An embodiment of a system for controlling a marine vessel includes an electrical power steering unit coupled to a mechanical control system, the mechanical control system including a steering wheel connected by a shaft to a mechanical cable assembly, the mechanical cable assembly configured to be actuated by the steering wheel to control a steering mechanism of the marine vessel. The electrical power steering unit includes an electric motor configured to apply a torque to the mechanical cable assembly. The system also includes a processor configured to control the electrical power steering unit to provide at least one of steering assist and control of the marine vessel.
COLUMN BASED ELECTRIC ASSIST MARINE POWER STEERING

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of an earlier filing date from U.S. Provisional Application Ser. No. 62/197,773 filed Jul. 28, 2015, the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] Embodiments described herein relate to electrical power steering assist and control for marine applications. Embodiments described herein also relate to global positioning system (GPS) enabled control and speed-sensitive assist for marine applications.

[0003] Current marine vessel steering systems include hydraulic powered assist systems and mechanical flex-cable driven non-power assisted system. Mechanical systems are used on smaller and lower cost marine vessels (vessels having a length that is typically 18-22 feet or less), where assist is not considered essential and the application of a hydraulic powered steering system can be cost-prohibitive.

SUMMARY OF THE INVENTION

[0004] An embodiment of a system for controlling a marine vessel includes an electrical power steering unit coupled to a mechanical control system, the mechanical control system including a steering wheel connected by a shaft to a mechanical cable assembly, the mechanical cable assembly configured to be actuated by the steering wheel to control a steering mechanism of the marine vessel. The electrical power steering unit includes an electric motor configured to apply a torque to the mechanical cable assembly. The system also includes a processor configured to control the electrical power steering unit to provide at least one of steering assist and control of the marine vessel.

[0005] An embodiment of a method of controlling a marine vessel includes receiving sensor data from a sensor at a processor, the sensor data including at least one of a rotational position of a steering wheel and a torque applied by the steering wheel, the steering wheel connected by a shaft to a mechanical cable assembly, the mechanical cable assembly configured to be actuated by the steering wheel to control a steering mechanism of the marine vessel. The method also includes generating a motor torque command to an electrical power steering unit coupled to at least one of the mechanical cable, the electrical power steering unit including an electric motor configured to apply a torque to the mechanical cable assembly, and providing at least one of steering assist and control of the marine vessel by the electric motor in response to the motor torque command.

[0006] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0008] FIG. 1 depicts an embodiment of an electrical steering assist and/or control system for a marine vessel;

[0009] FIG. 2 depicts an embodiment of a column electric power steering (CEPS) unit for a marine vessel; and

[0010] FIG. 3 shows a block diagram of communication flow of an electrical steering assist and/or control system.

DETAILED DESCRIPTION

[0011] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features. The Figures are provided to describe various embodiments, without limiting same.

[0012] Systems and methods are provided for control of a mechanical steering system of a marine vessel. An embodiment of a control system for a marine vessel includes an electrical steering assist unit including an electric motor configured to apply torque to a steering wheel and/or mechanical steering cable. In one embodiment, the electrical steering assist unit is positioned at the shaft of a steering wheel or configured to connect to the shaft of the steering wheel to provide assist and/or control. The electrical steering assist unit may be configured to provide steering assist and/or direct control of the steering system.

[0013] Referring now to FIG. 1, an embodiment of a control system 10 of a marine vessel is illustrated. The control system 10 includes a mechanical steering system 12 connected to a propulsion system 14 by a mechanical cable 16 (e.g., a flex cable). Components of the steering system 12, which may be included at the helm region of the vessel (but can be included at any suitable location), include a steering wheel 18 connected to the cable 16, and an electrical steering assist unit 20 coupled to a steering shaft 22. Engaging the steering wheel 18 causes a mechanical actuator 24, such as a rack and pinion or a push-pull rod, to turn a rudder 26 (or other steering mechanism) on the stern of the marine vessel. The steering assist unit 20 is connected to a mechanical cable assembly that includes the cable 16 and a mechanical adapter to connect the steering assist unit 20 in operable relationship with the cable 16.

