[0005] In some cases, the state of the environment is dynamic. For example, some waterways may be prone to regular shifts in the navigation channels, e.g. due to shifting sand bars. As such, the pilot must regularly update his or her knowledge of the environment, so as to be able to safely aid navigation of vessels through the environment.

[0006] Embodiments of the present invention aim to address the aforementioned problems.

SUMMARY

[0007] A first aspect of the present invention provides a system for determining a dynamic virtual representation of at least part of an environment that is navigable by a ship, the system having: at least one beacon remote from the ship, the or each beacon comprising: at least one sensor for sensing surroundings information representative of a topography of at least part of the environment, a transmitter, and a controller connected to the at least one sensor and configured to cause the surroundings information to be transmitted via the transmitter; and a control centre remote from the ship, the control centre comprising: a receiver configured to receive the surroundings information, and a control unit connected to the receiver and configured to determine a dynamic virtual representation of at least part of the environment based on the surroundings information, wherein the dynamic virtual representation comprises a topographical map.

[0008] Such a virtual representation may be usable by a pilot to provide navigation instructions, or at least information relating to the environment, to the captain so that the captain is able to navigate the environment without issue. Alternatively, the virtual representation may be providable to, and usable by, the captain or crew themselves to aid navigation of their ship in the environment. In either scenario, the virtual representation may provide sufficient situational awareness of the environment that the pilot need not board the ship to assist. For example, on the basis of the virtual representation, the pilot may be able to conduct piloting of the ship from a location remote from the ship, such as by issuing navigation instructions to the ship via a communications link between the pilot (e.g. in the control centre) and the ship.

[0009]

[0010] It will further be noted that, since beacon(s) remote from the ship are used, the system is usable to aid navigation of ships that do not themselves comprise such sensor(s) for sensing surroundings information representative of at least part of the environment. Accordingly, the system is very versatile and can be implemented without any modifications being required to shipping fleets. Furthermore, the system can be used to determine a virtual representation of at least part of the environment before the ship has arrived in the environment.

[0011] Optionally, the control unit is configured to update at least a portion of the dynamic virtual representation based on further surroundings information sensed by the at least one sensor and received via the receiver.

[0012] Optionally, the control centre comprises a transmitter connected to the control unit, and the control unit is configured to cause the virtual representation to be transmitted by the transmitter of the control centre. Optionally, the system has a terminal, comprising: a receiver configured to receive the virtual representation, an output device, and a control unit connected to the receiver of the terminal and configured to cause information to be output on the output device based on the virtual representation received. Optionally, the terminal is portable.

[0013] Optionally, the control unit is configured to determine navigation information for use in assisting navigation of the ship based on the surroundings information or based on the virtual representation. Optionally, the control centre comprises a transmitter connected to the control unit, and the control unit is configured to cause the navigation information to be transmitted by the transmitter of the control centre. Optionally, the transmitter is configured to transmit the navigation information to the ship. Optionally, the transmitter is configured to transmit the navigation information to a terminal of the system.

[0014] Optionally, the control unit is configured to generate an instruction to sense surroundings information representative of at least part of the environment, the control

centre comprises a transmitter connected to the control unit, the control unit is configured to cause the transmitter of the control centre to transmit the instruction, and the beacon comprises a receiver configured to receive the instruction. Optionally, the beacon comprises one or more manoeuvring units for controlling movement of the beacon in water, and the controller of the beacon is connected to the receiver of the beacon and is configured to control the one or more manoeuvring units based on the instruction.

[0015] Optionally, the at least one sensor comprises one or more of: a camera, a LIDAR sensor, a SONAR sensor, and a RADAR sensor.

[0016] Optionally, the surroundings information comprises one or more of: one or more images, one or more videos, LIDAR information from one or more LIDAR sensors, SONAR information from one or more SONAR sensors, RADAR information from one or more RADAR sensors, sound information from one or more microphones, position information from one or more position sensors, and movement information from one or more movement sensors.

[0017] Optionally, the topographical map comprises a LIDAR map.

[0018] Optionally, the at least one beacon comprises a static land-based beacon, a mobile land-based beacon, a static water-based beacon, or a mobile water-based beacon.

