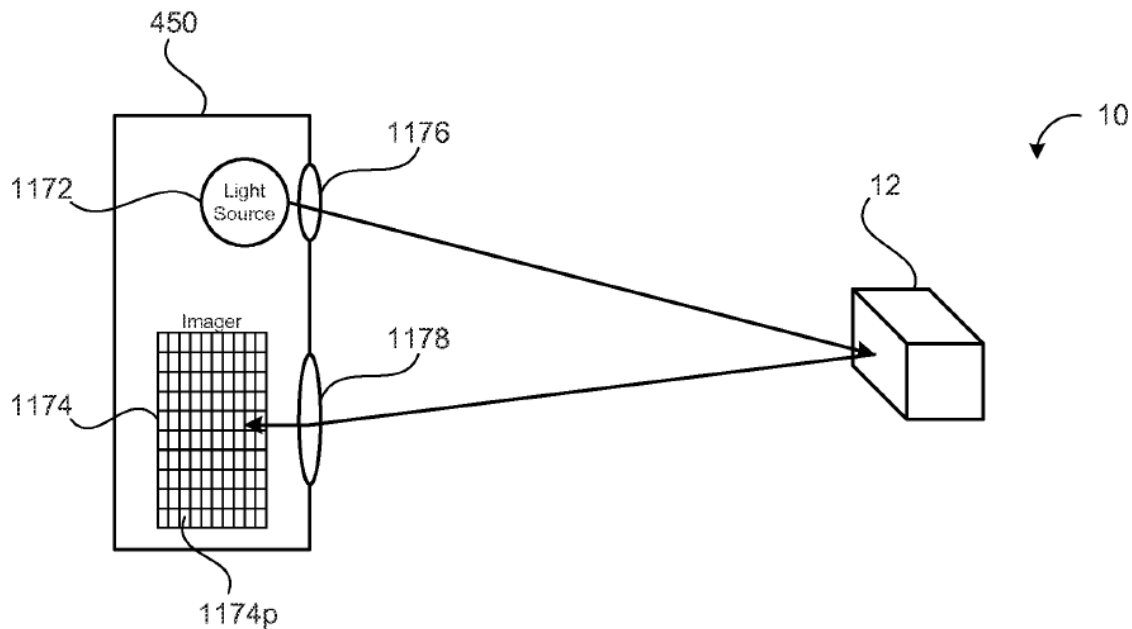


FIG. 11

Ex1004, Fig. 11.

Additionally, referring to Fig. 15, reproduced below, Rosenstein also discloses that “in some implementations, the 3-D imaging sensor 450 includes a 3D

time-of-flight (TOF) camera 1500 for obtaining depth image data. The 3D TOF camera 1500 includes a light source 1510, a complementary metal oxide semiconductor (CMOS) sensor 1520 (or charge-coupled device CCD), a lens 1530, and control logic or a camera controller 1540.” Ex1004, [00182]. The CMOS or CCD sensor 1520 “may include an array of pixel detectors 1522, or other arrangement of pixel detectors 1522, where each pixel detector 1522 is capable of detecting the intensity and phase of photonic energy impinging on it.” *Id.* As seen in Fig. 15, the pixel detectors 1522, which are the claimed photo sensitive elements, are what make up one or more sensing layers and each sensing layer is then axially displaced from one another. Ex1003, ¶134.

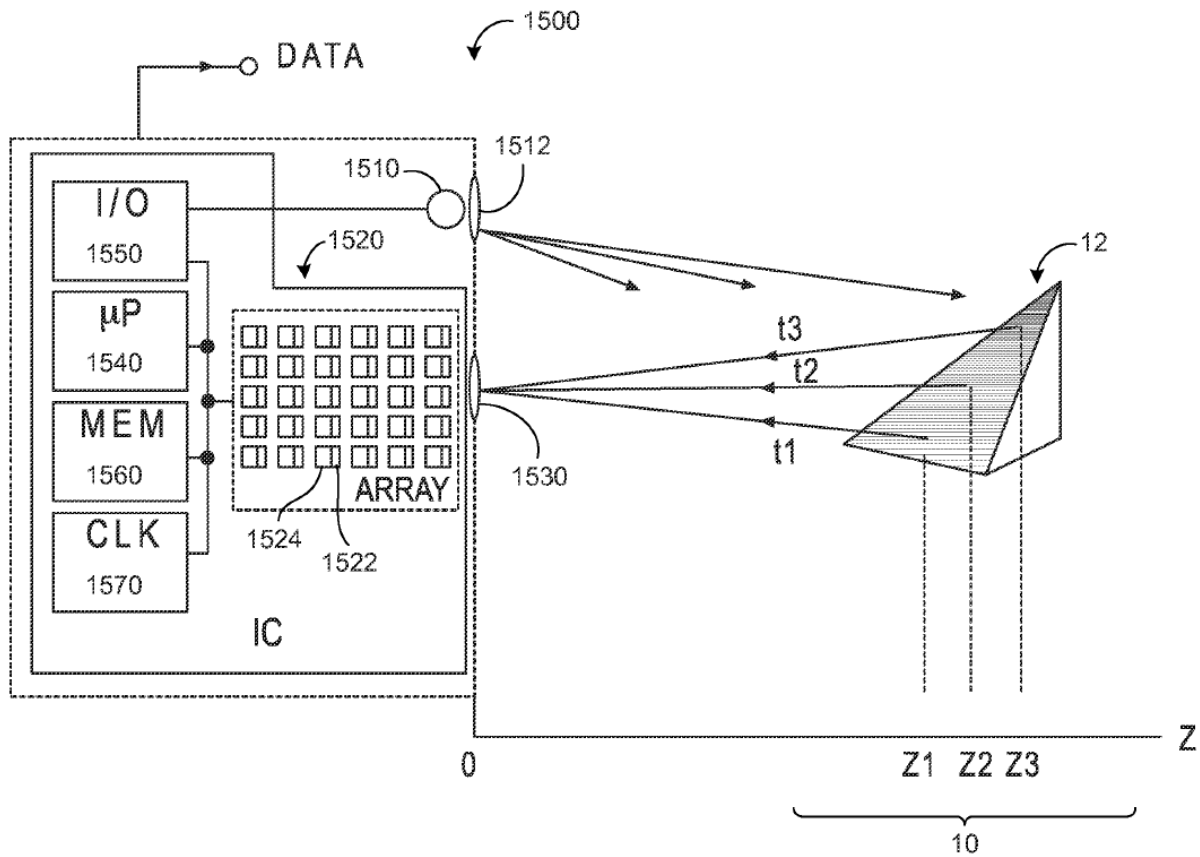


FIG. 15

Ex1004, Fig. 15.

o. Claim 10

“The method of claim 9, wherein the axial displacement of the one or more sensing layers is configured to produce an axial distribution of multiple focal planes, and wherein the axial distribution of multiple focal planes is configurable to enable detection of object positioned in front of the apparatus.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003,

¶135.

