

SPECIFICATION

TITLE OF INVENTION:

DATA PROCESSING APPARATUS FOR ESTIMATING TIME AND FUEL CONSUMPTION AMOUNT REQUIRED FOR NAVIGATION OF SHIP, PROGRAM, AND STORAGE MEDIUM

TECHNICAL FIELD

[0001] The present invention relates to technology for estimating the time and the fuel consumption amount that are required for the navigation of a ship.

BACKGROUND ART

[0002] When navigating a ship, the time required for navigation is an important factor in determining whether or not a destination port can be reached by an estimated time of arrival that has been set. The fuel consumption amount required for navigation is also an important factor that greatly influences the cost required for navigation. If the navigation speed is raised in order to cut down the time required for navigation, the fuel consumption amount required for navigation generally increases.

[0003] The time and the fuel consumption amount that are required for ship navigation are influenced by individual ship performance, the weight of cargo during navigation, and the like, as well as the weather/maritime environment encountered during ship navigation. A combination of wind direction, wind speed, wave direction, wave height, wave period, current direction, current speed, and the like makes up the weather/maritime environment that influences the time and the fuel consumption amount that are required for ship navigation.

[0004] Technology has been proposed for giving consideration to the

weather/maritime environment that will be encountered during ship navigation when searching for an optimum ship route in view of the time and the fuel consumption amount that are required for navigation. For example, Patent Document 1 proposes a system for calculating an optimum ship route in a target sea area with use of weather/maritime forecast data for the target sea area. In addition to using forecast data, the system described in Patent Document 1 calculates an optimum ship route with use of measurement data that indicates weather/maritime conditions measured by various ships that are navigating the target sea area.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0005] Patent Document 1: JP 2014-013145A

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] As mentioned above, the time and the fuel consumption amount that are required for the navigation of a ship are influenced by the weather/maritime environment that will be encountered by the ship during navigation. However, future weather/maritime conditions cannot be predicted accurately. Also, the farther the time of the predicted weather/maritime conditions is from the current time, the lower the precision of the prediction is. Accordingly, it has not been possible to accurately estimate the time and the fuel consumption amount that are required for the navigation of a ship.

[0007] In addition to using weather/maritime forecast data, the system described in Patent Literature 1 also uses measurement data indicating weather/maritime conditions that have actually been measured by ships

navigating the target sea area at the current time, thus predicting future weather/maritime conditions with higher precision than in the case of only using prediction data. However, the measurement data indicates current weather/maritime conditions, not future weather/maritime conditions. The system described in Patent Literature 1 therefore cannot solve the aforementioned problem that the farther the time of the predicted weather/maritime conditions is from the current time, the lower the precision of the prediction is.

[0008] In light of the foregoing situation, the present invention provides a means for making it possible to reasonably estimate the time and the fuel consumption amount that are required for the navigation of a ship, which are factors influenced by weather/maritime conditions that are difficult to predict.

MEANS FOR SOLVING THE PROBLEM

[0009] In order to solve the aforementioned problem, the present invention provides, as a first aspect, a data processing apparatus including: a performance data acquisition unit that acquires performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment; a weather/maritime condition data acquisition unit that acquires weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period; a variable data acquisition unit that acquires variable data that indicates a designated value related to the first variable in a case where the ship navigates a ship route that passes through the one or more sea areas; a calculation unit that, with use of the performance data and the

weather/maritime condition data, for each of a plurality of past times, calculates a value that indicates one of a value related to the second variable and a fuel consumption amount required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data acquired by the variable data acquisition unit; and a statistical processing unit that performs statistical processing on the values calculated by the calculation unit for the plurality of past times.

[0010] As a second aspect, a configuration may be employed in which, in the data processing apparatus according to the first aspect, the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit for the plurality of past times.

[0011] As a third aspect, a configuration may be employed in which the data processing apparatus according to the second aspect further includes a fuel consumption amount specification unit that, with use of the probability distribution estimated by the statistical processing unit, specifies a fuel consumption amount that is sufficient, with a predetermined probability, in order for the ship to navigate the ship route at a navigation speed that corresponds to the value indicated by the variable data acquired by the variable data acquisition unit.

[0012] Also, the present invention provides, as a fourth aspect, a data processing apparatus including: a performance data acquisition unit that acquires performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment; a weather/maritime condition data acquisition unit that acquires weather/maritime condition data that, for

each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period; a variable data acquisition unit that acquires variable data that indicates a designated value related to the second variable in a case where the ship navigates a ship route that passes through the one or more sea areas; a calculation unit that, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, calculates a value that indicates one of a value related to the first variable and a time required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data acquired by the variable data acquisition unit; and a statistical processing unit that performs statistical processing on the values calculated by the calculation unit for the plurality of past times.

