PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: MARK S. LEONARDO
BROWN RUDNICK LLP
ONE FINANCIAL CENTER
BOSTON, MA 02111

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	25 JUN 2020

Applicant's or agent's file reference	FOR FURTHER ACTION
FARS-013/01WO 23619/12	See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 19/55435	09 October 2019 (09.10.2019)	10 October 2018 (10.10.2018)

International Patent Classification (IPC) or both national classification and IPC

IPC - G01S 15/88; G01S 15/89 (2020.01)

CPC - G01S 15/88; G01S 15/89; G01S15/66; G01S 15/87; G01S15/96

Applicant FARSOUNDER, INC.

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	27 May 2020	Lee Young PCT Help Desk Telephone No. 571-272-4300

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:
   - [x] the international application in the language in which it was filed.
   - [ ] a translation of the international application into ____________________ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. [ ] This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(b)).

3. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
   a. [ ] forming part of the international application as filed:
      - [ ] in the form of an Annex C/ST.25 text file.
      - [ ] on paper or in the form of an image file.

   b. [ ] furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. [ ] furnished subsequent to the international filing date for the purposes of international search only:
      - [ ] in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
      - [ ] on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. [ ] In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	6, 18, 24	YES
	Claims	1-5, 7-17, 19-23, 25-27	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-27	NO
Industrial applicability (IA)	Claims	1-27	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-5, 7-17, 19-23 and 25-27 lack novelty under PCT Article 33(2) as being anticipated by US 2017/0371039 A1 to NAVICO HOLDING AS (hereinafter 'NAVICO').

Regarding claim 1, NAVICO discloses a method for detecting and classifying underwater features (para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view."), the method comprising:

obtaining three-dimensional forward-looking sonar (3D-FLS) data (para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view."; para [0054] "Additionally, though not shown, one or more transducer arrays (such as the transducer array 24) may be aimed forwardly and downwardly from the watercraft such that the transducer array is configured to be forward looking.");

providing the 3D-FLS data as input to a machine learning algorithm (para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image.");

and using the algorithm to detect a feature in the 3D-FLS data and classify the feature as seafloor or an in-water target (para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view."; para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image.").

Regarding claim 2, NAVICO discloses the method of claim 1, and further discloses wherein the 3D-FLS data comprises a point cloud of backscatter strength data (para [0071] "Blocks 404-412, which in some embodiments may correspond to block 306 in FIG. 3, describe a process for determining and/or identifying clusters of points corresponding to objects in, for example, the voxelized 3D point cloud. The clustering may be performed by calculating the weighted standard deviation of the distance of all of the other points in a swath from a given point. The points within a certain ratio of the weighted standard deviation are included within a cluster for a given point. This results in separating different clusters of points in the point cloud.").

Regarding claim 3, NAVICO discloses the method of claim 1, and further discloses wherein the 3D-FLS data comprises metadata comprising one or more of: sensor acceleration readings, gyroscope readings, sensor roll orientation, sensor pitch orientation, sensor heave, sensor heading, sensor course, sensor latitude, sensor longitude, water temperature, water salinity, and sound speed profile (water temperature, para [0100] "Still further, the processor, in combination with the storage module 906, may store incoming transducer data or screen images for future playback or transfer, or alter images with additional processing to implement zoom or lateral movement, or to correlate data, such as fish or bottom features to a GPS position or temperature.").

Regarding claim 4, NAVICO discloses the method of claim 1, and further discloses wherein the 3D-FLS data are obtained from a 3D-FLS system configured to be mounted on the hull of a boat (para [0102] "The transducer assembly 912 according to an exemplary embodiment may be provided in one or more housings that provide for flexible mounting with respect to a hull of the vessel on which the sonar system 900 is employed.").

Regarding claim 5, NAVICO discloses the method of claim 4, and further discloses wherein the algorithm is run on a processor operably connected to the 3D-FLS system (para [0099] "The sonar signal processor 902 may be any means such as a device or circuitry operating in accordance with software or otherwise embodied in hardware or a combination of hardware and software (e.g., a processor operating under software control or the processor embodied as an application specific integrated circuit (ASIC) or field programmable gate array (FPGA) specifically configured to perform the operations described herein, or a combination thereof) thereby configuring the device or circuitry to perform the corresponding functions of the sonar signal processor 902 as described herein. In this regard, the sonar signal processor 902 may be configured to analyze electrical signals communicated thereto by the transceiver 904 to provide sonar data indicative of the size, location, shape, etc. of objects detected by the sonar system 900.").