[0014] In one embodiment, the steering assist unit 20 is configured as a column electric power steering (CEPS) unit applied to a marine propulsion system. The steering assist unit 20 includes an electric motor as an actuator to provide assist to an operator in turning the steering wheel 18 and controlling the vessel. The steering assist unit 20 may also be configured as a semi-autonomous or autonomous steering unit that controls actuation of the cable without engagement of the steering wheel 18 by an operator. In some instances, the steering assist unit 20 can take over control of the vessel, e.g., in response to another system (e.g., a GPS or a proximity monitoring system), to respond to various conditions, such as an oncoming obstruction or other vessel. The steering assist unit 20 can switch to autonomous mode in response to various conditions, or in response to an instruction by an operator, for example, via an autopilot switch 28. The steering assist unit 20 can be connected directly to the cable 16 or connected via a gearbox 30.

[0015] The steering assist unit 20, in one embodiment, is positioned between the steering wheel 18 and the gearbox 30 and/or cable 16. For example, the steering assist unit 20 may be installed on the original steering wheel shaft or positioned
between the steering wheel shaft and the cable 16 and/or gear box 30. FIG. 2 shows an example of a configuration of the steering assist unit 20. In this example, the steering assist unit 20 is configured as a CEPS unit that includes an electric motor 40 (e.g., a 12 volt direct current (DC) motor) that drives a gear mechanism 42 such as a worm gear right angle drive-assist mechanism. An onboard electronics unit 44 includes suitable circuitry and processing devices to control the motor 40 in response to instructions from an operator and/or in response to sensing devices such as an onboard torque sensor.

[0016] The steering assist unit 20 can be installed as original manufacturer equipment (OEM), or installed on pre-existing components without requiring substantial reconfiguration of the propulsion system.

[0017] In one embodiment, the steering assist unit 20 is physically fit within a marine steering column mounting area. The unit 20 may be powered with a power supply such as a 12 volt system located within the steering housing and/or helm.

[0018] For example, as shown in FIG. 2, the steering wheel shaft 22 can fit directly into an input shaft or adapter of the gear mechanism 42 or other suitable location on the steering assist unit 20. An output shaft or adapter opposite the input shaft is configured to couple directly to the cable 16, directly to the gear box 30 or to a connecting shaft coupled to the cable 16 and/or gear box 30. The steering assist unit 20 (or components thereof) may be disposed in a housing having environmental protection based on the properties of the marine vessel system.

[0019] FIG. 3 illustrates a block diagram of a command flow of the steering assist unit 20, which may be executed by a processing device (also referred to as a processor) according to suitable algorithms to affect various methods of controlling a marine vessel. The steering assist unit 20 includes a processing device located at any suitable location to allow the processing device to receive sensor data and generate motor commands. For example, the processing device is incorporated in the electronics unit 44.

[0020] In one embodiment, the steering assist unit 20 includes a torque sensor 46 in communication with a controller 48. The controller 48 is configured to control the motor 40 to provide steering assist and/or vessel steering control (e.g., manually or autonomously or semi-autonomously).

[0021] In one embodiment, the steering assist unit 20 includes or is in communication with various control or processing modules such as a steering wheel position control module 50 and a location signal processing module 52. In one embodiment, the controller 48, the position control module 50 and/or the location signal processing module 52 are configured to control the vessel as part of an autopilot mode.

[0022] The steering assist unit 20 is configured to perform various vessel control and steering assist functions. The following descriptions illustrate various embodiments of a method of controlling aspects of a marine vehicle. It is noted that, although the embodiments are described in conjunction with the system 10 and steering assist unit 20, the embodiments are not so limited and may be performed in conjunction with any suitable processing device or system.

[0023] An embodiment of a method of controlling a marine vessel includes receiving a human input at the steering wheel, and measuring a rotational position and/or torque of the steering wheel via a position and/or torque sensor such as the torque sensor 46. Position and torque measurements may be performed by a combined position and torque sensor or by separate position sensor(s) and torque sensor(s). In one embodiment, the position and/or torque sensor includes an absolute position sensor. The position and/or torque sensor converts the mechanical signal provided by the steering wheel to a processor such as the controller 48, which generates a torque command to an electric motor such as the motor 40 to apply torque to assist the human operator in steering the vessel or to directly control vessel steering. The motor 40 and the controller 48 provide assistance in turning a mechanical gear, for example, which transmits torque to the cable 16 connected to the stern.

