

DESCRIPTION

Title of Invention: SHIP MANEUVERING ASSISTANCE SYSTEM AND SHIP MANEUVERING ASSISTANCE METHOD

Technical Field

[0001] The present invention relates to a system and method for assisting persons involved in ship maneuvering for departure or berthing of a ship (main ship) when the departure or berthing of the ship is assisted using at least one tugboat (the persons include a pilot, a main ship captain, a tug operator, and an onshore worker).

Background Art

[0002] It is conventional practice to use at least one tugboat to assist the navigation of a large ship (main ship) such as a cargo ship or passenger ferry when the ship berths at or departs from a quay in a harbor. The tugboat pulls or tows the main ship by a tug line extending between the tugboat and the main ship. The tugboat also pushes the main ship by contacting the main ship via fenders (such as tires). The main ship captain maneuvers the main ship which is being pushed or towed by the tugboat. In many cases, the pilot is on board the main ship, and aids the main ship captain by using nautical instruments such as a GPS device as appropriate and communicating with the tug operator and onshore worker via the marine VHF radio in order to guide the main ship safely to the target place.

[0003] In the above ship maneuvering for departure or berthing with assistance from a tugboat, the current situation is that the persons involved communicate with one another based on information visually acquired by each person and using wireless transceivers. Thus, the persons involved in the ship maneuvering for departure or berthing could fail to fully share necessary information among them or fail to exactly communicate the details of information to one another (miscommunication). These are problems to be addressed to accomplish efficient departure and berthing. Patent Literatures 1 to 4 propose communication tools for solving the problems in ship maneuvering for departure and berthing.

[0004] Patent Literature 1 discloses a device mounted on a tugboat to instruct the tug operator what action should be performed on the main ship by the tugboat. This device includes: a microphone and a speaker for intercommunication as conventionally established through wireless transceivers; a small screen that displays a text representing an instruction from the main ship to the tugboat; and a large screen that displays a graphic representing the location and moving direction of the tugboat relative to the main ship and indicating which of pushing and pulling actions should be performed on the main ship by the tugboat.

[0005] Patent Literature 2 discloses that a ship operator and an assistant carry terminal devices and that the terminal devices communicate with each other to exchange pieces of information such as ship maneuvering assistance information and ship maneuvering command information and share the pieces of information.

[0006] Patent Literature 3 discloses an assistance system including a display that superimposes a bird's-eye view of a ship on a bird's eye view of a harbor facility from which the ship departs or at which the ship berths and that further displays the location of the ship, the distance between the quay and the ship, the speed over ground of the ship, the heading of the ship, clearing line information, standard course information, and information related to the wind and hydrographic phenomena in the harbor.

[0007] In Patent Literature 4, captured images of a ship and the surroundings of the ship are used to create a bird's eye view image including the ship and surroundings, and the bird's eye view image is displayed on a first display unit mounted on the ship and a second display unit mounted on a tugboat or a related facility.

Citation List

Patent Literature

[0008] PTL 1: Japanese Laid-Open Utility Model Application Publication No. S61-105298

PTL 2: WO 2004/019302 A1

PTL 3: Japanese Laid-Open Patent Application Publication (Translation of PCT Application) No. 2019-512428

PTL 4: WO 2019/093416 A1

Summary of Invention

Technical Problem

[0009] None of Patent Literatures 1 to 4 disclose a configuration in which the presence or absence and the directions of thrust forces generated by thrusters of the tugboat (these pieces of information will be referred to as "current states of thrusters" hereinafter) are displayed in an easily identifiable manner together with the locations and bearings of the main ship and tugboat. The current states of the thrusters of the tugboat are important information for estimating the thrust force acting on the tugboat and the motion of the tugboat. Thus, if the persons involved can acquire this information and share it among them, smooth, safe, and efficient ship maneuvering for departure and berthing can be accomplished.

[0010] The present invention has been made in view of the above circumstances, and an

object of the present invention is to present the states of thrusters mounted on a tugboat as well as the locations and bearings of a main ship and the tugboat in an intuitively understandable manner to persons involved in ship maneuvering for departure or berthing of the main ship, thereby helping the persons involved to assess the situation and assisting the ship maneuvering for departure or berthing.

Solution to Problem

[0011] A ship maneuvering assistance system according to one aspect of the present invention is used when a main ship departs from or berths at a quay with assistance from at least one tugboat, and includes: a storage storing a nautical chart image, a main ship graphic, and a tugboat graphic, the nautical chart image including the quay; at least one detector that detects locations and bearings of the main ship and the tugboat; at least one display; and a processor that controls the display to display a ship maneuvering assistance screen. The ship maneuvering assistance screen includes: the nautical chart image; the main ship graphic placed on the nautical chart image based on the location and bearing of the main ship which have been detected by the detector; the tugboat graphic placed on the nautical chart image based on the location and bearing of the tugboat which have been detected by the detector; and pieces of tugboat thruster information placed on the tugboat graphic and representing respectively directions of thrust forces generated by tugboat thrusters mounted on the tugboat.

[0012] A ship maneuvering assistance method according to one aspect of the present invention includes controlling at least one display by a processor to display a ship maneuvering assistance screen when a main ship departs from or berths at a quay with assistance from at least one tugboat, the processor being included in an information terminal configured to assist maneuvering of the main ship and the tugboat. The ship maneuvering assistance screen includes: a nautical chart image including the quay; a main ship graphic placed on the nautical chart image in accordance with a location and a bearing of the main ship; a tugboat graphic placed on the nautical chart image in accordance with a location and a bearing of the tugboat; and pieces of tugboat thruster information placed on the tugboat graphic and representing respectively directions of thrust forces generated by tugboat thrusters mounted on the tugboat.

[0013] In the ship maneuvering assistance system and method as described above, the “tugboat thruster information placed on the tugboat graphic” is not limited to tugboat thruster information placed to visually overlap the tugboat graphic on the screen, but may include tugboat thruster information placed in proximity to the tugboat graphic on the nautical chart image so that the correspondence relation between the tugboat thruster information and the tugboat

thruster mounted on the tugboat is visually clear.

[0014] In the ship maneuvering assistance system and method as described above, the positional relation between the main ship and tugboat is indicated by the main ship graphic and tugboat graphic presented on the nautical chart image displayed on the display, and the directions of the thrust forces generated by the tugboat thrusters are indicated by the pieces of tugboat thruster information. In this manner, one and the same screen displayed on the display graphically presents both information indicating the positional relation between the main ship and tugboat and information indicating the states of the tugboat thrusters. Thus, the persons involved who are viewing this screen can intuitively know the interrelation among the main ship, the tugboat, and the tugboat thrusters. The states of the tugboat thrusters are important information for estimating the magnitude and direction of the thrust force acting on the tugboat

3. Intuitive and easy acquisition of this information by the persons involved leads to smooth and efficient ship maneuvering for departure and berthing.

Advantageous Effects of Invention

[0015] In the present invention, the locations and bearings of a main ship and a tugboat and the states of thrusters mounted on the tugboat are presented in an intuitively understandable manner to persons involved in ship maneuvering for departure or berthing of the main ship. Thus, the persons involved can be helped to assess the situation, and the ship maneuvering for departure or berthing can be assisted.

Brief Description of Drawings

[0016] FIG. 1 shows a schematic configuration of a ship maneuvering assistance system according to an exemplary embodiment of the present invention.

FIG. 2 shows a schematic configuration of a tugboat.

FIG. 3 is a block diagram showing a configuration of an information collector.

FIG. 4 is a block diagram showing a configuration of an information terminal.

FIG. 5 is a block diagram showing a configuration of a processing unit.

FIG. 6 shows a ship maneuvering assistance screen.

FIG. 7 shows a ship maneuvering assistance screen.

FIG. 8 shows a ship maneuvering assistance screen.

FIG. 9A shows pushing points set on a main ship.

FIG. 9B shows towing points set on the main ship.

FIG. 10 shows a ship maneuvering assistance screen.

FIG. 11 shows a ship maneuvering assistance screen.

FIG. 12 shows a ship maneuvering assistance screen.

FIG. 13 shows a ship maneuvering assistance screen.