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Regarding claim 7, NAVICO discloses the method of claim 1, and further discloses wherein the algorithm has been trained on labeled 3D-FLS training data (para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image. That is, those clusters that correspond to fish exhibit different and identifiable characteristics, and embodiments herein may be configured to determine a value of one or more metrics, each metric alone or in combination with a second metric, capable of being utilized in the determination of a fish.").

Regarding claim 8, NAVICO discloses the method of claim 7, and further discloses further comprising: obtaining data from a secondary source; and improving the labeled 3D-FLS training data with the secondary source data (para [0078] " In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image. That is, those clusters that correspond to fish exhibit different and identifiable characteristics, and embodiments herein may be configured to determine a value of one or more metrics, each metric alone or in combination with a second metric, capable of being utilized in the determination of a fish.").

Regarding claim 9, NAVICO discloses the method of claim 8, wherein the secondary source data comprises one or more of: manually labeled volumetric backscatter strength data; bathymetric survey data from a reference source; multibeam echosounder data (MEES); single beam echosounder data (SEES); 3D-FLS data obtained from the same sonar system at a different angle or time; nautical chart data; radar data; and automatic identification system (AIS) data (multibean eschosounder data (MEES), (para [0046] "These echoes or sonar returns may strike the transducer or a separate receiver element, which converts the echoes back into an electrical signal which is processed by a processor (e.g., a sonar signal processor) and sent to a display (e.g., an LCD) mounted in the cabin or other convenient location in the boat. This process is often called 'sounding'. Since the speed of sound in water is constant (approximately 4800 feet per second in fresh water), the time lapse between the transmitted signal and the received echoes can be measured and the distance to the objects determined."; para [0047] "For example, the sound waves 12 may bounce off the floor 14 of the body of water and reflect back to the boat, thereby indicating a depth of the water at that location.").

Regarding claim 10, NAVICO discloses the method of claim 9, and further discloses wherein the MEES or SEES data are obtained from the same vessel as the 3D-FLS data (para [0046] "These echoes or sonar returns may strike the transducer or a separate receiver element, which converts the echoes back into an electrical signal which is processed by a processor (e.g., a sonar signal processor) and sent to a display (e.g., an LCD) mounted in the cabin or other convenient location in the boat. This process is often called 'sounding'. Since the speed of sound in water is constant (approximately 4800 feet per second in fresh water), the time lapse between the transmitted signal and the received echoes can be measured and the distance to the objects determined."; para [0047] "For example, the sound waves 12 may bounce off the floor 14 of the body of water and reflect back to the boat, thereby indicating a depth of the water at that location.").

Regarding claim 11, NAVICO discloses the method of claim 8, wherein the secondary source data comprise information about position, speed, and heading (position in relation to the seafloor, (para [0046] "These echoes or sonar returns may strike the transducer or a separate receiver element, which converts the echoes back into an electrical signal which is processed by a processor (e.g., a sonar signal processor) and sent to a display (e.g., an LCD) mounted in the cabin or other convenient location in the boat. This process is often called 'sounding'. Since the speed of sound in water is constant (approximately 4800 feet per second in fresh water), the time lapse between the transmitted signal and the received echoes can be measured and the distance to the objects determined."; para [0047] "For example, the sound waves 12 may bounce off the floor 14 of the body of water and reflect back to the boat, thereby indicating a depth of the water at that location.").

Regarding claim 12, NAVICO discloses the method of claim 1, and further discloses further comprising sub-classifying the in-water targets as one or more of: wakes; buoys; fish; boats; and engine noise (fish, para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view. ").