[0013] As a fifth aspect, a configuration may be employed in which, in the data processing apparatus according to the fourth aspect, the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit for the plurality of past times.

[0014] As a sixth aspect, a configuration may be employed in which the data processing apparatus according to the fifth aspect further includes a time specification unit that, with use of the probability distribution estimated by the statistical processing unit, specifies a time that is required in order for the ship to completely navigate the ship route with a predetermined probability.

[0015] As a seventh aspect, a configuration may be employed in which, in the data processing apparatus according to the sixth aspect, the variable data acquisition unit acquires a plurality of pieces of the variable data, the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation

unit, for each of the plurality of pieces of the variable data, and the time specification unit specifies a second variable according to which the ship completely navigates the ship route within a predetermined time with a predetermined probability, with use of the probability distributions estimated by the statistical processing unit for the plurality of pieces of the variable data.

[0016] As an eighth aspect, a configuration may be employed in which the data processing apparatus according to the fifth aspect further includes a probability specification unit that, with use of the probability distribution estimated by the statistical processing unit, specifies a probability that the ship completely navigates the ship route within a predetermined time.

[0017] As a ninth aspect, a configuration may be employed in which, in the data processing apparatus according to the eighth aspect, the variable data acquisition unit acquires a plurality of pieces of the variable data, the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit, for each of the plurality of pieces of the variable data, and the probability specification unit specifies a second variable according to which the ship completely navigates the ship route within a predetermined time with a predetermined probability, with use of the probability distributions estimated by the statistical processing unit for the plurality of pieces of the variable data.

[0018] As a tenth aspect, a configuration may be employed in which the data processing apparatus according to any of the first to ninth aspects further includes a loading amount data acquisition unit that acquires loading amount data that indicates a loading amount in navigation of the ship along the ship route, wherein for each of a plurality of the loading amounts, the performance data acquisition unit acquires the

performance data that indicates a relationship between the first variable and the second variable in a case where the ship navigates while carrying cargo corresponding to the loading amount, and the calculation unit performs the calculation with use of the performance data regarding the loading amount indicated by the loading amount data.

[0019] Also, the present invention provides, as an eleventh aspect, a program for causing a computer to execute processing of: acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment; acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period; acquiring variable data that indicates a designated value related to the first variable in a case where the ship navigates a ship route that passes through the one or more sea areas; calculating, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the second variable and a fuel consumption amount required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and calculating a statistical value of the values that are related to the second variable or the fuel consumption amount and were calculated for the plurality of past times.

[0020] Also, the present invention provides, as a twelfth aspect, a computer-readable storage medium permanently storing a program for causing a computer to perform processing of: acquiring performance data that, for each of a plurality of weather/maritime environments,

indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment; acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period; acquiring variable data that indicates a designated value related to the first variable in a case where the ship navigates a ship route that passes through the one or more sea areas; calculating, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the second variable and a fuel consumption amount required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and calculating a statistical value of the values that are related to the second variable or the fuel consumption amount and were calculated for the plurality of past times.

[0021] Also, the present invention provides, as a thirteenth aspect, a program for causing a computer to execute processing of: acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment; acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period; acquiring variable data that indicates a designated value related to the second variable in a case where the ship navigates a ship route that passes through the one or more sea areas; calculating, with use of the performance data and the

weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the first variable and a time required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and calculating a statistical value of the values that are related to the first variable or the time and were calculated for the plurality of past times.

[0022] Also, the present invention provides, as a fourteenth aspect, a computer-readable storage medium permanently storing a program for causing a computer to perform processing of: acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment; acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period; acquiring variable data that indicates a designated value related to the second variable in a case where the ship navigates a ship route that passes through the one or more sea areas; calculating, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the first variable and a time required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and calculating a statistical value of the values that are related to the first variable or the time and were calculated for the plurality of past times.

EFFECTS OF THE INVENTION

[0023] According to the present invention, past weather/maritime conditions in sea areas that are to be navigated by a ship are used to calculate a statistical value of the navigation speed and the time or the fuel consumption per unit time and the fuel consumption amount that are required for navigation in consideration of the influence of weather/maritime conditions on navigation when the ship navigates the sea areas. Accordingly, with use of the statistical value calculated according to the present invention, it is possible to perform a reasonable estimation of the time and the fuel consumption amount that are required for the navigation of the ship, which are influenced by weather/maritime conditions that are difficult to predict.

BRIEF EXPLANATION OF THE DRAWINGS

[0024] [FIG. 1] A diagram showing a configuration of a system according to an embodiment.