FIG. 14 shows a ship maneuvering assistance screen.

FIG. 15 shows a ship maneuvering assistance screen.

FIG. 16 shows a ship maneuvering assistance screen.

Description of Embodiments

[0017] Hereinafter, an exemplary embodiment of the present invention will be described with reference to the drawings. FIG. 1 shows a schematic configuration of a ship maneuvering assistance system 1. The ship maneuvering assistance system 1 shown in FIG. 1 can be used for ship maneuvering for departure and berthing of a large ship (hereinafter referred to as “main ship 2”) assisted by at least one tugboat 3.

[0018] FIG. 2 shows a schematic configuration of the tugboat 3. As shown in FIG. 2, the tugboat 3 according to the present embodiment includes a hull 38 equipped with a pair of left and right thrusters 68. Inside the hull 38 there are, for example, a crew space and a machinery room (both of which are not shown). A mast 39 is mounted on and rises from the hull 38, and a remote camera 34 is mounted on the mast 39. The remote camera 34 can capture images of the environment in front of the tugboat 3. Each thruster 68 is, for example, an azimuth thruster including a variable-pitch propeller that can turn through 360 degrees. The thrust direction can be adjusted by changing the turning angle of the variable-pitch propeller, and the thrust force can be adjusted by changing the pitch angle of the variable-pitch propeller. The above configuration is merely an example, and the present invention is applicable to any kind of ship maneuvering assistance using the tugboat 3 equipped with a thruster such as a common azimuth thruster or Schneider propeller.

[0019] Referring back to FIG. 1, the ship maneuvering assistance system 1 according to the present embodiment includes information terminals 20, information collectors 30, an information processing unit 40, and a wireless communication network 5 through which the information terminals 20, information collectors 30, and information processing unit 40 are connected to exchange information with one another.

[0020] The information processing unit 40 is disposed on the main ship 2. The information processing unit 40 may be disposed on the land or the tugboat 3. The information processing unit 40 can be operated by a pilot or a main ship captain. The information terminals 20 may be mounted on the main ship 2 and the tugboats 3 or carried by persons involved which

include the pilot, the main ship captain, tug operators, and onshore workers. The information collectors 30 are mounted on the main ship 2, the tugboats 3, and other ships located in the harbor. In the following description, the word “ship” may be used to refer to any of the main ship 2, the tugboats 3, and the other ships located in the harbor without distinction between them. The communication via the wireless communication network 5 may be established through a wireless base station 50 located on the land or ship or established through a mobile base station located on the ship.

[0021] [Information collector 30]

FIG. 3 is a block diagram showing the configuration of the information collector 30. The information collector 30 shown in FIG. 3 includes a computer 31 and a wireless communicator 35. Various nautical instruments 32, various machinery information detectors 33, and the remote camera 34 are communicatively connected to the computer 31. The computer 31 acquires information and data from the nautical instruments 32, machinery information detectors 33, and remote camera 34, and transmits the acquired information and data to the information processing unit 40 through the communicator 35 and the wireless communication network 5 along with identification information of the ship.

[0022] The nautical instruments 32 include, for example: a GPS device including a positioning antenna disposed at a given location on the ship; a gyrocompass (bearing indicator); a water depth indicator; a wind direction/speed indicator; a ship speed indicator; and a draft indicator. The GPS device can receive the time of day (coordinated universal time) and the location (latitude and longitude) and determine the speed and course over ground from the received pieces of information. The gyrocompass can detect the heading and determine the rate of turn based on the turning angle of the ship as obtained from the detected information. The machinery information detectors 33 of the main ship 2 include detectors such as those for the rudder angle, the rotational speed of the drive shaft, and the rotational speeds of the side thrusters (stern thrusters/bow thrusters). The machinery information detectors 33 of the tugboat 3 include detectors such as those for the rotational speeds of the propellers of the azimuth thrusters and the directions of the axes of the propellers.

[0023] The remote cameras 34 are disposed at any suitable locations on the ships (see FIG. 1). The remote cameras 34 mounted on the main ship 2 may be disposed to capture images of the quay from a lateral side of the main ship 2. As previously mentioned, the remote cameras 34 are mounted also on the tugboats 3.

[0024] The information collector 30 may incorporate an AIS (Automatic Identification System) as conventionally mounted on ships. In this case, a VHS communicator (not shown) of

the AIS may be used as the communicator 35. The AIS automatically transmits and receives ship-related data by means of VHF waves to know the states of nearby ships. The information transmitted and received by the AIS typically includes dynamic information, static information, and navigation-related information of the ship equipped with the AIS. The dynamic information typically includes the time of day (coordinated universal time), the location (latitude and longitude), the speed over ground, the course over ground, information related to location accuracy, the heading, the rate of turn, and the navigation status. The static information typically includes the MMSI (Maritime Mobile Service Identity), the call sign, the ship name, the ship type, the IMO number, the location of the positioning antenna, and the length and width of the ship. The navigation-related information typically includes the draft of the ship, the destination, the estimated date and time of arrival, and the type of dangerous cargoes. The AIS is a well-known system and will therefore not be described in more detail.

[0025] [Information terminal 20]

FIG. 4 is a block diagram showing the configuration of the information terminal 20. The information terminal 20 shown in FIG. 4 includes a computer 21, an input interface 23, an output interface 24, a storage 25, and a communicator 26. The computer 21 includes a processor 211, a memory 212 such as a RAM or ROM, an input controller 213, an output controller 214, a disk controller 215, a communication controller 216, and various other interfaces 217. The input interface 23 is connected to the input controller 213. The input interface 23 includes a touch panel 231 and a microphone 232. The input interface 23 may include at least one selected from a keyboard, a pointing device, and other operation interfaces such as a button and a stick. The output interface 24 is connected to the output controller 214. The output interface 24 includes a display 241 and a speaker 242. The storage 25 such as a hard disk is connected to the disk controller 215. The communicator 26 is wirelessly connected to the communication controller 216. The communicator 26 includes a transmitting/receiving antenna and can exchange information with the other information terminals 20 and the information processing unit 40 through the antenna and the wireless base station 50.

[0026] The information terminal 20 incorporates a display program 7 pre-installed. The processor 211 executes a program stored in the memory 212, carries out a computing process using at least one selected from information input through the input interface 23, information stored in the memory 212 or storage 25, information acquired externally through the communicator 26, and information acquired externally through the interfaces 217, and outputs the result of the process to the output interface 24 and/or the communicator 26.

[0027] [Information processing unit 40]

FIG. 5 is a block diagram showing the configuration of the information processing unit 40. The information processing unit 40 shown in FIG. 5 includes a computer 41, an input interface 43, an output interface 44, a storage 45, and a communicator 46. The computer 41 includes a processor 411, a memory 412 such as a RAM or ROM, an input controller 413, an output controller 414, a disk controller 415, a communication controller 416, and various other interfaces 417. The input interface 43 is connected to the input controller 413. The input interface 43 includes a touch panel 431 and a microphone 432. The input interface 43 may include at least one selected from a keyboard, a pointing device, and other operation interfaces such as a button and a stick. The output interface 44 is connected to the output controller 414. The output interface 44 includes a display 441 and a speaker 442. The storage 45 such as a hard disk is connected to the disk controller 415. The wireless communicator 46 is wirelessly connected to the communication controller 416. The communicator 46 includes a transmitting/receiving antenna and can exchange information with the information terminals 20 and the information collectors 30 through the antenna and the wireless base station 50. The processor 411 executes a program stored in the memory 412, carries out a computing process using at least one selected from information input through the input interface 43, information stored in the memory 412 or storage 45, information acquired externally through the communicator 46, and information acquired externally through the interfaces 417, and outputs the result of the process to the output interface 44 and/or the communicator 46.

[0028] In the storage 45, a harbor information database, a ship information database, and a navigational information database are constructed.

[0029] The harbor information database stores information related to the harbor that the main ship 2 enters. The information related to the harbor includes a nautical chart including the harbor, the types of quays for departure and berthing, target berthing locations, the locations of buoys, clearing lines, standard courses, water depths, fathom lines, tides, obstacles (including structures such as shoals and fish cages), necessary pass points through which ships need to pass, navigation-prohibited areas, entry-prohibited areas defined for different ships, and local weather and hydrographic conditions in the harbor. A different standard course may be defined and prestored for each quay or ship. The quays may include a sea berth located in a sea area with a great depth.