Regarding claim 13, NAVICO discloses the method of claim 1, and further discloses wherein the algorithm generates an output comprising a classification for each point in the 3D-FLS data, the classification representing a likelihood that the point corresponds to (i) seafloor, (ii) an in-water target, or (iii) background (para [0043] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view. In some embodiments, the present invention may provide for allowing real-time tracking of fish. In some embodiments, the fish or other objects may be displayed over a continuous surface geometry based on sonar returns from a lake, sea, or river 'floor.'"; para [0116] "For example, the sonar signal processor 902 may be configured to compare the power or gain data to a predetermined sonar return energy threshold. In this regard, objects in the sonar return data may have a higher power and/or gain value than background values. As such, the predetermined return threshold may be, for example, a preset power or gain, a predetermined value above an average power or gain for the sonar return, a predetermined value above one or more adjacent data points, among many other object recognition based differentiation methods. In some embodiments, in an instance in which the power or gain values exceed the predetermined sonar return energy threshold, the corresponding sonar return data may be identified as an object.").

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Regarding claim 14, NAVICO discloses a system for real-time detection and classification of underwater features (para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view. In some embodiments, the present invention may provide for allowing real-time tracking of fish."), the system comprising:
a three-dimensional forward-looking sonar (3D-FLS) device configured to insonify a region ahead of a vessel and collect 3D-FLS data (para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view."; para [0054] "Additionally, though not shown, one or more transducer arrays (such as the transducer array 24) may be aimed forwardly and downwardly from the watercraft such that the transducer array is configured to be forward looking.");

and a processor operably coupled to the 3D-FLS device, the processor configured to run a machine learning algorithm on the 3D-FLS data to detect and classify features in the 3D-FLS data (para [0099] "The sonar signal processor 902 may be any means such as a device or circuitry operating in accordance with software or otherwise embodied in hardware or a combination of hardware and software (e.g., a processor operating under software control or the processor embodied as an application specific integrated circuit (ASIC) or field programmable gate array (FPGA) specifically configured to perform the operations described herein, or a combination thereof) thereby configuring the device or circuitry to perform the corresponding functions of the sonar signal processor 902 as described herein. In this regard, the sonar signal processor 902 may be configured to analyze electrical signals communicated thereto by the transceiver 904 to provide sonar data indicative of the size, location, shape, etc. of objects detected by the sonar system 900."; para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image."),

the features comprising seafloor and in-water targets para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view."; para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image.").

Regarding claim 15, NAVICO discloses the system of claim 14, and further discloses wherein the 3D-FLS device is configured to be mounted on the hull of a boat (para [0102] "The transducer assembly 912 according to an exemplary embodiment may be provided in one or more housings that provide for flexible mounting with respect to a hull of the vessel on which the sonar system 900 is employed.")

Regarding claim 16, NAVICO discloses the system of claim 14, and further discloses wherein the 3D-FLS data comprise sonar return signals forming a volumetric point cloud of backscatter strength data (para [0071] "Blocks 404-412, which in some embodiments may correspond to block 306 in FIG. 3, describe a process for determining and/or identifying clusters of points corresponding to objects in, for example, the voxelized 3D point cloud. The clustering may be performed by calculating the weighted standard deviation of the distance of all of the other points in a swath from a given point. The points within a certain ratio of the weighted standard deviation are included within a cluster for a given point. This results in separating different clusters of points in the point cloud.").

Regarding claim 17, NAVICO discloses the system of claim 14, and further discloses wherein the 3D-FLS data comprise metadata comprising one or more of: sensor acceleration readings, gyroscope readings, sensor roll orientation, sensor pitch orientation, sensor heave, sensor heading, sensor course, sensor latitude, sensor longitude, water temperature, water salinity, and sound speed profile (water temperature, para [0100] "Still further, the processor, in combination with the storage module 906, may store incoming transducer data or screen images for future playback or transfer, or alter images with additional processing to implement zoom or lateral movement, or to correlate data, such as fish or bottom features to a GPS position or temperature.").

Regarding claim 19, NAVICO discloses the system of claim 14, and further discloses wherein the algorithm has been trained on labeled 3D-FLS training data (para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image. That is, those clusters that correspond to fish exhibit different and identifiable characteristics, and embodiments herein may be configured to determine a value of one or more metrics, each metric alone or in combination with a second metric, capable of being utilized in the determination of a fish.").

Regarding claim 20, NAVICO discloses the system of claim 19, and further discloses wherein the processor is configured to improve the training data with manually labeled volumetric backscatter strength data (para [0078] "In some exemplary embodiments, for example, machine learning algorithms which are capable of automatic pattern classification, and when executed via, for example, a sonar signal processor or the like, may determine if an object of interest (e.g., a fish) is present using one or more characteristics of an image. That is, those clusters that correspond to fish exhibit different and identifiable characteristics, and embodiments herein may be configured to determine a value of one or more metrics, each metric alone or in combination with a second metric, capable of being utilized in the determination of a fish.").