[FIG. 2] A diagram showing a configuration of a computer used as hardware of a terminal apparatus according to an embodiment.

[FIG. 3] A diagram showing a configuration of a computer 20 used as hardware of a server apparatus according to an embodiment.

[FIG. 4] A diagram showing a function configuration of the terminal apparatus according to an embodiment.

[FIG. 5] A diagram showing a configuration of a performance data group used by the terminal apparatus according to an embodiment.

[FIG. 6] A group of graph lines that indicate relationships between navigation speed and fuel consumption per unit time indicated by performance data according to an embodiment.

[FIG. 7] A diagram showing a configuration of a ship route table used by the terminal apparatus according to an embodiment.

[FIG. 8] A diagram showing a configuration of a group of

weather/maritime condition tables used by the terminal apparatus according to an embodiment.

[FIG. 9] A diagram showing a screen displayed by the terminal apparatus according to an embodiment.

[FIG. 10] A diagram showing a configuration of an operation table used by the terminal apparatus according to an embodiment.

[FIG. 11] A diagram showing a configuration of a sample table used by the terminal apparatus according to an embodiment.

[FIG. 12A] A diagram showing a flow of processing performed by the terminal apparatus according to an embodiment.

[FIG. 12B] A diagram showing a flow of processing performed by the terminal apparatus according to an embodiment.

[FIG. 13] A diagram showing a screen displayed by the terminal apparatus according to an embodiment.

[FIG. 14] A diagram showing a screen displayed by the terminal apparatus according to an embodiment.

[FIG. 15] A diagram showing a screen displayed by the terminal apparatus according to a variation.

[FIG. 16] A diagram showing a configuration of a navigation speed table used by the terminal apparatus according to a variation.

[FIG. 17] A diagram showing a configuration of a fuel consumption table used by the terminal apparatus according to a variation.

[FIG. 18] A diagram showing a screen displayed by the terminal apparatus according to a variation.

[FIG. 19] A diagram showing a screen displayed by the terminal apparatus according to a variation.

[FIG. 20] A diagram showing a flow of processing performed by the terminal apparatus according to a variation.

[FIG. 21] A diagram showing a screen displayed by the terminal

apparatus according to a variation.

[FIG. 22] A diagram showing a flow of processing performed by the terminal apparatus according to a variation.

[FIG. 23] A diagram showing a screen displayed by the terminal apparatus according to a variation.

MODES FOR CARRYING OUT THE INVENTION

[0025] [Exemplary embodiment]

The following describes system 1 according to an embodiment of the present invention. System 1 is a system that provides a user with information regarding the time and the fuel consumption amount that are required for ship navigation. System 1 estimates, based on past weather/maritime conditions, the time and the fuel consumption amount that are required for a ship to navigate according to a designated ship route, and presents the estimated time and fuel consumption amount to the user. Processing that is performed in system 1 to estimate the time and the fuel consumption amount that are required for navigation will hereinafter be called “estimation processing”.

[0026] FIG. 1 is a diagram showing a configuration of system 1. System 1 includes terminal apparatus 11 and server apparatus 12 that can perform data communication via network 9. Note that although only one terminal apparatus 11 is shown in FIG. 1, the number of terminal apparatuses 11 changes according to the number of users of system 1.

[0027] The hardware of terminal apparatus 11 is a general computer for use as a terminal apparatus, for example. FIG. 2 is a diagram showing a configuration of computer 10 that is used as hardware of terminal apparatus 11. Computer 10 includes memory 101 for storing various types of data, processor 102 for performing various types of data processing in accordance with programs stored in memory 101,

communication IF 103 that is an IF (interface) for data communication performed with an external apparatus, display apparatus 104 that is a liquid crystal display or the like for displaying images to a user, and operation apparatus 105 that is a keyboard or the like for receiving user operations. Note that an external display apparatus that is connected to computer 10 may be used instead of, or in addition to, display apparatus 104 that is built into computer 10. Also, an external operation apparatus that is connected to computer 10 may be used instead of, or in addition to, operation apparatus 105 that is built into computer 10.

[0028] The hardware of server apparatus 12 is a general computer for use as a server apparatus, for example. FIG. 3 is a diagram showing a configuration of computer 20 that is used as hardware of server apparatus 12. Computer 20 includes memory 201 for storing various types of data, processor 202 for performing various types of data processing in accordance with programs stored in memory 201, and communication IF 203 for data communication performed with an external apparatus.

[0029] FIG. 4 is a diagram showing a function configuration of terminal apparatus 11. Computer 10, which constitutes the hardware of terminal apparatus 11, operates as an apparatus that includes configuration units shown in FIG. 4 by executing data processing in accordance with a program for terminal apparatus 11. The configuration units of terminal apparatus 11 shown in FIG. 4 will be described hereinafter.