[0030] The ship information database stores information related to the characteristics of ships in association with the identification information of the ships. The information related to the characteristics of the ships include the respective shape characteristics and motion characteristics of the ships. The shape characteristics include the length, the width, the outline,

the location of a reference point relative to the hull, and the location of the positioning antenna relative to the hull. In particular, the shape characteristics of the main ship 2 further include the locations of pushing points called strong points relative to the hull and the locations of towing points, where bollards are placed, relative to the hull. The motion characteristics include thrusters mounted on the ships, the properties (such as the type and rated output) of the thrusters, and a calculation model for determining the thrust forces.

[0031] The navigational information database stores information acquired from the information collectors 30 mounted on ships located in the harbor, with the stored information being associated with the identification information of the ships. The navigational information database may store information acquired from the AISs mounted on ships located in the harbor, with the stored information being associated with the identification information of the ships.

[0032] The computer 41 of the information processing unit 40 executes a program stored in the memory 412 or storage 45 to implement the functions of an information acquisition module, a future location calculation module, a collision avoidance module, a course planning module, a thrust force calculation module, a sound communication module, and a display data generation module.

[0033] The information acquisition module acquires information transmitted from the information collectors 30 and stores the acquired information into the navigational information database. The information in the navigational information database is retrieved and used for another computing process.

[0034] The future location calculation module determines the location at which a ship will be located after a given period of time (future location). This determination is performed at every moment based on the current location, speed, and bearing of the ship.

[0035] A departure/berthing distance calculation module determines a ship-to-quay distance based on the current location of a ship, harbor information, and information related to the shape characteristics of the ship. The ship-to-quay distance may be the shortest distance between the ship and the quay. The departure/berthing distance calculation module may determine the distance between the ship and a target berthing location.

[0036] The collision avoidance module transmits information to the ship(s) of interest so that the ship(s) may take collision avoidance actions in compliance with ship operation rules provided for preventing ship collisions at sea. The collision avoidance module determines the risk of collision between ships based on the current and future locations of the ships. The collision avoidance module also determines the risk of collision between a ship and an obstacle based on the current and future location of the ship and the location of the obstacle. The risk of

collision is indicated, for example, by a numerical value or a level. In case that the risk of collision is higher than a predetermined threshold, the collision avoidance module generates warning information and transmits the generated information to the information terminal(s) 20 through the wireless communication network 5. The warning information is not limited to information of the ship(s) to be warned of collision, but may include information indicating which ship should be instructed to take an avoidance action, when the avoidance action should be taken, and what the avoidance action is.

[0037] The course planning module sets a recommended course for berthing or departure of the main ship 2 based on necessary pass point information (location, bearing, and speed), navigation-prohibited area information, hydrographic and weather conditions (wind and tidal forces), and main ship motion characteristics. Setting information of the recommended course includes waypoints, the bearing and speed of the main ship 2 at each waypoint, and times when the tug line is tied and untied. For example, the course planning module is configured to determine a suitable course by calculation using a model in which the weather and hydrographical conditions in the harbor and the locations of other ships are variables and configured to set the suitable course as the recommended course. The suitable course may be one that is suitable in terms of particular factors such as safety and economy. Alternatively, the course planning module may be configured to select one of predefined candidate courses based on the weather and hydrographical conditions in the harbor and the locations of the other ships and set the selected course as the recommended course. Alternatively, the course planning module may be configured to set a navigation course planned by the captain or pilot as the recommended course. Alternatively, the course planning module may be configured to set a prestored standard course as the recommended course.

[0038] The thrust force calculation module determines thrust forces currently generated by the main thruster and side thrusters (stern thrusters/bow thrusters) of the main ship 2 and thrust forces currently generated by the azimuth thrusters of the tugboats 3. Each thrust force includes a translational thrust force and a rotational moment thrust force. The thrust force calculation module determines the thrust force based on the output (rotational speed) of the main thruster (or the side or azimuth thruster) using a given calculation model. The thrust force calculation module further determines a resultant thrust force (main ship resultant thrust force) acting on the main ship 2, the resultant thrust force being the sum of the thrust forces generated by the thrusters (including the side thrusters) of the main ship 2 and the thrust forces generated by the thrusters of the tugboats 3.

[0039] The sound communication module digitally converts a sound detected by the

microphone 432 into sound data and transmits the sound data to the information terminal 20 which is a sound communication partner through the communicator 46. The sound communication module receives sound data transmitted from the information terminal 20 which is a sound communication partner, converts the received sound data to analog form, and outputs the resulting sound through the speaker 442.

[0040] The ship maneuvering state data generation module generates ship maneuvering state data. The ship maneuvering state data includes information to be presented on various ship maneuvering assistance screens displayed on the display 441 of the information processing unit 40 and the displays 241 of the information terminals 20. The computer 41 of the information processing unit 40 transmits the generated ship maneuvering state data to the information terminals 20 through the communication controller 416 and the wireless communication network 5. In the computer 21 of each information terminal 20, the memory 212 stores the received ship maneuvering state data, and the processor 211 executes the display program 7 to display at least one ship maneuvering assistance screen on the display 241 based on the ship maneuvering state data. The display program 7 identical to that of the information terminals 20 may be pre-installed in the computer 41 of the information processing unit 40. In this case, the processor 411 of the computer 41 of the information processing unit 40 executes the display program 7 to display at least one ship maneuvering assistance screen on the display 441 based on the ship maneuvering state data. The ship maneuvering assistance screen displayed on the display 241 of each information terminal 20 and the ship maneuvering assistance screen displayed on the display 441 of the information processing unit 40 may be synchronized. The computers 21 and 41 output substantially the same ship maneuvering assistance screens and allow the screens to be displayed in substantially the same way. Thus, the displaying of the screens on the display 241 of each information terminal 20 will be described in detail, and the displaying of the screens on the display 441 of the information processing unit 40 will not be described.

[0041] FIG. 6 shows an example of a ship maneuvering assistance screen S displayed on each display 241. The ship maneuvering assistance screen S includes a current state display region 98. In the current state display region 98, a nautical chart image 60 including the harbor is displayed based on nautical chart information. The nautical chart image 60 presents a quay 61 and further presents buoys and obstacles (all of which are not shown). The nautical chart image 60 may present water depths and fathom lines.

[0042] In a lower left portion of the current state display region 98, a quay type graphic 62 is presented which represents the type of the quay from which the main ship 2 departs or at

which the main ship 2 berths. Typical examples of the type of the quay include a gravity quay, a sheet pile quay, a pier quay, and a floating pier. In FIG. 6, a schematic side view of a pier quay is shown as the quay type graphic 62. Since the quay is represented by a graphic, in particular the quay type graphic 62, the persons involved can intuitively know the type of the quay which is difficult to identify on the nautical chart image 60 which is a bird's eye view.

[0043] In a lower right portion of the current state display region 98, a tide vector 63 representing the flow (direction) of the tide is presented based on tide information. The direction of the arrow of the tide vector 63 represents the flow (direction) of the tide, and the length of the arrow of the tide vector 63 represents the magnitude of the tide. Since the tide is represented by a graphic rather than by a text, the persons involved can intuitively know the state of the tide by viewing the current state display region 98.

[0044] In the current state display region 98, a graphic schematically representing the main ship 2 (hereinafter referred to as "main ship graphic 2s") is superimposed on the nautical chart image 60 based on the location information, bearing information, and shape characteristics of the main ship 2. The main ship graphic 2s is, for example, a graphic representing the outline of the main ship 2 as viewed in plan. The location and bearing of the main ship graphic 2s on the nautical chart image 60 in the current state display region 98 correspond to the actual location and bearing of the main ship 2.

[0045] In the current state display region 98, graphics schematically representing the tugboats 3 (hereinafter referred to as "tugboat graphics 3s") are superimposed on the nautical chart image 60 based on the location information, bearing information, and shape characteristics of the tugboats 3. The tugboat graphics 3s are, for example, graphics representing the outlines of the tugboats 3 as viewed in plan. The locations and bearings of the tugboat graphics 3s on the nautical chart image 60 in the current state display region 98 correspond to the actual locations and bearings of the tugboats 3.