Petitioner incorporates by reference the disclosures provided under Claim 9. Regarding Figure 15, reproduced below, and as previously discussed, the photo sensitive elements, *e.g.*, pixel detectors 1522, make up one or more sensing layers and each sensing layer is axially displaced from one another. Ex1003, ¶136. See *supra*, §IV.A.2.n. Rosenstein also discloses that the one or more sensing layers are configured to produce an axial distribution of multiple focal planes, corresponding to a range of depths, *e.g.*, Z1, Z2, Z3, as shown in Fig. 15. Ex1003, ¶136.

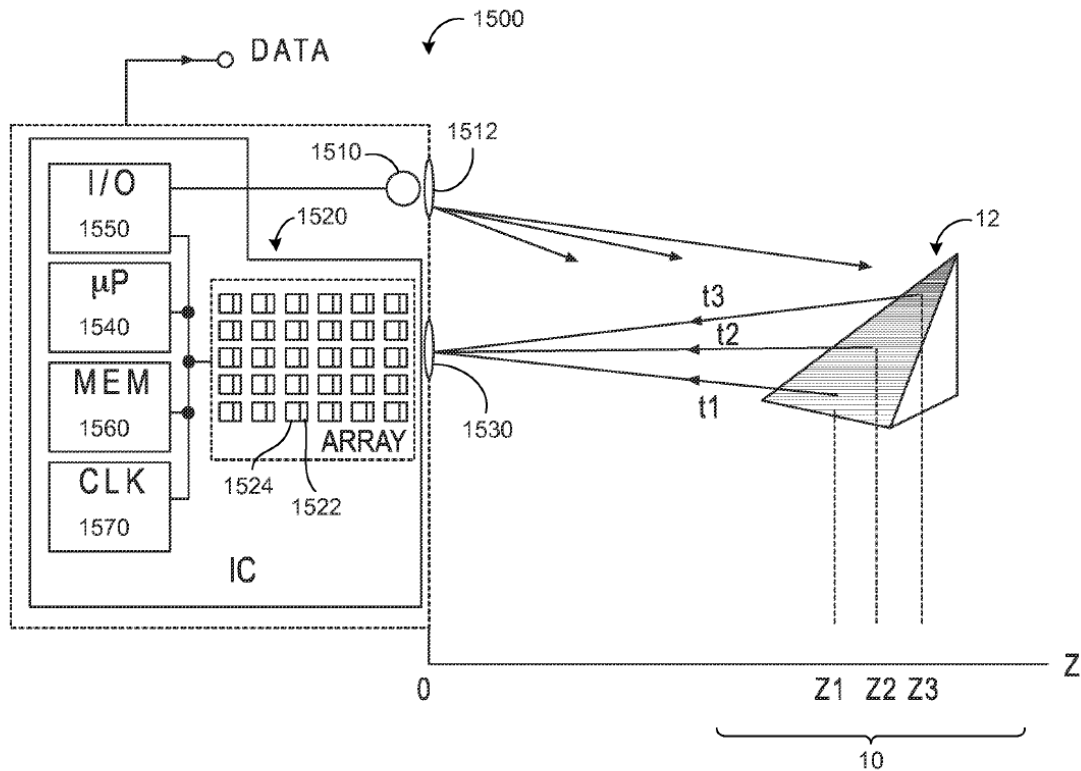


FIG. 15

Ex1004, Fig. 15. A POSITA would understand that the multiple focal planes, Z1, Z2, and Z3, would enable the claimed detection of the object positioned in front of

the apparatus. Ex1003, ¶136.

Additionally, regarding Figure 13, below, Rosenstein also discloses that the robot may include an “imager 1320” which “may include objective optics 1322, which focus the image onto an image sensor 1324 having an array of light detectors 1326, such as a CCD or CMOS-based image sensor.” Ex1004, [00174]. A “speckle emitter 1310 emits a speckle pattern into the scene 10 and the imager 1320 captures reference images of the speckle pattern in the scene 10 at a range of different object distances Z_n from the speckle emitter 1310.” *Id.*, [00175]. The “reference images of the projected speckle pattern are captured at a succession of planes at different, respective distances from the origin, such as at the fiducial locations marked Z_1 , Z_2 , Z_3 , and so on.” *Id.*; Ex1003, ¶137.