[0019] Optionally, the at least one beacon comprises a tugboat or a buoy. Optionally, the at least one beacon comprises a plurality of tugboats and/or buoys.

[0020] Optionally, the at least one beacon comprises plural such beacons, the receiver of the control centre is configured to receive surroundings information from respective transmitters of the beacons, and the control unit is configured to determine the dynamic virtual representation of the at least part of the environment based on the surroundings information received from the respective transmitters of the beacons.

[0021] Also disclosed is a tugboat, comprising: at least one sensor for sensing surroundings information representative of at least part of an environment; a transmitter, and a controller connected to the at least one sensor and configured to cause the transmitter to transmit the surroundings information towards a receiver of a control centre remote from the tugboat.

[0022] Optionally, the tugboat comprises: one or more manoeuvring units for controlling movement of the tugboat in water, and a receiver configured to receive an instruction from a transmitter of the control centre, wherein the controller is connected to the receiver and configured to control the one or more manoeuvring units based on the instruction.

[0023] Optionally, the surroundings information is representative of topography of the at least part of the environment.

[0024] Optionally, the at least one sensor comprises one or more of: a camera, a LIDAR sensor, a SONAR sensor, and a RADAR sensor.

[0025] Optionally, the surroundings information comprises one or more of: one or more images, one or more videos, LIDAR information from one or more LIDAR sensors, SONAR information from one or more SONAR sensors, RADAR information from one or more RADAR sensors, sound information from one or more microphones, position information from one or more position sensors, and movement information from one or more movement sensors.

[0026] Also disclosed is a buoy, comprising: at least one sensor for sensing surroundings information representative of at least part of an environment; a transmitter, and a controller connected to the at least one sensor and configured to cause the transmitter to transmit the surroundings information towards a receiver of a control centre remote from the buoy.

[0027] Optionally, the surroundings information is representative of topography of the at least part of the environment.

[0028] Optionally, the at least one sensor comprises one or more of: a camera, a LIDAR sensor, a SONAR sensor, and a RADAR sensor.

[0029] Optionally, the surroundings information comprises one or more of: one or more images, one or more videos, LIDAR information from one or more LIDAR sensors, SONAR information from one or more SONAR sensors, RADAR information from one or more RADAR sensors, sound information from one or more microphones, position information from one or more position sensors, and movement information from one or more movement sensors.

[0030] A second aspect of the present invention provides a method of determining a dynamic virtual representation of at least part of an environment that is navigable by a ship, the method comprising: receiving, from a beacon remote from the ship and at a control centre remote from the ship, surroundings information representative of a topography of at least part of the environment, and determining a dynamic virtual representation, comprising a topographical map, of at least part of the environment based on the surroundings information.

[0031] Optionally, the topographical map comprises a LIDAR map.

[0032] Optionally, the method comprises receiving, from plural beacons remote from the ship and at a control centre remote from the ship, surroundings information representative of at least part of the environment, and determining the virtual representation of the at least part of the environment based on the surroundings information received from the plurality of beacons.

[0033] Optionally, the surroundings information comprises one or more of: one or more images, one or more videos, LIDAR information from one or more LIDAR sensors, SONAR information from one or more SONAR sensors, RADAR information from one or more RADAR sensors, sound information from one or more microphones, position

information from one or more position sensors, and movement information from one or more movement sensors.

[0034]

[0035] A third aspect of the present invention provides a non-transitory computer-readable storage medium storing instructions that, if executed by a processor of a control centre, cause the processor to carry out the method of the second aspect of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0037] Figure 1 shows a schematic view of an example of a system for determining a virtual representation of at least part of an environment that is navigable by a ship;

[0038] Figure 2 shows a schematic view of an example of a tugboat;

[0039] Figure 3 shows a schematic view of an example of a control centre of the system of Figure 1;

[0040] Figure 4 shows a flow chart illustrating an example of a method of determining a virtual representation of at least part of an environment that is navigable by a ship; and

[0041] Figure 5 shows a flow chart illustrating an example of another method of determining a virtual representation of at least part of an environment that is navigable by a ship.