[0046] In the current state display region 98, a rudder graphic 67 schematically representing the rudder of the main ship 2 is superimposed on the main ship graphic 2s based on information of the rudder angle of the main ship 2. The rudder graphic 67 is not limited to a rudder graphic 67 placed to visually overlap the main ship graphic 2s on the current state display region 98, but may include a rudder graphic 67 placed in proximity to the main ship graphic 2s on the nautical chart image 60 so that the correspondence relation between the rudder graphic 67 and the rudder of the main ship 2 is visually clear.

[0047] The relative positional relation between the main ship graphic 2s and the rudder graphic 67 on the current state display region 98 corresponds to the relative positional relation

between the main ship 2 and the rudder mounted on the main ship 2. The rudder graphic 67 is a line segment representing a rudder plate as viewed in plan, and placed on the main ship graphic 2s at an angle corresponding to the rudder angle of the rudder plate relative to the hull of the main ship 2.

[0048] In the current state display region 98, a main ship thruster graphic 70 schematically representing a thruster of the main ship 2 is superimposed on the main ship graphic 2s based on information of the thruster of the main ship 2. The relative positional relation between the main ship graphic 2s and the ship thruster graphic 70 on the current state display region 98 corresponds to the relative positional relation between the main ship 2 and the thruster mounted on the main ship 2. In the current state display region 98 illustrated in FIG. 6, the main ship thruster graphic 70 is presented as a dashed rectangle having a length and a width, and placed on the main ship graphic 2s at a location corresponding to the location of a side thruster on the hull of the main ship 2. The ship thruster graphic 70 is not limited to the above visual appearance. The main ship 2 includes a main thruster and side thrusters (or azimuth thrusters) and, in the current state display region 98 according to the present embodiment, only the main ship thruster graphic 70 representing a side thruster that operates in ship maneuvering for departure or berthing is displayed. A main ship thruster graphic 70 representing the main thruster may be displayed in the current state display region 98.

[0049] The main ship thruster graphic 70 is displayed in the current state display region 98 so as to enable intuitive knowing of the current state of a thruster of the main ship 2. In the case where the thruster of the main ship 2 is a side thruster, the shaft angle of the propeller of the side thruster relative to the main ship 2, namely the thrust direction with respect to the main ship 2, is constant. In the case where the thruster of the main ship 2 is an azimuth thruster, the shaft angle of the propeller of the azimuth thruster relative to the main ship 2 is variable, and the thrust direction with respect to the main ship 2 varies. Thus, in the present embodiment, the in-plane direction of the rotational plane of the propeller of the thruster relative to the main ship 2 and the longitudinal direction of the main ship thruster graphic 70 relative to the main ship graphic 2s correspond to each other so that the thrust direction of the thruster of the main ship 2 with respect to the main ship 2 is clearly known.

[0050] In the current state display region 98, pieces of tugboat thruster information 68s representing respectively the directions of thrust forces generated by the thrusters 68 of the tugboats 3 are placed on the tugboat graphics 3s. The tugboat thruster information 68s is not limited to tugboat thruster information 68s placed to visually overlap the tugboat graphic 3s on the current state display region 98, but may include tugboat thruster information 68s placed in

proximity to the tugboat graphic 3s on the nautical chart image 60 so that the correspondence relation between the tugboat thruster information 68s and the tugboat thruster 68 mounted on the tugboat 3 is visually clear.

[0051] The relative positional relation between the tugboat graphic 3s and the tugboat thruster information 68s on the current state display region 98 corresponds to the relative positional relation between the tugboat 3 and the thruster 68 mounted on the tugboat 3. In the case where the thruster 68 mounted on the tugboat 3 is an azimuth thruster as shown in FIG. 2, the direction of the thrust force generated by the azimuth thruster is substantially parallel to the propeller shaft direction. In this case, the direction of the thrust force generated by the thruster 68 can be known from information of the propeller shaft direction. In the case where the thruster 68 mounted on the tugboat 3 is a screw propeller, the direction of the thrust force generated by the screw propeller is defined by the direction of a rudder mounted in combination with the screw propeller. In this case, the direction of the thrust force generated by the thruster 68 can be known from information of the direction of the rudder.

[0052] In FIG. 6, a graphic schematically representing the propeller is superimposed as the tugboat thruster information 68s on the tugboat graphic 3s based on information of the propeller shaft direction. This tugboat thruster information 68s is a line segment representing the rotational plane of the propeller as viewed in plan, and the direction perpendicular to the line segment is the propeller shaft direction (i.e., the direction of the thrust force generated by the thruster 68). Each tugboat 3 according to the present embodiment is equipped with two thrusters 68, and the tugboat thruster information 68s is displayed for each of the thrusters 68. Thus, the pieces of tugboat thruster information 68s are displayed in the current state display region 98 so as to enable intuitive knowing of the current states of the thrusters 68 of the tugboats 3, in particular the number (or operation states) of the thrusters 68, and the direction of the generated thrust force of each thruster 68 with respect to the tugboat 3. The persons involved who are viewing the current state display region 98 can estimate the direction of the thrust force acting on each tugboat 3 based on those directions of the generated thrust forces of the thrusters 68 which are represented by the pieces of tugboat thruster information 68s on the screen.

[0053] In the current state display region 98, a numerical value and an arrow that represent a distance 64 from the main ship 2 to the quay 61 are superimposed on the nautical chart image 60 based on the main ship 2-to-quay distance determined by the departure/berthing distance calculation module. Since the distance 64 from the main ship 2 to the quay 61 is clearly indicated by a numerical value, the main ship captain or pilot can maneuver the ship with this

distance 64 in mind.

[0054] In the current state display region 98, a velocity vector 69 representing the moving direction and speed of the main ship 2 is displayed based on the course and speed over ground of the main ship 2. The velocity vector 69 is an arrow extending from the bow of the main ship graphic 2s in the moving direction and having a length corresponding to the speed. The speed of the main ship 2 may include the speed at which the main ship 2 continues to move by inertia in the direction in which the main ship 2 has been steered after stop of the engine of the ship (the speed at which the main ship 2 is making way). The speed of the main ship 2 may be indicated by a numerical value in addition to being represented by the velocity vector 69.

[0055] In the current state display region 98, a connection instruction text 73a giving an instruction to connect the tugboat 3 and the main ship 2 by a tug line is displayed. The connection instruction text 73a is displayed, for example, based on connection location information as to the main ship 2 and the tugboat 3 at the time when the main ship 2 and the tugboat 3 arrive at a connection location. Likewise, a disconnection instruction text 73b (see FIG. 7) giving an instruction to disconnect the tugboat 3 and the main ship 2 by untying the tug line is displayed in the current state display region 98. The disconnection instruction text 73b is displayed, for example, based on disconnection location information as to the main ship 2 and the tugboat 3 at the time when the main ship 2 and the tugboat 3 arrive at a disconnection location. The connection location information and disconnection location information are derived from the recommended course. These pieces of information may be included in the setting information of the recommended course, or the operator of the information processing unit 40 may operate the information processing unit 40 to display the connection instruction text 73a or disconnection instruction text 73b at a desired time.

[0056] The ship maneuvering assistance screen S displays a channel designation text 71 representing information of the VHF channel used for wireless transceivers.

[0057] The ship maneuvering assistance screen S includes a call button 72. Once the call button 72 is selected, the computer 21 receives an operation input for starting sound communication and activates the sound communication module. The operator of each of the information terminals 20 can establish sound communication with the information processing unit 40 and the other information terminals 20. Likewise, the operator of the information processing unit 40 can establish sound communication with one or a combination of two or more of the information terminals 20. In the case where the information processing unit 40 and information terminals 20 are equipped with cameras for communication, the information processing unit 40 and information terminals 20 can establish video communication with one

another.