[0030] Acquisition unit 111 acquires data that has been transmitted from an external apparatus such as server apparatus 12, and data input by a user. In the case of acquiring data that has been transmitted from an external apparatus, acquisition unit 111 is realized by communication IF 203. Also, in the case of acquiring data input from a user, acquisition unit

111 is realized by operation apparatus 105.

[0031] Storage unit 112 stores data acquired by acquisition unit 111. Storage unit 112 is realized by memory 101.

[0032] Storage unit 112 stores a performance data group that includes performance data indicating the performances of respective ships, a ship route table that includes ship route data indicating ship routes, and a weather/maritime condition table group that includes weather/maritime condition data indicating past weather/maritime conditions in respective sea areas.

[0033] FIG. 5 is a diagram showing a configuration of the performance data group. The performance data group is a group of performance data regarding respective ships. The performance data is data indicating a relationship between navigation speed and fuel consumption per unit time when a ship navigates. The relationship between navigation speed and fuel consumption per unit time during ship navigation changes according to the loading amount of the ship (in the present embodiment, the loading amount is indicated by a percentage (%) of the maximum loading amount) and the weather/maritime conditions encountered during ship navigation. Accordingly, for each ship, performance data is prepared for various loading amounts, and performance data is prepared for various weather/maritime conditions.

[0034] FIG. 6 shows a group of graph lines that indicate relationships between navigation speed and fuel consumption per unit time indicated by performance data regarding a certain loading amount for a certain ship. The horizontal axis of the graph in FIG. 6 indicates the navigation speed (knot), and the vertical axis indicates the fuel consumption per unit time (ton/day).

[0035] FIG. 6 includes nine graph lines respectively corresponding to Beaufort (BF) numbers 0 to 8. Beaufort scale is originally a scale of

wind force, but in the present embodiment, is used as an indicator of the calmness of the weather/maritime environment that is influencing the navigation of a ship, and the smaller the value is, the calmer the weather/maritime environment is. For example, Beaufort number 1 is indicated by a combination of weather/maritime parameters such as a wind speed of 1.0 m/s, a wave height of 0.1 m, and a wave period of 1.2 sec. Note that for all Beaufort numbers, the wind direction, the wave direction, and the like are envisioned to be directions from head-on with respect to the forward direction of the ship. In other words, the nine graph lines included in FIG. 6 indicate the relationship between navigation speed and fuel consumption per unit time in cases where a ship is navigating in representative weather/maritime environments.

[0036] Note that although FIG. 6 shows the relationship between navigation speed and fuel consumption per unit time under nine weather environments corresponding to Beaufort numbers 0 to 8, the actual performance data indicates the relationship between navigation speed and fuel consumption per unit time under more various weather environments (e.g., various combinations of wind speed, wind direction, wave height, wave direction, wave period, and the like).

[0037] FIG. 7 is a diagram showing the configuration of a ship route table. The ship route table is a group of data records regarding respective ship routes (ship route data). The ship route table has “route name”, “port name”, “berthing period”, “sea area name”, and “distance” as data fields. The data field “route name” stores route names that identify ship routes. The data field “port name” stores data indicating the names of ports along the corresponding ship route (including the departure port and the destination port), and this data is stored in order along the ship route. The data field “berthing period” stores data indicating the berthing period at the corresponding port. The data field “sea area name” stores

data indicating the names of sea regions along the ship route in navigation sections from corresponding ports to subsequent ports along the ship route, and this data is stored in order along the ship route. The data field “distance” stores data indicating distances travelled in corresponding sea areas along the ship route.

[0038] The performance data group and the ship route table are data that is directly input to terminal apparatus 11 by a user, for example. Note that the method by which terminal apparatus 11 acquires the performance data group and the ship route table is not limited to input by a user. For example, a configuration is possible in which the performance data group and the ship route table are generated in an apparatus that is not shown in FIG. 1, and terminal apparatus 11 receives the performance data group and the ship route table from that apparatus.

[0039] FIG. 8 is a diagram showing the configuration of a weather/maritime condition table group. The weather/maritime condition table group is a group of weather/maritime condition tables that respectively correspond to sea areas. Each weather/maritime condition table is a group of data records that respectively correspond to time periods of a predetermined duration. Each weather/maritime condition table has “time period” and “weather/maritime condition” data fields. The data field “time period” stores data indicating the time period. The data field “weather/maritime condition” includes “wind direction”, “wind speed”, “wave direction”, “wave height”, “wave period”, “current direction”, and “current speed” sub fields. These sub fields store data indicating the wind direction, wind speed, and the like (the weather/maritime condition parameters that correspond to the names of the sub fields) in the past time period indicated by the data field “time period”, for the corresponding sea area in the weather/maritime condition table.