[0024] In one embodiment, the method includes receiving steering wheel position information and applying torque to the steering wheel 18 and/or mechanical gear 30. For example, the controller 48 is configured to receive position information from a sensor and identify the rotational center of the steering wheel 18. The position control module 50 (or other suitable processor) determines whether the steering wheel 18 is at center and whether the operator is applying a torque to the steering wheel. If no torque is being applied and the steering wheel is off center, the controller 48 and/or position control module 50 transmits a torque command to the motor 40 to apply a torque that causes the steering wheel 18 to rotate back to center.

[0025] In one embodiment, the method includes receiving steering wheel position information and applying torque to the steering wheel 18 and/or mechanical gear 30 to simulate an end stop and prevent the steering wheel 18 from being rotated to the wheel's mechanical end stop. For example, the controller 48 receives position information and determines the rotational position of the steering wheel 18 with respect to the mechanical end stop. The controller 48 may direct the motor 40 to apply a torque to dampen steering or restrict further rotation when the rotational position of the steering wheel 18 is within a selected angular distance from the mechanical end stop. The controller 48 may determine various steering or operational conditions and respond thereto by applying an appropriate torque. For example, the position and/or torque sensor can be used to monitor steering wheel vibrations and apply appropriate torque to dampen such vibrations.

[0026] The controller 48 or other processor may be configured to apply torque and/or steering control in response to various other conditions. In one embodiment, the electrical power steering system is configured to provide speed-dependent steering assist. A vehicle speed sensor is incorporated into the marine vessel and provides vessel speed measurements to the controller 48. Based on the speed of the vessel, the controller 48 applies a variable level of torque assist. For example, the controller 48 directs the motor 40 to increase an amount of torque assist as speed increases or exceeds one or more speed thresholds. In another example, as speed increases or exceeds one or more speed thresholds, the controller 48 directs the motor to reduce the amount of torque assist to reduce steering responsiveness or sensitivity to make steering safer at higher speeds. In a further example, as speed decreases or is below one or more speed thresholds, the controller 48 directs the motor to increase the amount of torque assist, e.g., assist in tight space maneuvering like trailering, docking, etc.
The controller 48 may further be in communication with a geographic location system such as a GPS system, which may be utilized by the controller 48 to provide automated location guidance. In one embodiment, the controller 48 receives geographic location information and provides different levels of torque assist based on the geographic location of the vessel. For example, the controller 48 is configured to direct the electric motor 40 to provide higher levels of assist when the marine vessel is within a selected range of a shore or docking location, e.g., to provide additional assistance when tight maneuvers are needed.

Speed and/or geographic location dependent assist control can prove useful in various situations. For example, under low speeds in a docking maneuver, the operator may fight conditions such as wind and tight spaces that are of less concern when travelling at higher speeds and/or when further from the shore. Such assist control provides additional assistance for the operator, who may need to rapidly rotate the wheel many degrees of rotation, to reduce the potential for fatigue.

In addition to steering assist, the controller may be configured to provide autopilot capability that can be activated by the operator (e.g., via the autopilot switch 28) or made available in certain conditions. For example, the controller 48 is configured to allow a user to select autopilot at geographic locations that are a selected distance from shore or otherwise in areas conducive to higher speeds. In another example, the controller 48 is configured to allow a user to select autopilot at low speeds or when close to the shore, e.g., to allow the controller to autonomously perform docking maneuvers.

Embodiments described herein provide various advantages. For example, the steering assist unit provides power assist to an operator and/or prevents the operator for over-rotating the steering wheel.

In addition, the steering assist unit may be the only component of the vessel steering system that is electrically powered. In the event of loss of electrical power, the mechanical steering system would remain operational.