[0058] In the current state display region 98, the pieces of information related to the speed, rudder direction, and thrust force of the main ship 2 can be selectively displayed or hidden. Likewise, in the current state display region 98, the pieces of information related to the speeds and thrust forces of the tugboats 3 can be selectively displayed or hidden. The ship maneuvering assistance screen S includes a display item switching region 99 in which switching buttons are displayed. In the display item switching region 99, a choice can be made between displaying and hiding the display items in the current state display region 98. Once a current state button is selected from the switching buttons of the display item switching region 99, buttons for choosing between displaying and hiding the pieces of information related to the speed, rudder direction, and thrust force of the main ship 2 are displayed, and buttons for choosing between displaying and hiding the pieces of information related to the speeds and thrust forces of the tugboats 3 are also displayed. Thus, in the current state display region 98, the number of pieces of information to be displayed can be reduced, and desired pieces of information can be selectively displayed.

[0059] In a current state display region 98a of the ship maneuvering assistance screen S shown in FIG. 7, information related to the speed of the main ship 2 and pieces of information related to the speeds of the tugboats 3 are displayed, and pieces of information related to the direction of the rudder of the main ship 2 and the thrust forces of the main ship 2 and tugboats 3 are hidden.

[0060] In the current state display region 98a, the velocity vector 69 representing the speed of the main ship 2 is displayed based on the course and speed over ground of the main ship 2. Further, in the current state display region 98a, a tugboat velocity vector 96 representing the speed of the tugboat 3 is displayed based on the course and speed over ground of the tugboat 3. The tugboat velocity vector 96 is an arrow extending from the bow of the tugboat graphic 3s along the course over ground of the tugboat 3 and having a length corresponding to the speed over ground of the tugboat 3. The speed of the tugboat 3 may be indicated by a numerical value in addition to being represented by the tugboat velocity vector 96.

[0061] In a current state display region 98b of the ship maneuvering assistance screen S shown in FIG. 8, information related to the thrust force of the main ship 2 and pieces of information related to the thrust forces of the tugboats 3 are displayed, and pieces of information related to the direction of the rudder of the main ship 2 and the speeds of the main ship 2 and tugboats 3 are hidden.

[0062] In the current state display region 98b, a main ship thrust force vector 65a

representing the direction and magnitude of the thrust force acting on the main ship 2 is displayed based on the thrust force of the main ship 2 as determined by the thrust force calculation module, and tugboat thrust force vectors 66a representing the directions and magnitudes of the thrust forces acting on the tugboats 3 are displayed based on the thrust forces of the tugboats 3 as determined by the thrust force calculation module. In the current state display region 98b, a main ship resultant thrust force 75 may be displayed. The main ship thrust force vector 65a is a solid arrow (directed line segment) extending from the location of the thruster of the main ship 2 in the direction of the translational thrust force and having a length corresponding to the magnitude of the translational thrust force. The tugboat thrust force vector 66a is a solid arrow extending from the location of the thruster of the tugboat 3 in the direction of the generated translational thrust force and having a length corresponding to the magnitude of the translational thrust force.

[0063] In the current state display region 98b, a main ship commanded thrust force vector 65b representing the direction and magnitude of a commanded thrust force for the main ship 2 and tugboat commanded thrust force vectors 66b representing the directions and magnitudes of commanded thrust forces for the tugboats 3 may be further displayed.

[0064] The main ship commanded thrust force vector 65b is a dashed arrow extending from a point 86 on which the thrust force acts (pushing or towing point) in the direction of the thrust force and having a length corresponding to the magnitude of the thrust force. The tugboat commanded thrust force vector 66b is a dashed arrow extending from the location of the thruster of the tugboat 3 in the direction of the thrust force to be generated and having a length corresponding to the magnitude of the thrust force.

[0065] The contents of the commands are displayed by texts in the vicinity of the main ship commanded thrust force vector 65b and tugboat commanded thrust force vectors 66b. For example, the contents of the commands are displayed as absolute values in the unit of “N” or “PS”. For example, the contents of the commands are displayed as percentages to the rated outputs. For example, the contents of the commands are displayed as command terms conventionally used in ship towing, such as “Slow Ahead” and “Full Ahead”.

[0066] In the current state display region 98b, the main ship thrust force vector 65a and the main ship commanded thrust force vector 65b are superimposed on each other. The tugboat thrust force vector 66a and the tugboat commanded thrust force vector 66b are superimposed on each other. This enables comparison between the currently generated thrust force (i.e., output value) and the thrust force to be generated in response to the command (i.e., command value). The persons involved who are viewing the current state display region 98b can intuitively know

future changes of the thrust forces. This can prevent the persons involved from misunderstanding the commands and allow the persons involved to share the understanding of the commands among them.

[0067] The direction and magnitude of the commanded thrust force for the main ship 2 and the directions and magnitudes of the thrust forces acting on the tugboats 3 are input through the information terminal 20 or information processing unit 40 operated by the main ship captain (or pilot). In other words, the information terminal 20 or information processing unit 40 operated by the main ship captain (or pilot) permits input of commands concerning the thrust forces.

[0068] FIG. 9A shows pushing points 36 set on the main ship 2, and FIG. 9 B shows towing points 37 set on the main ship 2. Those pushing points 36 on the main ship 2 with which the tugboats 3 contact when pushing the main ship 2 are predetermined as shown in FIG. 9A, and vary from ship to ship. Those towing points 37 on the main ship 2 to which tug lines are tied when the tugboats 3 tow the main ship 2 are predetermined as shown in FIG. 9B, and vary from ship to ship. Pulling/towing commands given to the tugboats 3 include the location of the pushing point 36 or towing point 37 relative to the hull of the main ship 2 and the direction and magnitude of the thrust force to be applied to the pushing point 36 or towing point 37. For easy command input, it is recommended that the command specifying the location of the pushing point 36 or towing point 37 be issued by selecting the pushing point 36 or towing point 37 from all the pushing points 36 or towing points 37 displayed on the display 441 of the information processing unit 40. It is recommended that the command specifying the magnitude and direction of the thrust force to be applied be received through the input interface 43 and displayed as a vector or numerical value on the display 441.

[0069] In the current state display region 98 of the ship maneuvering assistance screen S, information related to ship maneuvering instructions can be displayed. FIG. 10 shows a ship maneuvering assistance screen S3 on which information related to ship maneuvering instructions is displayed. The ship maneuvering assistance screen S3 is displayed on the display 441 upon execution of the display program 7 by the processor 411 of the computer 41 of the information processing unit 40. In the display item switching region 99 of the ship maneuvering assistance screen S3, a choice can be made between displaying and hiding the information related to ship maneuvering instructions in the current state display region 98. The information related to ship maneuvering instructions includes, for example, thrust forces, pushing points, towing points, and routes specified for the tugboats. In the current state display region 98 of the ship maneuvering assistance screen S3 illustrated in FIG. 10, the main ship graphic 2s representing the location and bearing of the main ship 2 and the tugboat graphics 3s representing the locations and bearings of

the tugboats 3 are displayed on the nautical chart image 60, and the information related to ship maneuvering instructions is further displayed on the nautical chart image.

[0070] In the case where the tugboat graphics 3s are displayed on the ship maneuvering assistance screen S3, each tugboat graphic 3s is displayed in association with the corresponding commanded thrust force vector 87 to make clear the combination of the tugboat graphic 3s and the commanded thrust force vector 87. Examples of the way of associating the tugboat graphic 3s and the commanded thrust force vector 87 include: differentiating the combination of the tugboat graphic 3s and the corresponding commanded thrust force vector 87 by color; labeling the commanded thrust force vector 87 with the name of the tugboat 3; and drawing a dashed line between the origin (point of action 86) of the commanded thrust force vector 87 and the tugboat graphic 3s. The terminal operated by the commander (pilot or main ship captain) permits input of thrust force commands on the ship maneuvering assistance screen S3, and the thrust forces to be applied to the main ship 2 by the tugboats 3 can be input as the commanded thrust force vectors 87.

[0071] In the current state display region 98 of the ship maneuvering assistance screen S, a captured image 82 obtained by the remote camera 34 can be displayed. Referring back to FIG. 6, once a monitor button is selected from the switching buttons arranged in the display item switching region 99 of the ship maneuvering assistance screen S, the computer 21 controls the display 241 to display a ship maneuvering assistance screen S2 including the display item switching region 99 provided with buttons for monitor selection.