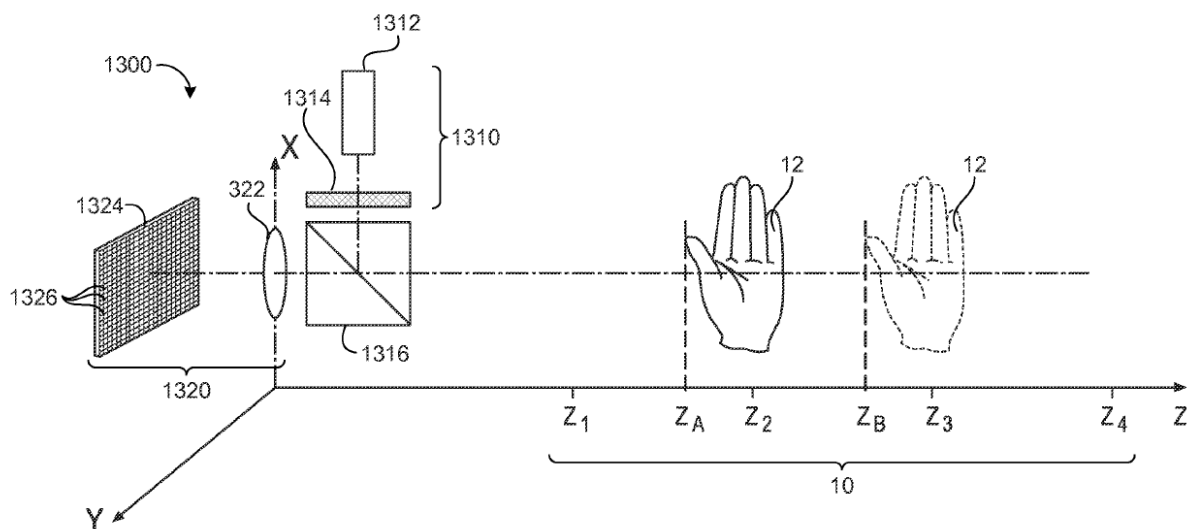


FIG. 13

Ex1004, Fig. 13.

p. Element 11[pre]

“A non-transitory computer-readable storage medium having computer readable instructions stored thereon, that when executed by at least one controller device configure the at least one controller device to:”

To the extent the preamble is limiting, the Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶138. Rosenstein discloses “reasoning or control software, executable on a processor (e.g., of the robot controller 500)” which “uses a combination of algorithms executed using various data types generated by the sensor system.” Ex1004, [00165]. The “reasoning software” then “processes the data collected from the sensor system 400” and “outputs data for making navigational decisions on where the robot 100 can move without colliding with an obstacle.” *Id.*

q. Element 11[a]

“receive data from at least one sensor, the data comprising at least one image of an environment;”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶141. Rosenstein discloses that the “reasoning software processes the data collected from the sensor system 400” and “accumulate[s] imaging data over time of the robot’s surroundings.” Ex1004, [00165]. A POSITA would have understood this disclosure to teach the claimed “receiving data” from “at least one image of an environment.” Ex1003, ¶142. *See also* IV.A.2.b (Element 1(a); incorporated herein

by reference).

r. Element 11[b]

“analyze an image, from the data generated by the at least one sensor, to determine a contrast parameter of the image, the contrast parameter comprising a deviation parameter, a reference value, and/or threshold associated with object detection, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value;”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶143. *See also* IV.A.2.c–d (Elements 1(b) and 1(c); incorporated herein by reference).

s. Element 11[c]

“determine presence of the object based on comparing the contrast parameter of the image to a threshold, the threshold being dynamically configured based on one or more parameters; and”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶144. *See also* IV.A.2.d (Element 1(c); incorporated herein by reference).

t. Element 11[d]

“determine a location of the object from the contrast parameter meeting or exceeding the threshold at the location of the object.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶145. *See also* IV.A.2.d (Element 1(c); incorporated herein by reference).

u. Element 12[a]

“The non-transitory computer-readable storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: receive data from the at least one sensor, the data comprising dynamic lighting parameters of the environment; and”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶146. Petitioner incorporates by reference the disclosures provided under Claim 11. As discussed, the “3-D imaging sensor 450 provides three types of information,” including “ambient light intensity at each pixel detector location.” Ex1004, [00185]. The “ambient light image is of ambient light reflected off of the target object 12” and the provided sensor information allows for “additional robustness, particularly when lighting conditions are poor (e.g., too dark or excessive ambient lighting).” *Id.* See also IV.A.2.i (Claim 5; incorporated herein by reference). A POSITA would have understood that the “ambient light image” information provided by the sensor discloses the claimed “data comprising dynamic lighting parameters of the environment,” and that those lighting parameters necessarily change depending on the ambient lighting conditions of the environment being imaged. Ex1003, ¶148.

v. Element 12[b]

“adjust the threshold for object detection based on the data from the at least one sensor.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶149.

To the extent Rosenstein is found not to disclose this limitation, Xu discloses

it. Ex1003, ¶150.

As explained above with respect to Element 1[c], Xu teaches that the computed local maximum gradient magnitude, *e.g.*, contrast parameter, is compared to a threshold by performing hysteresis thresholding (which is Step 6 of the Canny edge detection algorithm). Ex1006, 501-502, 504; Ex1003 ¶151. Xu also discloses that the threshold is “adjusted for objection detection” because Xu’s distributed Canny edge detection algorithm “proposes a new threshold selection algorithm based on the distribution of pixel gradients in a block of pixels to overcome the dependency between the blocks.” Ex1006, 501-502, 504, Fig. 4. In the Rosenstein/Canny/Xu combination, the distribution of pixel gradients would then be obtained from the image that is captured by the imaging sensor, as discussed above with respect to Element 12[a].

w. Claim 13

“The non-transitory storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: determine a contrast parameter criterion comprising a fixed or a dynamic value from statistics of multiple images gathered by the at least one sensor.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶152. Petitioner incorporates by reference the disclosures provided under Claim 11.

As previously discussed, Rosenstein discloses the non-transitory storage

medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions based on data received from a sensor. Ex1003, ¶154. *See* IV.A.2.p-q (Element 11(pre), 11(a); incorporated herein by reference). Additionally, Xu also discloses determining a contrast parameter criterion comprising a fixed or dynamic value from statistics of multiple images. Ex1003, ¶154. *See* IV.A.2.c-d (Elements 1(b) and 1(c); incorporated herein by reference). It would have been obvious for a POSITA to configure Rosenstein's computer readable instructions, which interpret image data that is received from a sensor for purposes of object detection, in order to determine a contrast parameter criterion, as disclosed by Xu. Ex1003, ¶155.

x. Element 14[a]

“The non-transitory storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: partition a first image into at least two sub-images, the at least two sub-images comprise different energy spectra or regions of the first image; and”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶156. *See also* IV.A.2.g (Claim 3; incorporated herein by reference).

y. Element 14[b]

“apply filtering operations to the at least one of the two sub-images prior to the determination of a contrast parameter criterion.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003,

¶159.