The steering assist unit provides steering assist to an operator, allowing for use of mechanical cable steering systems in vessels that conventionally require more expensive hydraulic steering. For example, conventional cable steering systems are restricted to lower power (e.g., less than 150 horsepower) vessels, as conventional cable steering systems in higher power vessels would not allow an operator to comfortably steer the vessel. The embodiments described herein allow for the use of less expensive cable steering systems in higher power and larger vessels.

In addition, the steering assist unit described herein can be readily installed as original manufacturer equipment or subsequently installed without requiring reconfiguration of the current steering and propulsion systems.

While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description.

Having thus described the invention, it is claimed:

1. A system for controlling a marine vessel comprising: an electrical power steering unit coupled to a mechanical control system, the mechanical control system including a steering wheel connected by a shaft to a mechanical cable assembly, the mechanical cable assembly configured to be actuated by the steering wheel to control a steering mechanism of the marine vessel, the electrical power steering unit including an electric motor configured to apply a torque to the mechanical cable assembly; and a processor configured to control the electrical power steering unit to provide at least one of steering assist and control of the marine vessel.

2. The system of claim 1 wherein the electrical power steering unit is a column electrical power steering (CEPS) unit.

3. The system of claim 1 wherein the electrical power steering unit is disposed within a marine steering column mounting area, and disposed between the steering wheel and a connection to the mechanical cable.

4. The system of claim 1 wherein the electrical power steering unit includes a mechanical gear assembly having an input adapter configured to engage the shaft connected to the steering wheel.

5. The system of claim 1 wherein the processor is configured to autonomously control the mechanical control system.

6. The system of claim 1 further comprising a torque and/or position sensor configured to measure at least one of a torque applied by the steering wheel and a rotational position of the steering wheel.

7. The system of claim 6 wherein the processor is configured to receive rotational position information from the torque and/or position sensor, and generate a motor torque command to the motor to apply an amount of torque to the mechanical control system based on a rotational position of the steering wheel.

8. The system of claim 6 wherein the processor is configured to receive rotational position information from the torque and/or position sensor, and autonomously generate a motor torque command to the motor to apply a selected amount of torque to return the steering wheel to a center position.

9. The system of claim 6 wherein the processor is configured to generate the motor torque command to apply torque based on the rotational position of the steering wheel relative to a mechanical end stop.

10. The system of claim 1 wherein the processor is configured to generate a motor torque command to the motor to apply a selected amount of torque to assist an operator, the selected amount of torque based on a speed of the marine vessel.

11. A method of controlling a marine vessel, the method comprising:

receiving sensor data from a sensor at a processor, the sensor data including at least one of a rotational position of a steering wheel and a torque applied by the steering wheel, the steering wheel connected by a shaft to a mechanical cable assembly, the mechanical cable
assembly configured to be actuated by the steering wheel to control a steering mechanism of the marine vessel;
generating a motor torque command to an electrical power steering unit coupled to at least the mechanical cable, the electrical power steering unit including an electric motor configured to apply a torque to the mechanical cable assembly; and
providing at least one of steering assist and control of the marine vessel by the electric motor in response to the motor torque command.

12. The method of claim 11, wherein the electrical power steering unit is a column electrical power steering (CEPS) unit.

13. The method of claim 11, wherein the electrical power steering unit is disposed within a marine steering column mounting area, and disposed between the steering wheel and a connection to the mechanical cable.

14. The method of claim 11, wherein the electrical power steering unit includes a mechanical gear assembly having an input adapter configured to engage the shaft connected to the steering wheel.

15. The method of claim 11, further comprising autonomously controlling the mechanical cable assembly in response to an instruction by an operator.

16. The method of claim 11, wherein the motor torque command is based on a rotational position of the steering wheel.

17. The method of claim 16, further comprising autonomously generating a motor torque command to the motor to apply a selected amount of torque to return the steering wheel to a center position.

18. The method of claim 16, wherein the motor torque command is based on a rotational position of the steering wheel relative to a mechanical end stop.

19. The method of claim 11, wherein the motor torque command directs the motor to apply a selected amount of torque to assist an operator, the selected amount of torque based on a speed of the marine vessel.

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