[0072] FIG. 11 shows the ship maneuvering assistance screen S2 provided with the buttons for monitor selection. In the display item switching region 99 of the ship maneuvering assistance screen S2, buttons for choosing which captured image 82 to display in the current state display region 98 are displayed. In the display item switching region 99 of the ship maneuvering assistance screen S2 illustrated in FIG. 11, “ON” has been selected for the monitors of the three tugboats 3, TUG 1, TUG 2, and TUG 3. In the current state display region 98 of the ship maneuvering assistance screen S2, the captured images 82 (video images) are displayed in addition to the nautical chart image 60, main ship graphic 2s, and tugboat graphics 3s, and arranged next to one another so that the captured images 82 can be viewed collectively.

[0073] The captured images 82 are labeled with “TUG 1”, “TUG 2”, and “TUG 3”, respectively. Each label indicates identification information of the tugboat 3 equipped with the remote camera 34 capturing the image to which the label is attached. In this example, the remote camera 34 is located at the bow of each tugboat 3 to face forward, and the captured image 82 showing the environment in front of the tugboat 3 is displayed. The captured image 82 is

obtained by the remote camera 34 that is so mounted on the mast 39 located at the center of the tugboat 3 that the remote camera 34 is directed toward the environment in front of the tugboat 3 from a point above the tugboat 3. The current state display region 98 displaying the captured images 82 reveals that the tugboat 3 labeled with “TUG 1” is towing the bow of the main ship 2 connected to the tugboat 3 by a tug line, the tugboat 3 labeled with “TUG 2” is pushing a front lateral portion of the main ship 2, and the tugboat 3 labeled with “TUG 3” is pushing a rear lateral portion of the main ship 2. Thus, the pilot or main ship captain viewing the ship maneuvering assistance screen S2 can know, almost in real time, the situation of the environment lying in front of each tugboat 3 and viewed from a point above the tugboat 3. This allows the pilot or main ship captain to infer the situations of the tug operators and give instructions to the tug operators without pacing the bridge.

[0074] Although in the above example the captured images 82 are those obtained by the remote cameras 34 mounted on the tugboats 3, the captured images 82 may include a captured image 82 of the remote camera 34 mounted on the main ship 2 or placed at the quay.

[0075] In the current state display region 98 of the ship maneuvering assistance screen S, a course plan can be displayed. Referring back to FIG. 6, once a course plan button is selected from the switching buttons arranged in the display item switching region 99, the computer 21 controls the display 241 to display a ship maneuvering assistance screen S4 provided with a button for choosing between displaying and hiding the course plan.

[0076] FIG. 12 shows the ship maneuvering assistance screen S4 provided with a button for choosing between displaying and hiding the course plan. The display item switching region 99 of the ship maneuvering assistance screen S4 is provided with a button for choosing between displaying and hiding the course plan in the current state display region 98.

[0077] In the current state display region 98 of the ship maneuvering assistance screen S4 illustrated in FIG. 12, the velocity vector 69 representing the speed of the main ship 2 is displayed based on the course and speed over ground of the main ship 2. In the ship maneuvering assistance screen S4, the tugboat velocity vectors 96 representing the speeds of the tugboats 3 are also displayed based on the courses and speeds over ground of the tugboats 3.

[0078] In the current state display region 98 of the ship maneuvering assistance screen S4, a recommended course 84 of the main ship 2 is superimposed on the nautical chart image 60 based on the recommended course set by the course planning module. In this example, the recommended course 84 is presented as a dashed line extending from the current location of the main ship graphic 2s to the target berthing location. Waypoints 97 are displayed on the recommended course 84. In this example, the waypoints 97 are represented by ship-shaped

figures and circled numbers.

[0079] The current state display region 98 of the ship maneuvering assistance screen S4 is provided with a magnification change button 83 for zooming in and out. Once zooming in is selected at the magnification change button 83, the computer 41 receives the command to change the display magnification of the ship maneuvering assistance screen S4 and controls the display 241 to display a ship maneuvering assistance screen S5 which is a partially enlarged version of the ship maneuvering assistance screen S4. Once the main ship 2 comes close to a waypoint 97, the screen magnification may be automatically changed so that the details of the waypoint 97 are displayed. The persons involved who are viewing the ship maneuvering assistance screen S4 or S5 can know the entire course from entry of the main ship 2 into the harbor to the berthing of the main ship 2 and at the same time know the relation between the main ship 2 and the tugboats 3 at each waypoint 97. Although not described in detail, at least the current state display region 98 of the ship maneuvering assistance screen S permits the displayed image to be freely zoomed in or out in its entirety or in part.

[0080] FIG. 13 shows the ship maneuvering assistance screen S5 displaying a course plan. In the current state display region 98 of the ship maneuvering assistance screen S5, the third waypoint (circled number 3), fourth waypoint (circled number 4), and fifth waypoint (circled number 5) of the waypoints 97 are displayed. The fifth waypoint (circled number 5) corresponds to the target berthing location. The main ship graphic 2s is displayed at each waypoint 97, and the velocity vector 69 and rudder graphic 67 are superimposed on the main ship graphic 2s. At the fourth waypoint (circled number 4) and fifth waypoint (circled number 5), the tugboat graphics 3s representing the tugboats 3 assisting the main ship 2 are displayed.

[0081] The main ship 2 is navigated from the first waypoint (circled number 1) to the third waypoint (circled number 3) without assistance from the tugboats 3. During this navigation, the main ship 2 gains the thrust force from its own thrusters, and the thrusters are stopped once the main ship 2 reaches a give location between the first waypoint (circled number 1) and third waypoint (circled number 3), such as upon entry into the harbor. When the thrusters of the main ship 2 are in operation, the tugboats 3 need to be kept away from the main ship 2 to prevent contact between the main ship 2 and the tugboats 3. To this end, the information processing unit 40 and information terminals 20 can display, on the displays 241 and 441, a retreat instruction to the tugboat 3 at the risk of contacting the main ship 2.

[0082] FIG. 14 shows a ship maneuvering assistance screen S6 displaying the retreat instructions. The main ship graphic 2s, the tugboat graphics 3s, and an entry-prohibited area 93 are displayed in the current state display region 98 of the ship maneuvering assistance screen S6.

The entry-prohibited area 93 is predefined. The entry-prohibited area 93 may be defined by absolute coordinates or by relative coordinates with respect to the main ship 2. The entry-prohibited area 93 may be in any shape although the entry-prohibited area 93 is in the shape of a rectangle enclosing the main ship graphic 2s in the example shown in FIG. 14. It is recommended that the extent of the entry-prohibited area 93 be definable on the display 441 of the information processing unit 40.

[0083] In the current state display region 98 of the ship maneuvering assistance screen S6, warnings are displayed for the tugboats 3 located within the entry-prohibited area 93. In the example shown in FIG. 14, the tugboats 3 located within the entry-prohibited area 93 are indicated by a different color than the tugboat 3 located outside the entry-prohibited area 93 and are blinking. Additionally, word balloons containing the text “RETREAT NEEDED” are displayed. In this manner, the tugboats 3 that should retreat from the entry-prohibited area 93 are clearly indicated on the ship maneuvering assistance screen S6.

[0084] The persons involved can at their discretion operate the information processing unit 40 or information terminal 20 to display the ship maneuvering assistance screen S6 presenting the retreat instructions on the display 241 (and/or display 441). The information processing unit 40 monitors the locations of the main ship 2 and tugboats 3 in the portion of the course where the entry-prohibited area 93 is defined, and it is possible to force the information processing unit 40 and information terminals 20 to display the ship maneuvering assistance screen S6 presenting the retreat instructions upon entry of any tugboat 3 into the entry-prohibited area 93.

[0085] Referring back to FIG. 13, at the fourth waypoint (circled number 4), the tugboat 3 labeled with “TUG 1” moves to a location for pushing of the main ship 2, and the tugboat 3 labeled with “TUG 2” moves to a location for towing of the main ship 2 and is connected to the main ship 2 by a tug line. The information processing unit 40 and information terminals 20 can display, on the displays 241 and 441, a ship maneuvering assistance screen S7 presenting courses that the tugboats 3 should take when approaching the main ship 2.