To the extent Rosenstein is found not to disclose this limitation, Xu discloses it. Ex1003, ¶160.

Xu's distributed Canny edge detection algorithm first takes the image and "partition[s] [it] into q sub-images and each sub-image is further divided into $p \times m \times m$ blocks." Ex1006, 502. Xu's distributed Canny edge detection algorithm then "detects the edge map of an $m \times m$ block image," by, at step 1, applying a "[s]moothing unit using Gaussian filter." *Id.*, 503. As previously discussed, the contrast parameter is determined at Step 4 in Xu via non-maximal suppression (NMS). Therefore, a POSITA would have understood that Xu's distributed Canny edge detection algorithm applies the claimed "filtering operation," *e.g.*, the "Gaussian filter" to at least "one of the two sub-images" prior to the determination of a contrast parameter criterion. Ex1003, ¶162–63.

z. Claim 15

"The non-transitory storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: apply an asymmetrical filter to the at least one image received from the at least one sensor to facilitate the detection of an object at a target orientation."

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶164.

To the extent Rosenstein is found not to disclose this limitation, Canny discloses it. Ex1003, ¶165.

Petitioner incorporates by reference the disclosures provided under Claim 11. Canny discloses that “when edge contours are locally straight, highly directional operations will give better results than operators with a circular support.” Ex. 1005, 697. Canny therefore “proposed” a “method” for the efficient generation of highly directional masks,” *i.e.*, filters, “at several orientations, and their integration into a single description.” *Id.*; *see also id.*, 695 (disclosing “[c]onsidering the advantages, it is obviously preferable to use directional operators whenever they are applicable”); *see also* Fig. 10(c) reproduced below (showing the impulse response of asymmetrical directional filters). A POSITA would understand that Canny’s “directional masks,” each having an elongated directional impulse response (which are also referred to as “directional operators”) refer to asymmetrical filters. Ex1003, ¶167.

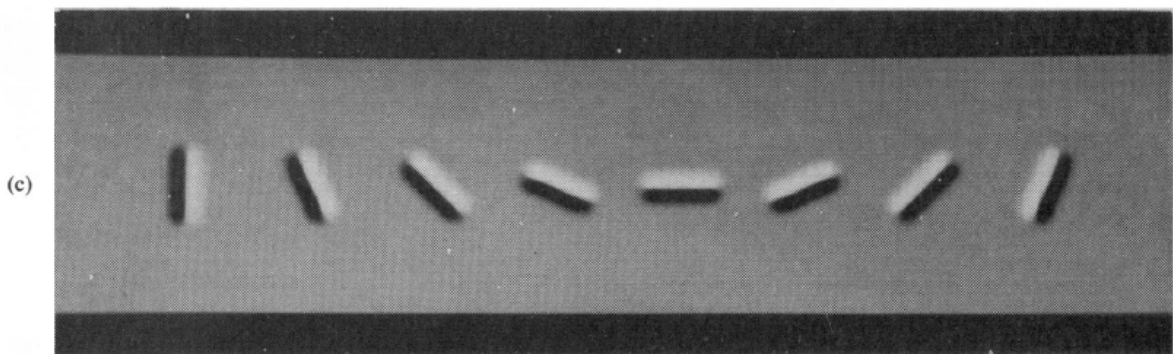


Fig. 10. Directional step edge mask. (a) Cross section parallel to the edge direction. (b) Cross section normal to edge direction. (c) Two-dimensional impulse responses of several masks.

Ex1005, Fig.10(c).

aa. Element 16[pre]

“A method for detection of objects near an apparatus, comprising:”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶168. *See also* IV.A.2.b–c (Elements 1(a) and 1(b); incorporated herein by reference).

bb. Element 16[a]

“gathering data from at least one sensor, the data comprising at least one image of an environment surrounding the apparatus;”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶169. *See also* IV.A.2.b, IV.A.2.q (Elements 1(a) and 11(a); incorporated herein by reference).

cc. Element 16[b]

“analyzing the at least one image, to determine a contrast parameter of the at least one image, the contrast parameter comprising a deviation parameter, a reference value, and/or threshold associated with object detection, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value;”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶170. *See also* IV.A.2.c–d, IV.A.2.r (Elements 1(b), 1(c), and 11(b); incorporated herein by reference).

dd. Element 16[c]

“determining if an object is present in the image based on comparing the contrast parameter of the at least one image to a threshold, the threshold being dynamically configured based on one or parameters.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶171. *See also* IV.A.2.d, IV.A.2.s (Elements 1(c) and 11(c); incorporated herein by reference).

ee. Element 17[a]

“The method of claim 16, further comprising: partitioning a first image, from the plurality of images, into at least two sub-images comprising two different energy spectra or regions of the first image; and”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶172. *See also* IV.A.2.g, IV.A.2.x (Claim 3 and Element 14(a); incorporated herein by reference).

ff. Element 17[b]

“applying filtering and/or cropping operations to the at least one of the two sub-images prior to the determination of a contrast parameter criterion.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶173. *See also* IV.A.2.y (Element 14(b); incorporated herein by reference).

gg. Claim 18

“The method of claim 16, further comprising: applying an asymmetrical filter to the data from the at least one sensor to facilitate detection of objects at a target orientation.”

The Rosenstein/Canny/Xu combination discloses this limitation. Ex1003, ¶174. *See also* IV.A.2.z (Claim 15; incorporated herein by reference).

B. Ground 2: Nourbakhsh in View of Tsutsumi Render Obvious Claims 1-2, 6-7, 11, 13-14, and 16-17

Nourbakhsh's mobile robot combined with Tsutsumi's method for creating a depth map disclose all elements of the Challenged Claims (Ground 2) and render the Challenged Claims obvious.