CLAIMS:

1. A system for determining a dynamic virtual representation of at least part of an environment that is navigable by a ship, the system having:

at least one beacon remote from the ship, the or each beacon comprising:

at least one sensor for sensing surroundings information representative of a topography of at least part of the environment,

a transmitter, and

a controller connected to the at least one sensor and configured to cause the surroundings information to be transmitted via the transmitter; and

a control centre remote from the ship, the control centre comprising:

a receiver configured to receive the surroundings information, and

a control unit connected to the receiver and configured to determine a dynamic virtual representation of at least part of the environment based on the surroundings information, wherein the dynamic virtual representation comprises a topographical map.

2. The system according to claim 1, wherein the control unit is configured to update at least a portion of the virtual representation based on further surroundings information sensed by the at least one sensor and received via the receiver.

3. The system according to claim 1 or claim 2, wherein the control centre comprises a transmitter connected to the control unit, and wherein the control unit is configured to cause the virtual representation to be transmitted by the transmitter of the control centre.

4. The system according to claim 3, wherein the system has a terminal, comprising:

a receiver configured to receive the virtual representation,

an output device, and

a control unit connected to the receiver of the terminal and configured to cause information to be output on the output device based on the virtual representation received.

5. The system according to claim 4, wherein the terminal is portable.

6. The system according to any one of claims 1 to 5, wherein the control unit is configured to determine navigation information for use in assisting navigation of the ship based on the surroundings information or based on the virtual representation.

7. The system according to claim 6, wherein the control centre comprises a transmitter connected to the control unit, and wherein the control unit is configured to cause the navigation information to be transmitted by the transmitter of the control centre.

8. The system according to any one of claims 1 to 7, wherein the control unit is configured to generate an instruction to sense surroundings information representative of at least part of the environment,

wherein the control centre comprises a transmitter connected to the control unit,

wherein the control unit is configured to cause the transmitter of the control centre to transmit the instruction, and

wherein the beacon comprises a receiver configured to receive the instruction.

9. The system according to claim 8, wherein the beacon comprises one or more manoeuvring units for controlling movement of the beacon in water, and

wherein the controller of the beacon is connected to the receiver of the beacon and is configured to control the one or more manoeuvring units based on the instruction.

10. The system according to any one of claims 1 to 9, wherein the at least one sensor comprises one or more of: a camera, a LIDAR sensor, a SONAR sensor, and a RADAR sensor.

11. The system according to any one of claims 1 to 10, wherein the surroundings information comprises one or more of: one or more images, one or more videos, LIDAR information from one or more LIDAR sensors, SONAR information from one or more SONAR sensors, RADAR information from one or more RADAR sensors, sound

information from one or more microphones, position information from one or more position sensors, and movement information from one or more movement sensors.

12. The system according to any one of claims 1 to 11, wherein the topographical map comprises a LIDAR map.

13. The system according to any one of claims 1 to 12, wherein the at least one beacon comprises a static land-based beacon, a mobile land-based beacon, a static water-based beacon, or a mobile water-based beacon.

14. The system according to any one of claims 1 to 13, wherein the at least one beacon comprises a plurality of tugboats and/or buoys.

15. The system according to any one of claims 1 to 14, wherein the at least one beacon comprises plural such beacons, wherein the receiver of the control centre is configured to receive surroundings information from respective transmitters of the beacons, and wherein the control unit is configured to determine the virtual representation of the at least part of the environment based on the surroundings information received from the respective transmitters of the beacons.

16. A method of determining a dynamic virtual representation of at least part of an environment that is navigable by a ship, the method comprising:

receiving, from a beacon remote from the ship and at a control centre remote from the ship, surroundings information representative of a topography of at least part of the environment, and

determining a dynamic virtual representation, comprising a topographical map, of at least part of the environment based on the surroundings information.

17. The method according to claim 16, comprising receiving, from plural beacons remote from the ship and at a control centre remote from the ship, surroundings information representative of at least part of the environment, and

determining the virtual representation of the at least part of the environment based on the surroundings information received from the plurality of beacons.

18. A non-transitory computer-readable storage medium storing instructions that, if executed by a processor of a control centre, cause the processor to carry out the method of claim 16 or 17.