[0086] FIG. 15 shows the ship maneuvering assistance screen S7 presenting a course that one of the tugboats 3 should take when approaching the main ship 2. The main ship graphic 2s representing the location and bearing of the main ship 2 and the tugboat graphic 3s representing the location and bearing of the tugboat 3 are displayed in the current state display region 98 of the ship maneuvering assistance screen S7. In the current state display region 98 of the ship maneuvering assistance screen S7, an arrival point 90 and at least one waypoint 89 in the approach of the tugboat 3 to the main ship 2 are further displayed. An approach course 88

leading from the tugboat graphic 3s to the arrival point 90 through the waypoints 89 can be planned by performing interpolation between the waypoints 89 and between the last waypoint 89 and the arrival point 90 using a suitable interpolation function. In the ship maneuvering assistance screen S7, the approach course 88 is indicated by a dashed line. By viewing the ship maneuvering assistance screen S7, the tug operator can maneuver the tugboat 3 so that the tugboat 3 is navigated along the approach course 88.

[0087] In the current state display region 98 of the ship maneuvering assistance screen S7, an actual course 88' of the tugboat 3 is superimposed on the approach course 88. The approach course 88 and actual course 88' are displayed in different manners. In this example, the approach course 88 is indicated by a dashed line, and the actual course 88' is indicated by a solid line. The difference between the approach course 88 and actual course 88' can be clearly known by comparing the courses 88 and 88'.

[0088] FIG. 16 shows a ship maneuvering assistance screen S8 presenting courses that the tugboats 3 should take when approaching the main ship 2. Upon an increase in the number of the tugboats 3 that approach the main ship 2, the approach course 88 is displayed for each of the increased number of the tugboats 3 in a manner as described above. In the case where one approach course 88 and another approach course 88 intersect each other or are so close to each other that the distance between the approach courses 88 is smaller than a given threshold, an attention-calling area 92 and a word balloon containing the text "BE AWARE OF CONTACT" are displayed on the ship maneuvering assistance screen S8.

[0089] The ship maneuvering assistance screen S7 or S8 is displayed on the display 241 upon execution of the display program 7 by the processor 211 of the information terminal 20. The information processing unit 40 monitors the locations of the main ship 2 and tugboats 3, and it is possible to force the information processing unit 40 and information terminals 20 to display the ship maneuvering assistance screen S7 or S8 just before the tugboats 3 begin to approach the main ship 2.

[0090] Referring back to FIG. 13, the main ship 2 is navigated from the fourth waypoint (circled number 4) to the fifth waypoint (circled number 5) in the harbor along the recommended course with assistance from the tugboats 3. At the fifth waypoint (circled number 5), the main ship 2 and the tugboat 3 labeled with "TUG 2" are disconnected, and the main ship 2 receives assistance only from the tugboat 3 labeled with "TUG 1". The thrust forces applied to the main ship 2 by the tugboats 3 may be displayed as the thrust force vectors on the ship maneuvering assistance screens S6, S7, and S8 when the main ship 2 is being pushed or towed by the tugboats 3.

[0091] As described above, a ship maneuvering assistance system 1 according to the present embodiment is used when a main ship 2 departs from or berths at a quay with assistance from at least one tugboat 3, and includes: a storage (memory 212, 412; storage 25, 45) storing a nautical chart image 60, a main ship graphic 2s, and a tugboat graphic 3s, the nautical chart image 60 including the quay; at least one detector (nautical instrument 32) that detects the locations and bearings of the main ship 2 and the tugboat 3; at least one display (241; 441); and a processor (211; 411) that controls the display (241; 441) to display a ship maneuvering assistance screen S. The processor (211; 411) executes a display program 7, thereby controlling the display (241; 441) to display the ship maneuvering assistance screen S based on ship maneuvering state data.

[0092] The ship maneuvering assistance screen S includes: the nautical chart image 60 stored in the storage and including the quay 61; a main ship graphic 2s placed on the nautical chart image 60 based on the location and bearing of the main ship 2 which have been detected by the detector; a tugboat graphic 3s placed on the nautical chart image 60 based on the location and bearing of the tugboat 3 which have been detected by the detector; and pieces of tugboat thruster information 68s placed on the tugboat graphic 3s and representing respectively the directions of thrust forces generated by tugboat thrusters 68 mounted on the tugboat 3. The pieces of tugboat thruster information 68s are placed on the ship maneuvering assistance screen S such that the locations of the pieces of the tugboat thruster information 68s relative to the tugboat graphic 3s correspond to the locations of the tugboat thrusters 68 relative to the tugboat 3.

[0093] A ship maneuvering assistance method according to the present embodiment includes controlling at least one display (241; 441) by a processor (211; 411) to display a ship maneuvering assistance screen S when a main ship 2 departs from or berths at a quay with assistance from at least one tugboat 3, the processor (211; 411) being included in an information terminal (20; 40) configured to assist maneuvering of the main ship 2 and the tugboat 3. The ship maneuvering assistance screen S includes: a nautical chart image 60 including the quay; a main ship graphic 2s placed on the nautical chart image 60 based on the location and bearing of the main ship 2; a tugboat graphic 3s placed on the nautical chart image 60 based on the location and bearing of the tugboat 3; and pieces of tugboat thruster information 68s placed on the tugboat graphic 3s and representing respectively the directions of thrust forces generated by tugboat thrusters 68 mounted on the tugboat 3. The pieces of tugboat thruster information 68s are placed on a current state display region 98 such that the locations of the pieces of the tugboat thruster information 68s relative to the tugboat graphic 3s correspond to the locations of the tugboat thrusters 68 relative to the tugboat 3.

[0094] In the ship maneuvering assistance system 1 and method as described above, the

positional relation between the main ship 2 and tugboat 3 is indicated by the main ship graphic 2s and tugboat graphic 3s presented on the nautical chart image 60 displayed on the display 241 or 441, and the respective current states of the thrusters mounted on the tugboat 3 (e.g., the operation states of the thrusters and the directions of the generated thrust forces) are indicated by the pieces of tugboat thruster information 68s. In this manner, one and the same screen displayed on the display 241 or 441 graphically presents both information indicating the positional relation between the main ship 2 and tugboat 3 and information indicating the respective current states of the thrusters of the tugboat 3. Thus, the persons involved who are viewing this screen can intuitively know the interrelation among the main ship 2, the tugboat 3, and the thrusters. The respective current states of the thrusters mounted on the tugboat 3 are important information for estimating the thrust force acting on the tugboat 3. Intuitive and easy acquisition of this information by the persons involved leads to smooth and efficient ship maneuvering for departure and berthing.

[0095] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S includes a main ship rudder graphic 67 placed on the main ship graphic 2s and representing a rudder angle of a rudder mounted on the main ship 2.

[0096] Since the rudder graphic 67 is presented on the ship maneuvering assistance screen S in addition to the afore-mentioned elements, the persons involved who are viewing the screen can intuitively know the direction of the rudder of the main ship 2.

[0097] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S further includes a velocity vector 69 placed on the nautical chart image 60 and representing the moving direction and speed of the main ship 2.

[0098] Since the velocity vector 69 is graphically presented, the persons involved can intuitively know the moving direction and speed of the main ship 2. The speed is important information for determining the thrust force to be applied to the main ship 2 from the tugboat 3. Intuitive and easy acquisition of this information by the persons involved leads to smooth and efficient ship maneuvering for departure and berthing.

[0099] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S further includes: a main ship thrust force vector 65a (and/or a main ship commanded thrust force vector 65b) representing the direction and magnitude of a thrust force acting on the main ship 2; and a tugboat thrust force vector 66a (and/or a tugboat commanded thrust force vector 66b) representing the direction and magnitude of a thrust force acting on the tugboat 3.

[0100] Since the thrust force acting on the main ship 2 and the thrust force acting on the

tugboat 3 are indicated together on one and the same screen, the persons involved can know the thrust forces acting on the related entities collectively.

[0101] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S further includes a quay type graphic 62 representing the type of the quay 61.