1. Overview of Ground and Prior Art

a. Summary of Nourbakhsh

Nourbakhsh discloses a method of generating a categorical depth map of a scene using passive defocus sensing. Ex1007, Abstract. In one application, this method is used for collision avoidance and object detection as part of a mobile robot control system. *Id.* The mobile robot includes multiple cameras focused at different distances, which simultaneously capture images of the same scene. *Id.* 4:62-5:1. The images are passed to a microprocessor and memory for image processing. *Id.* 5:4-6. Each of the n images is broken into m regions, and a sharpness value is calculated for each region, representing "a nonnegative measure of the contrast between pixel intensities in that region." *Id.* 6:20-41. "A larger sharpness value indicates that the portion of the image in a given region is more in focus." *Id.* 6:41-42. The sharpness values are used to generate a depth map, which is "an array of categorical depth values, each value indicating the depth of the scene for a given

region,” for example “[d]epth values of 2, 1, and 0 correspond[ing] to close, medium, and far, respectively.” *Id.* 5:9-15.

Once generated, the depth map is communicated to a robot motion control computer, which sends motion control signals to the robot, “directing the robot to move while preventing collision with objects in the environment.” *Id.* 5:36-42. For example, the control computer may compare the depth map to the “normal depth map” of a flat open floor, where bottom rows of the depth map are medium range and the top rows are far range. *Id.* 5:50-65. “If the depth map deviates from the normal depth map, then it is presumed that an obstacle is in front of the robot.” *Id.* 5:62-65. Depending on whether the object is determined to be “dangerously close” or not, the robot either stops or moves forward slowly and turns in the direction (left or right) that is more open. *Id.* 6:1-14.

b. Summary of Tsutsumi

Tsutsumi discloses an apparatus for providing a “range image” (i.e., spatial distance data for each region of an image) based on images acquired by a camera array. Ex1008 1:8-11, 14:15-18. The overlapping area of the images is divided into N_i by N_j sub-areas. *Id.* 6:55-63. For each sub-area, the apparatus calculates a contrast value and uses the contrast values to select an in-focus image for each sub-area. *Id.* 7:11-19. Using the identification of which image is in-focus for each sub-area, the apparatus generates a range image. *Id.* 13:64-14:21.

The contrast value is calculated using the maximum and minimum monochrome pixel values of the image area (Imax and Imin, respectively), determined by calculating a histogram. *Id.* 10:51-67. The contrast value C(ii,jj,m) for image area (ii,jj) of image m is calculated according to the formula:

$$C(ii,jj,m) = (Imax(ii,jj,m) - Imin(ii,jj,m)) / (Imax(ii,jj,m) + Imin(ii,jj,m))$$

Id. 10:60-67. The contrast value is then compared to a threshold value, Th, to determine whether or not the image is in focus. *Id.* 12:7-11. The threshold is set at an initial value; however, if the number of in-focus images is fewer than two, the threshold value Th is decreased and the comparison step is repeated. *Id.* 11:66-12:3, 12:37-51. This enables the apparatus to “obtain a plurality of in-focus images in order from an image having the highest contrast value in the image area.” *Id.* 12:48-51.

c. Motivation to Combine Nourbakhsh and Tsutsumi

A POSITA reviewing Nourbakhsh and Tsutsumi would have been motivated to combine their teachings, specifically Tsutsumi’s method of computing a contrast parameter and selecting in-focus images with Nourbakhsh’s mobile robot and mobile robot control system. Ex1003, ¶176. Tsutsumi and Nourbakhsh each disclose very similar methods for generating depth information: each uses an array of cameras to capture multiple images of the same scene at different focal lengths, each divides the images into regions to determine the depth of each region, each

calculates a sharpness or contrast value for each region and uses it to determine which of the images has the region in focus. Ex1003, ¶177. A POSITA would understand that Tsutsumi's method has the advantage of generating actual distance information, compared to Nourbakhsh's method generating categorical or relative depth information. Ex1003, ¶178. Accordingly, a POSITA would be motivated to use Tsutsumi's method with the mobile robot of Nourbakhsh in order to have more accurate range information, thereby enabling more precise navigation of the mobile robot. Ex1003, ¶179. In light of the similarities between the approaches of Tsutsumi and Nourbakhsh, a POSITA would have found that combining Tsutsumi with Nourbakhsh is a simple substitution of in-focus determination methods yielding predictable results. Ex1003, ¶179.

2. Detailed Analysis of Ground 2

a. Element 1[pre]

To the extent the preamble is limiting, Nourbakhsh discloses it. Ex1003, ¶181. Nourbakhsh discloses an "obstacle avoidance system for a mobile robot," in which the depth map information is used by a "robot motion control computer" to "direct[] the robot to move while preventing collision with objects in the environment." Ex1007 4:58-61, 5:36-42. A POSITA would recognize that this represents a method of navigating an apparatus (i.e., the mobile robot). Ex1003, ¶182.

b. Element 1[a]

Nourbakhsh discloses this limitation. Ex1003, ¶183. Specifically, Nourbakhsh discloses three charge-coupled-device (CCD) cameras that are mounted on a robot and wired to simultaneously capture images of the robot’s surroundings. Ex1007 4:62-5:1. These cameras constitute the claimed “sensor,” and the robot is the claimed “apparatus.” Ex1003, ¶184. Nourbakhsh also discloses that the robot includes a “motor controller 38 for controlling the motion of the robot in three independent degrees of freedom: forward and backward translation, rotation of the wheel base, and rotation of the turret.” Ex1007 5:42-49. A POSITA would recognize that this disclosure indicates that the robot includes both a controller (i.e., motor controller 38) and an actuator (i.e., the motor that motor controller 38 controls). Ex1003, ¶184.

Tsutsumi also discloses obtaining images using a sensor. Ex1003, ¶185. Tsutsumi discloses “a camera array image capture device including a plurality of image capturing units.” Ex1008 3:35-59. Tsutsumi also discloses an “image acquisition unit” that acquires color and monochrome images from the image capturing units. *Id.* 5:33-37.

c. Element 1[b]

Nourbakhsh and Tsutsumi each discloses this limitation. Ex1003, ¶186. Nourbakhsh discloses that a microprocessor and memory “breaks each image into

an array of image regions, analyzes the regions, and generates a depth map.” Ex1007 5:9-11. The robot motion control computer then “checks if there is an obstacle in front of the obstacle in front of the robot” based on whether the “depth map deviates from the normal depth map.” *Id.* 5:36-42, 5:56-65. Additionally, Nourbakhsh discloses that its invention of “a device for producing a categorical depth map of a scene” has many applications, including “object detection.” *Id.* 3:51-4:17. Thus, a POSITA would recognize that Nourbakhsh’s generating a depth map and using it to both check for and avoid obstacles constitutes the claimed “analyzing the at least one image to detect the presence of an object in the image.” Ex1003, ¶187.