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Regarding claim 21, NAVICO discloses the system of claim 19, and further discloses wherein the algorithm has been further trained on reference seafloor data (para [0046] "These echoes or sonar returns may strike the transducer or a separate receiver element, which converts the echoes back into an electrical signal which is processed by a processor (e.g., a sonar signal processor) and sent to a display (e.g., an LCD) mounted in the cabin or other convenient location in the boat. This process is often called 'sounding'. Since the speed of sound in water is constant (approximately 4800 feet per second in fresh water), the time lapse between the transmitted signal and the received echoes can be measured and the distance to the objects determined."; para [0047] "For example, the sound waves 12 may bounce off the floor 14 of the body of water and reflect back to the boat, thereby indicating a depth of the water at that location.").

Regarding claim 22, NAVICO discloses the system of claim 21, and further discloses further comprising a downward-looking sonar operably connected to the processor and configured to obtain the reference seafloor data (para [0046] "These echoes or sonar returns may strike the transducer or a separate receiver element, which converts the echoes back into an electrical signal which is processed by a processor (e.g., a sonar signal processor) and sent to a display (e.g., an LCD) mounted in the cabin or other convenient location in the boat. This process is often called 'sounding'. Since the speed of sound in water is constant (approximately 4800 feet per second in fresh water), the time lapse between the transmitted signal and the received echoes can be measured and the distance to the objects determined."; para [0047] "For example, the sound waves 12 may bounce off the floor 14 of the body of water and reflect back to the boat, thereby indicating a depth of the water at that location."; para [0051] "In some embodiments, the downscan transducer 50 transmits sonar pulses at least downwardly in a fan-shaped beam, and each of the sidescan transducer arrays 22, 24 is configured to receive returns from the underwater environment on its respective side of the housing.").

Regarding claim 23, NAVICO discloses the system of claim 22, and further discloses wherein the downward-looking sonar comprises an echosounder (para [0046] "These echoes or sonar returns may strike the transducer or a separate receiver element, which converts the echoes back into an electrical signal which is processed by a processor (e.g., a sonar signal processor) and sent to a display (e.g., an LCD) mounted in the cabin or other convenient location in the boat. This process is often called 'sounding'. Since the speed of sound in water is constant (approximately 4800 feet per second in fresh water), the time lapse between the transmitted signal and the received echoes can be measured and the distance to the objects determined."; para [0047] "For example, the sound waves 12 may bounce off the floor 14 of the body of water and reflect back to the boat, thereby indicating a depth of the water at that location."; para [0051] "In some embodiments, the downscan transducer 50 transmits sonar pulses at least downwardly in a fan-shaped beam, and each of the sidescan transducer arrays 22, 24 is configured to receive returns from the underwater environment on its respective side of the housing.").

Regarding claim 25, NAVICO discloses the system of claim 14, and further discloses wherein the processor is further configured to sub-classify the inwater targets as one or more of: wakes; buoys; fish; boats; and engine noise (fish, para [0005] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view. ").

Regarding claim 26, NAVICO discloses the system of claim 14, and further discloses wherein the algorithm generates an output comprising a classification for each point in the 3D-FLS data, the classification representing a likelihood that the point corresponds to (i) seafloor, (ii) an in-water target, or (iii) background (para [0043] "Embodiments of the present invention provide for imaging an underwater environment, including analyzing sonar returns to identify and display objects, such as fish or debris, in a 3D view thus allowing differentiation between the sea floor and objects in a 3D sonar view. In some embodiments, the present invention may provide for allowing real-time tracking of fish. In some embodiments, the fish or other objects may be displayed over a continuous surface geometry based on sonar returns from a lake, sea, or river 'floor.'"; para [0116] "For example, the sonar signal processor 902 may be configured to compare the power or gain data to a predetermined sonar return energy threshold. In this regard, objects in the sonar return data may have a higher power and/or gain value than background values. As such, the predetermined return threshold may be, for example, a preset power or gain, a predetermined value above an average power or gain for the sonar return, a predetermined value above one or more adjacent data points, among many other object recognition based differentiation methods. In some embodiments, in an instance in which the power or gain values exceed the predetermined sonar return energy threshold, the corresponding sonar return data may be identified as an object.").