[0102] The type of the quay 61 is difficult to intuitively know from the nautical chart. Since the type of the quay 61 is graphically presented as the quay type graphic 62, the persons involved can intuitively know the type of the quay 61.

[0103] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S further includes a connection instruction text 73a that appears upon arrival of the main ship 2 and the tugboat 3 at a connection location to give an instruction to connect the tugboat 3 and the main ship 2 by a tug line. In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S further includes a disconnection instruction text 73b that appears upon arrival of the main ship 2 and the tugboat 3 at a disconnection location to give an instruction to disconnect the tugboat 3 and the main ship 2 by untying the tug line.

[0104] Thus, all of the persons involved who are viewing the displays 241 and 441 can share an understanding of when to tie or untie the tug line. This leads to smooth and efficient ship maneuvering for departure and berthing.

[0105] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S further includes a channel designation text 71 representing a VHF channel.

[0106] The channel used for transceivers is usually set before ship maneuvering for departure or berthing. During the ship maneuvering, the communication between the transceivers is sometimes disrupted due to interference or radio disturbance. In such a case, the channel to be used is presented through a stable communication route, and this allows the persons involved to smoothly switch the channel used for the transceivers.

[0107] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S (S7, S8) includes a planned course of the tugboat 3, the planned course being superimposed on the nautical chart image 60 and representing a course that the tugboat 3 should take when approaching the main ship 2 (that is, the planned course is an approach course 88).

[0108] Since the planned course (approach course 88) that the tugboat 3 should take when approaching the main ship 2 is presented to the persons involved, all of the persons involved who

are viewing the displays 241 and 441 can share an understanding of the approach course 88 of the tugboat 3. This leads to smooth and efficient ship maneuvering for departure and berthing.

[0109] In the ship maneuvering assistance system 1 according to the present embodiment, the ship maneuvering assistance screen S (S8) further includes an actual course 88' of the tugboat 3, the actual course 88' being superimposed on the planned course (i.e., approach course 88).

[0110] Since the planned course 88 and actual course 88' of the tugboat 3 are presented on one and the same screen, the persons involved can easily know deviation of the actual course 88' from the planned course 88.

[0111] In the present embodiment, a plurality of the tugboats 3 are employed, and the ship maneuvering assistance system 1 further includes cameras 34 mounted on the tugboats 3 to capture images of environments in front of the tugboats 3. The ship maneuvering assistance screen S (S2) includes at least one captured image 82 obtained by any of the cameras 34.

[0112] Thus, the pilot or main ship captain viewing the captured image 82 displayed on the ship maneuvering assistance screen S (S2) can know the situation of the environment lying in front of the tugboat 3 almost in real time. This allows the pilot or main ship captain to infer the state of the tugboat 3 and give instructions to the tug operator without pacing the bridge.

[0113] Although the foregoing has described a preferred embodiment of the present invention, the scope of the present invention embraces modifications made to the details of the structure and/or function of the above embodiment without departing from the gist of the present invention.

[0114] For example, although the information processing unit 40 is disposed on the main ship 2 or the land in the above embodiment, the information processing unit 40 may be configured as a mobile information terminal to be carried by the pilot or main ship captain like the information terminal 20.

Reference Signs List

- [0115] 1: ship maneuvering assistance system
 2: main ship
 2s: main ship graphic
 3: tugboat
 3s: tugboat graphic
 20: information terminal
 32: nautical instruments (example of the detector as recited in the appended claims)

34: remote camera
37: thruster
60: nautical chart image
61: quay
62: quay type graphic
65a: main ship thrust force vector
65b: main ship commanded thrust force vector
66a: tugboat thrust force vector
66b: tugboat commanded thrust force vector
68: tugboat thruster information
69: velocity vector
70: main ship thruster graphic
71: channel designation text
73: connection instruction text
73a: connection instruction text
73b: disconnection instruction text
88: approach course (planned course)
88': actual course
21: computer
211: processor
212: memory (example of the storage as recited in the appended claims)
241: display
25: storage (example of the storage as recited in the appended claims)
41: computer
411: processor
412: memory (example of the storage as recited in the appended claims)
441: display
45: storage (example of the storage as recited in the appended claims)
98: current state display region
99: display item switching region
S: ship maneuvering assistance screen

CLAIMS

1. A ship maneuvering assistance system used when a main ship departs from or berths at a quay with assistance from at least one tugboat, the system comprising:
 - a storage storing a nautical chart image, a main ship graphic, and a tugboat graphic, the nautical chart image including the quay;
 - at least one detector that detects locations and bearings of the main ship and the tugboat;
 - at least one display; and
 - a processor that controls the display to display a ship maneuvering assistance screen, wherein
 - the ship maneuvering assistance screen includes: the nautical chart image; the main ship graphic placed on the nautical chart image based on the location and bearing of the main ship which have been detected by the detector; the tugboat graphic placed on the nautical chart image based on the location and bearing of the tugboat which have been detected by the detector; and pieces of tugboat thruster information placed on the tugboat graphic and representing respectively directions of thrust forces generated by tugboat thrusters mounted on the tugboat.
2. The ship maneuvering assistance system according to claim 1, wherein the pieces of tugboat thruster information are placed on the screen such that locations of the pieces of tugboat thruster information relative to the tugboat graphic correspond to locations of the tugboat thrusters relative to the tugboat.
3. The ship maneuvering assistance system according to claim 1 or 2, wherein the ship maneuvering assistance screen includes a main ship rudder graphic placed on the main ship graphic and representing a rudder angle of a rudder mounted on the main ship.
4. The ship maneuvering assistance system according to any one of claims 1 to 3, wherein the ship maneuvering assistance screen further includes a velocity vector placed on the nautical chart image and representing a moving direction and a speed of the main ship.
5. The ship maneuvering assistance system according to any one of claims 1 to 4, wherein the ship maneuvering assistance screen further includes: a main ship thrust force vector representing a direction and a magnitude of a thrust force acting on the main ship; and a tugboat thrust force vector representing a direction and a magnitude of a thrust force acting on the

tugboat.

6. The ship maneuvering assistance system according to any one of claims 1 to 5, wherein the ship maneuvering assistance screen further includes a quay type graphic representing a type of the quay.

7. The ship maneuvering assistance system according to any one of claims 1 to 6, wherein the ship maneuvering assistance screen further includes a connection instruction text that appears upon arrival of the main ship and the tugboat at a predetermined connection location to give an instruction to connect the tugboat and the main ship by a tug line.

8. The ship maneuvering assistance system according to claim 7, wherein the ship maneuvering assistance screen further includes a disconnection instruction text that appears upon arrival of the main ship and the tugboat at a predetermined disconnection location to give an instruction to disconnect the tugboat and the main ship by untying the tug line.

9. The ship maneuvering assistance system according to any one of claims 1 to 6, wherein the ship maneuvering assistance screen further includes a channel designation text representing a VHF channel used for transceivers.

10. The ship maneuvering assistance system according to claim 1, wherein the ship maneuvering assistance screen further includes a planned course of the tugboat, the planned course being superimposed on the nautical chart image and representing a course that the tugboat should take when approaching the main ship.

11. The ship maneuvering assistance system according to claim 10, wherein the ship maneuvering assistance screen further includes an actual course of the tugboat, the actual course being superimposed on the planned course.

12. The ship maneuvering assistance system according to claim 1, further comprising cameras mounted on the tugboats to capture images of environments in front of the tugboats, wherein

the ship maneuvering assistance screen includes at least one captured image obtained by any of the cameras.

13. A ship maneuvering assistance method comprising:

controlling at least one display by a processor to display a ship maneuvering assistance screen when a main ship departs from or berths at a quay with assistance from at least one tugboat, the processor being included in an information terminal configured to assist maneuvering of the main ship and the tugboat, wherein

the ship maneuvering assistance screen includes: a nautical chart image including the quay; a main ship graphic placed on the nautical chart image in accordance with a location and a bearing of the main ship; a tugboat graphic placed on the nautical chart image in accordance with a location and a bearing of the tugboat; and pieces of tugboat thruster information placed on the tugboat graphic and representing respectively directions of thrust forces generated by tugboat thrusters mounted on the tugboat.