Tsutsumi also discloses that its system “has an effect to provide a range image including a main object and a background from an image group acquired by a camera array image capturing device.” Ex1008 2:18-22. A POSITA would understand that providing a range image, *i.e.*, an image indicating the distance to an object, involves detecting the object to which a distance is determined. Ex 1003, ¶188. Tsutsumi also discloses that distance to the object is determined by an image processing unit that analyzes the image to select in-focus images and computes the distance using the in-focus image and other data. Ex1008 5:33-58; Ex1003, ¶188.

d. Element 1[c]

The Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶189. As previously discussed, Nourbakhsh teaches using a depth map generated

by analyzing a set of images to detect the presence of an object, and Tsutsumi teaches determining the distance to an object. *See* IV.B.2.c (Element 1(b); incorporated herein by reference). Specifically, Nourbakhsh generates the depth map by identifying which of the set of images shows the region in-focus. Ex1007 6:36-50. Tsutsumi also discloses a method which is similar and consists of analyzing a set of images to determine which images show each region in-focus. Ex1008 7:16-18.

Tsutsumi also discloses a “contrast value $C(ii,jj,m)$ ” calculated using the difference between the maximum and minimum monochrome pixel values in the (ii,jj) image region, as described in Formula 4. *Id.* 10:54-67. A POSITA would have understood that Tsutsumi’s contrast value constitutes the claimed “contrast parameter” and that the minimum monochrome pixel value corresponds to the claimed “reference value.” Ex1003, ¶191. Additionally, given that Formula 4 involves subtracting the minimum pixel value (*i.e.*, reference value) from the maximum pixel value in the region, Tsutsumi’s contrast value “correspond[s] to a maximum absolute deviation of pixels . . . from a reference value,” as required by this limitation. Ex1003, ¶191.

Tsutsumi further discloses that the contrast value is compared to a threshold value Th to determine whether the selected image is in focus. Ex1008 11:64-12:1. Depending on the value of Nc , which indicates the number of in-focus images, Th may be decreased and the comparison process repeated. *Id.* 12:37-48. A POSITA

would recognize that this constitutes the claimed “comparing a contrast parameter . . . to a threshold, . . . the threshold being dynamically configured based on one or more parameters.” Ex1003, ¶192. Here, the threshold is dynamically configured based on the parameter Nc. Ex1003, ¶192.

By using Tsutsumi’s method for identifying in-focus images in Nourbakhsh’s system of generating a depth map for navigating a mobile robot, the Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶193.

e. Element 1[d]

Nourbakhsh discloses this limitation. Ex1003, ¶194. Nourbakhsh discloses that “[i]f the depth map deviates from the normal depth map, then it is presumed that an obstacle is in front of the robot and it is then determined whether an obstacle is dangerously close or not.” Ex1007 5:62-65. That means, if an obstacle is dangerously close, then a stop signal is sent to the robot. *Id.* 6:1-3. But if the obstacle is not dangerously close, the robot is signaled “to proceed at partial forward speed.” *Id.* 6:3-6.

f. Claim 2

Nourbakhsh discloses this limitation. Ex1003, ¶196. *See also* IV.B.2.e (Element 1(d), incorporated herein by reference).

g. Element 6[a]

Nourbakhsh discloses this limitation. Ex1003, ¶197. Petitioner incorporates by reference the disclosures provided under Claim 1. Nourbakhsh discloses that

“[t]he cameras are mounted on a robot 26 in a common direction approximately 35 degrees below the horizontal plane.” Ex1007 4:65-5:1. A POSITA would understand that this discloses the cameras being at a slanted angle. Ex1003, ¶198. Additionally, Nourbakhsh discloses that cameras are oriented to capture “very similar but slightly different perspectives of the scene due to their different positions,” such that the object is detected at multiple locations. Ex1007 3:67-4:3, 4:65-5:1; Ex1003, ¶198.

Tsutsumi’s disclosure is also compatible with this aspect of Nourbakhsh, because it states that the “the image capturing units can be arranged arbitrarily,” including “radially or linearly” or “at random.” Ex1008 3:55-59.

h. Element 6[b]

Nourbakhsh discloses this limitation. Ex1003, ¶200. Nourbakhsh discloses that, as the mobile robot moves, the control loop repeatedly checks the current depth map for obstacles, and classifies obstacles as being “dangerously close or not.” Ex1007 5:62-6:19. A POSITA would understand that this process enables the robot to determine whether the apparatus and object are approaching each other as required by this limitation. Ex1003, ¶202. Nourbakhsh further discloses that one of the objectives is to provide a method “that can operate in a wide variety of environmental conditions” including “in circumstances involving relative motion between the camera and objects in the scene.” Ex1007 3:9-14.

i. Claim 7

Nourbakhsh discloses this limitation. Ex1003, ¶203. Petitioner incorporates by reference the disclosures provided under Claim 1. Nourbakhsh discloses that the cameras are charge-coupled-device (CCD) cameras with a resolution of 768×493. Ex1007 4:62-65. A POSITA would recognize that the CCD’s resolution indicates the number of photo sensitive elements and indicates that they are arranged in a grid, comprising linear arrays as required by this limitation. Ex1003, ¶204.