Regarding claim 27, NAVICO discloses the system of claim 14, and further discloses further comprising a display for displaying the features with labels indicating their classifications or classification likelihoods (fig 9, para [0090] ". For example, where a fish is identified, a predefined fish icon may appear on the display. In some embodiments, where classification methods can determine and/or identify the size and/or shape of the particular object, the predefined icon may be shown in a relative size. For example, a particular object may be determined as being small, medium, or large sized, and as such, embodiments of the present invention may provide for displaying predefined icons in a size indicative of the determined size. For example, with reference to FIG. 9, predefined fish icons 740 and 741 are displayed in the underwater environment 700. As shown, the relative size of each fish icon may correspond to the size characteristic of the associated group or cluster of sonar returns.").

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Claims 6, 18, and 24 lack an inventive step under PCT Article 33(3) as being obvious over NAVICO in view of an article entitled "Convolutional neural network-based real-time ROV detection using forward-looking sonar image" by Kim et al. (hereinafter 'Kim').

Regarding claim 6, NAVICO discloses the method of claim 1, but does not disclose wherein the algorithm is a convolutional neural network. However, Kim, in the related art of a neural network based real-time object-detection for localization of the agent vehicle. The state-of-art and fast object-detection algorithm You Only Look Once (YOLO) shows the high-speed and exact detection [4]. We conducted this algorithm to our forward-looking sonar data. (p 396, right col, paragraph 4), does disclose wherein the algorithm is a convolutional neural network (p 398, left col, paragraph 4 "We used the machine learning algorithm that includes the training of a large number of image data. The model is 'Darknet Reference Model [16]' in the classical Convolutional Neural Networks (CNNs).").

It would have been obvious to one of ordinary skill in the art to modify the method, as disclosed by NAVICO, so as to include the use of convolutional neural network, as disclosed by Kim, because convolutional neural networks use relatively little pre-processing and requires less human intervention or effort, which improves the efficiency of the network.

Regarding claim 18, NAVICO discloses the system of claim 14, but does not disclose wherein the algorithm is a convolutional neural network. However, Kim, in the related art of a neural network based real-time object-detection for localization of the agent vehicle. The state-of-art and fast object-detection algorithm You Only Look Once (YOLO) shows the high-speed and exact detection [4]. We conducted this algorithm to our forward-looking sonar data. (p 396, left col, para 4), does disclose wherein the algorithm is a convolutional neural network (p 398, right col, para 4 "We used the machine learning algorithm that includes the training of a large number of image data. The model is 'Darknet Reference Model [16]' in the classical Convolutional Neural Networks (CNNs).").

It would have been obvious to one of ordinary skill in the art to modify the system, as disclosed by NAVICO, so as to include the use of convolutional neural network, as disclosed by Kim, because convolutional neural networks use relatively little pre-processing and requires less human intervention or effort, which improves the efficiency of the network.

Regarding claim 24, NAVICO discloses the system of claim 19, but does not disclose wherein the algorithm has been further trained on 3D -FLS data collected from the 3D-FLS device at a different angle or time. However, Kim, in the related art of a neural network based real-time object-detection for localization of the agent vehicle. The state-of-art and fast object-detection algorithm You Only Look Once (YOLO) shows the high-speed and exact detection [4]. We conducted this algorithm to our forward-looking sonar data. (p 396, left col, para 4), does disclose wherein the algorithm has been further trained on 3D-FLS data collected from the 3D-FLS device at a different angle or time (time, p 398, right col, paragraph 3, "First, take insufficient images of small ROB. We gathered 1,152 images of the small ROB and labeled them. Next, pre-scan the target region's backgrounds. We used 455 images of background. They can be used for training robust model. Then, make the data-set form and do the training by the powerful computation machine such as desktop computer with GPU [20]. After training is finished, we saved the training-weight data."). It would have been obvious to one of ordinary skill in the art to modify the system, as disclosed by NAVICO so as to include training the algorithm from data collected at a different angle or time, as disclosed by Kim, because training with images taken at a different time will improve the robustness of the training model and allows for data weighting (See Kim, p 398, right col, paragraph 3).

Claims 1-27 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.