Tsutsumi also discloses that the sensor in the image capturing units can be a CCD sensor. Ex1008 4:37-49.

j. Element 11[pre]

To the extent the preamble is limiting, Nourbakhsh discloses it. Ex1003, ¶206. Nourbakhsh discloses a “microprocessor and memory 32 for image processing.” Ex1007 5:4-15. A POSITA would recognize that the disclosed “memory” is a non-transitory computer-readable storage medium with instructions for the microprocessor to perform its image processing operations. Ex1003, ¶207.

k. Element 11[a]

Nourbakhsh discloses this limitation. Ex1003, ¶208. Nourbakhsh discloses that the image signals from the three cameras are digitized and “then transferred over a bus to a microprocessor and memory 32.” Ex1007 5:2-6.

l. Element 11[b]

Tsutsumi discloses this limitation. Ex1003, ¶210. *See also* IV.B.2.d (Element

1(c); incorporated herein by reference).

m. Element 11[c]

The Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶211. As previously discusses, Tsutsumi identifies in-focus image regions based on comparing a contrast parameter to a dynamic threshold, and Nourbakhsh utilizes the determination of in-focus regions to create a depth map that enables the detection of objects. Ex1003, ¶212. *See also* IV.B.2.c-d (Elements 1(b) and 1(c); incorporated herein by reference).

n. Element 11[d]

The Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶213. As previously discussed, Tsutsumi identifies in-focus image regions based on comparing a contrast parameter to a dynamic threshold, and Nourbakhsh uses the determination of in-focus regions to create a depth map. Ex1003, ¶214. *See also* IV.B.2.c-d (Elements 1(b) and 1(c); incorporated herein by reference). The depth map indicates the location of the object within the scene. Ex1007 5:19-31, 5:62-6:1. For example, Figure 2B, reproduced below, illustrates the depth map for a scene (Figure 2A) with an object (i.e., column) in a specific location:

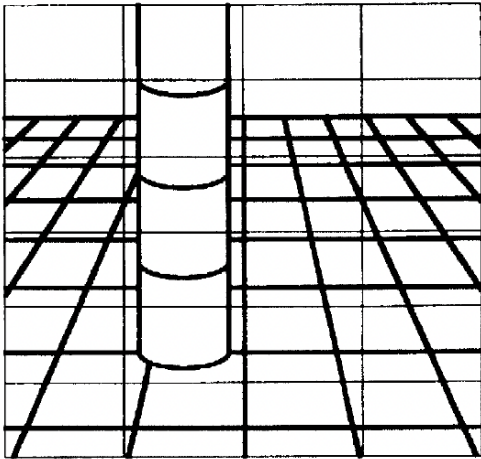


FIG. 2A

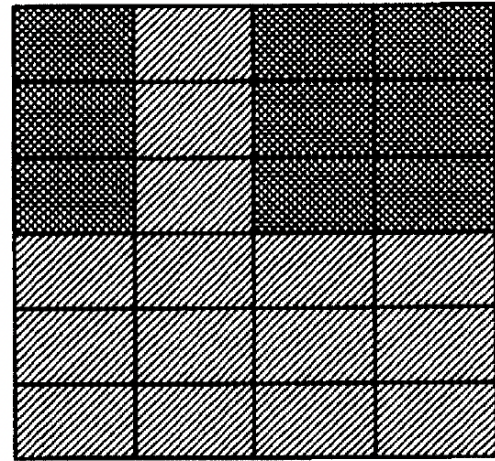


FIG. 2B

Ex1007 Figs. 2A, 2B.

o. Claim 13

Tsutsumi discloses this limitation. Ex1003, ¶216. Petitioner incorporates by reference the disclosures provided under Claim 11. Tsutsumi discloses that the contrast value of the same region from multiple images is compared to the threshold to identify the in-focus images. Ex1008 12:7-51. Each contrast value is calculated by using values from “a histogram based on values of pixels in the image area.” *Id.* 10:51-67. A POSITA would recognize that the in-focus determination of Tsutsumi involves the claimed contrast parameter criterion that uses statistics from multiple images (i.e., the histograms) gathered by the camera sensors. Ex1003, ¶216.

p. Element 14[a]

Nourbakhsh discloses this limitation. Petitioner incorporates by reference the disclosures provided under Claim 11. Ex1003, ¶217. Nourbakhsh discloses that the

image signals are “fed into the R, G, and B input lines of an RGB framegrabber.” Ex1007 5:2-4. A POSITA would understand that different colors of light are of different energy spectra, meaning that the R (red), G (green), and B (blue) signals of Nourbakhsh therefore constitute the claimed partitioning of the image into sub-images of different energy spectra. Ex1003, ¶218.

q. Element 14[b]

The Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶220. As discussed above, Nourbakhsh discloses partitioning the image into sub-images of different energy spectra. *See* IV.B.2.p (Element 14(a); incorporated herein by reference). Further, Tsutsumi discloses that the image capturing units include “an optical low pass filter 306.” Ex1008, 4:37-42. By applying Tsutsumi’s low-pass filter to Nourbakhsh’s sub-images, the Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶220.

r. Element 16[pre]

To the extent the preamble is limiting, Nourbakhsh discloses it. Ex1003, ¶221. *See also* VI.B.2.b-c (Elements 1(a) and 1(b); incorporated herein by reference).

s. Element 16[a]

Nourbakhsh and Tsutsumi each discloses this limitation. Ex1003, ¶222. *See also* IV.B.2.b; IV.B.2.k. (Elements 1(a) and 11(a); incorporated herein by reference).

t. Element 16[b]

Tsutsumi discloses this limitation. Ex1003, ¶223. *See also* IV.B.2.c-d, IV.B.2.1. (Elements 1(c), 1(b), and 11(b); incorporated herein by reference).

u. Element 16[c]

The Nourbakhsh/Tsutsumi combination discloses this limitation. Ex1003, ¶224. *See also* IV.B.2.d, IV.B.2.m (Elements 1(c) and 11(c); incorporated herein by reference).

v. Element 17[a]

Nourbakhsh and Tsutsumi each disclose this limitation. Ex1003, ¶225. *See also* IV.B.2.p (Element 14(a); incorporated herein by reference).

w. Element 17[b]

Nourbakhsh and Tsutsumi each disclose this limitation. Ex1003, ¶226. *See also* IV.B.2.q (Element 14(b); incorporated herein by reference).

V. ENABLEMENT AND SECONDARY CONSIDERATIONS

The prior art references relied upon in this Petition are enabled.

Petitioners are not aware of any secondary considerations of non-obviousness tied to the Challenged Claims. Ex. 1003, ¶¶227–29. To the extent Patent Owner alleges that any secondary considerations of non-obviousness are tied to the Challenged Claims, Petitioners may request leave to file a reply to respond to any such allegations. In any event, where, as here, there is a strong showing of obviousness, the Federal Circuit has held that even relevant secondary considerations supported by substantial evidence do not dislodge the primary

conclusion of obviousness. *Ohio Willow*, 735 F.3d at 1344.

VI. CONCLUSION

Petitioners have established a reasonable likelihood that the Challenged Claims are unpatentable. Petitioners therefore respectfully request that IPR be instituted and that all Challenged Claims be found unpatentable.

DATED: December 4, 2025

Respectfully Submitted,

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CERTIFICATION UNDER 37 C.F.R. § 42.24(d)

Under the provisions of 37 C.F.R. § 42.24(d), the undersigned attorney hereby certifies that the word count for Sections I–VI of the foregoing Petition for *Inter Partes* Review is 11,616 according to the word count tool in Microsoft Word.

DATED: December 4, 2024

By: /Brian M. Buroker/

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.6(e), the undersigned certifies that a complete copy of Petition for *Inter Partes* Review, power of attorney, and supporting materials including exhibits and declarations was served on the Patent Owner via FedEx Priority Overnight at the correspondence address of record for the '436 patent shown in the USPTO Patent Center:

197519 - Pierson Ferdinand, LLP
1101 Pennsylvania Avenue N.W., Suite 300
Washington, DC 20005
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*Petition for Inter Partes Review
of U.S. Patent No. 10,728,436*

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Respectfully Submitted,

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APPENDIX: CHALLENGED CLAIM LISTING

No.	Limitation
1[pre]	A method of navigating an apparatus, comprising:
1[a]	obtaining at least one image associated with surroundings of the apparatus using a sensor, the apparatus comprising a controller, an actuator and the sensor;
1[b]	analyzing the at least one image to detect a presence of an object in the at least one image;
1[c]	determining the presence of the object based on comparing a contrast parameter of the at least one image to a threshold, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value, and the threshold being dynamically configured based on one or more parameters; and
1[d]	causing the controller to selectively activate the actuator based on the determination that the object is within the range of the apparatus.
2	The method of claim 1, further comprising: adapting movement of the apparatus as the object is detected in the surroundings of the apparatus.
3	The method of claim 1, wherein the contrast parameter corresponds to partitioning of the at least one image into a low spatial frequency portion and a high spatial frequency portion.
4	The method of claim 1, wherein the partitioning is configured by selecting a first area and a second area within the at least one image, the first area corresponds to region around zero frequency, and the second area corresponds to the remaining portion of the spectrum.
5	The method of claim 1, wherein the one or more parameters include ambient light conditions surrounding the apparatus and time of day.
6[a]	The method of claim 1, further comprising: detecting the object at multiple locations from the apparatus based on the sensor being at a slanted angle; and
6[b]	determine, based on the detection of the object, whether the apparatus is approaching the object or the object is approaching the apparatus.
7	The method of claim 1, wherein the sensor comprising a linear array of photo sensitive elements.

No.	Limitation
8	The method of claim 7, wherein the linear array of photo sensitive elements disposed along axial direction of a lens.
9	The method of claim 1, wherein the sensor comprises one or more sensing layers axially displaced from one another, each one of the one or more sensing layers comprise a plurality of photo sensitive elements.
10	The method of claim 9, wherein the axial displacement of the one or more sensing layers is configured to produce an axial distribution of multiple focal planes, and wherein the axial distribution of multiple focal planes is configurable to enable detection of object positioned in front of the apparatus.
11[pre]	A non-transitory computer-readable storage medium having computer readable instructions stored thereon, that when executed by at least one controller device configure the at least one controller device to:
11[a]	receive data from at least one sensor, the data comprising at least one image of an environment;
11[b]	analyze an image, from the data generated by the at least one sensor, to determine a contrast parameter of the image, the contrast parameter comprising a deviation parameter, a reference value, and/or threshold associated with object detection, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value;
11[c]	determine presence of the object based on comparing the contrast parameter of the image to a threshold, the threshold being dynamically configured based on one or more parameters; and
11[d]	determine a location of the object from the contrast parameter meeting or exceeding the threshold at the location of the object.
12[a]	The non-transitory computer-readable storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: receive data from the at least one sensor, the data comprising dynamic lighting parameters of the environment; and
12[b]	adjust the threshold for object detection based on the data from the at least one sensor.

No.	Limitation
13	The non-transitory storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: determine a contrast parameter criterion comprising a fixed or a dynamic value from statistics of multiple images gathered by the at least one sensor.
14[a]	The non-transitory storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: partition a first image into at least two sub-images, the at least two sub-images comprise different energy spectra or regions of the first image; and
14[b]	apply filtering operations to the at least one of the two sub-images prior to the determination of a contrast parameter criterion.
15	The non-transitory storage medium of claim 11, wherein the at least one controller device is further configurable to execute the computer readable instructions to: apply an asymmetrical filter to the at least one image received from the at least one sensor to facilitate the detection of an object at a target orientation.
16[pre]	A method for detection of objects near an apparatus, comprising:
16[a]	gathering data from at least one sensor, the data comprising at least one image of an environment surrounding the apparatus;
16[b]	analyzing the at least one image, to determine a contrast parameter of the at least one image, the contrast parameter comprising a deviation parameter, a reference value, and/or threshold associated with object detection, the contrast parameter corresponding to a maximum absolute deviation of pixels within the at least one image from a reference value;
16[c]	determining if an object is present in the image based on comparing the contrast parameter of the at least one image to a threshold, the threshold being dynamically configured based on one or parameters.
17[a]	The method of claim 16, further comprising: partitioning a first image, from the plurality of images, into at least two sub-images comprising two different energy spectra or regions of the first image; and

No.	Limitation
17[b]	applying filtering and/or cropping operations to the at least one of the two sub-images prior to the determination of a contrast parameter criterion.
18	The method of claim 16, further comprising: applying an asymmetrical filter to the data from the at least one sensor to facilitate detection of objects at a target orientation.