- [0040] The data stored in the weather/maritime condition table group is data that terminal apparatus 11 has received from server apparatus 12. Server apparatus 12 accumulates new weather/maritime condition data as time passes. For example, each time a predetermined time period elapses, terminal apparatus 11 receives previously unreceived weather/maritime condition data from server apparatus 12 and adds the received data to the weather/maritime condition table group.
- [0041] The description of the configuration of terminal apparatus 11 will continue with reference to FIG. 4. Acquisition unit 111 has performance data acquisition unit 1111 that acquires the performance data group, ship route data acquisition unit 1112 that acquires a ship route table, and weather/maritime condition data acquisition unit 1113 that acquires weather/maritime condition data to be stored in the weather/maritime condition table group.
- [0042] Further, acquisition unit 111 has variable data acquisition unit 1114 for acquiring variable data that indicates a navigation speed and a fuel consumption per unit time that a user inputs to terminal apparatus 11 in a later-described setting screen, and loading amount data acquisition unit 1115 for acquiring loading amount data that indicates a loading amount that the user inputs to terminal apparatus 11 in the setting screen.
- [0043] Note that the data acquired by acquisition unit 111 is not limited to data acquired by performance data acquisition unit 1111 to loading amount data acquisition unit 1115. For example, acquisition unit 111 acquires various types of data, such as data indicating a departure time that is used in estimation processing.
- [0044] Display unit 113 displays various types of information to the user. Display unit 113 is realized by display apparatus 104 that operates under control of processor 102. FIG. 9 is a diagram showing a setting

screen that is displayed by display unit 113. The setting screen is a screen in which the user sets various parameters that are to be used in estimation processing.

[0045] Area A1 in the setting screen displays an input field for a ship name. When the user clicks the button on the right side of the input field in area A1, a list of ship name options is displayed in the setting screen. The ship names that are displayed in the list are ship names that respectively correspond to the performance data included in the performance data group (see FIG. 5). The user can easily input a ship name to the input field by selecting a desired ship name from the list.

[0046] Area A2 of the setting screen displays a radio button for selecting either a “constant navigation speed mode” or a “constant fuel consumption amount mode”, and input fields for variables corresponding to the modes. The constant navigation speed mode is a navigation method in which the ship navigates so as to maintain a constant navigation speed. The constant fuel consumption amount mode is a navigation method in which the ship navigates so as to maintain a constant fuel consumption per unit time.

[0047] In the case of selecting the radio button that corresponds to the constant navigation speed mode in area A2, the user can then enter a navigation speed to the navigation speed input field. Also, in the case of selecting the radio button that corresponds to the constant fuel consumption amount mode in area A2, the user can enter a fuel consumption per unit time to the fuel consumption per unit time input field. Note that the data input to the input fields in area A2 is variable data that is acquired by variable data acquisition unit 114.

[0048] Area A3 in the setting screen displays a route name input field and a world map. When the user clicks the button on the right side of the input field in area A3, a list of route name options is displayed in the

setting screen. The route names that are displayed in the list are route names that respectively correspond to the data records included in the ship route table (see FIG. 7). The user can easily input a route name to the input field by selecting a desired route name from the list. When a route name is input by the user, the route that corresponds to the input route name is displayed on the world map in area A3.

[0049] Area A4 of the setting screen displays an input field for the name of a departure port, an input field for a departure time (the time of departure from the departure port), an input field for the name of a destination port, and an input field for an arrival time (the time of arrival at the destination port). When the user clicks the button on the right side of the input field for the departure port or the destination port, a list of port name options is displayed in the setting screen. The port names that are displayed in the list are the names of portions along the ship route indicated by the ship route data (see FIG. 7) that corresponds to the route name that was input in area A3. The user can easily input a port name to the input field by selecting a desired port name from the list.

[0050] In the case where the constant navigation speed mode has been selected in area A2, if a navigation speed is input to the navigation speed input field in area A2, an arrival time is automatically input to the arrival time input field in area A4. When a navigation speed is input to the navigation speed input field in area A2, first, terminal apparatus 11 obtains the length of the section between the ports that correspond to the port names (hereinafter, this section being called the “designated section”) that were input to the input fields for the departure port and the destination port in area A4, based on the distances between ports along the ship route that are indicated by the ship route data (see FIG. 7) that corresponds to the route name that was input in area A3, and divides the obtained length by the navigation speed that was input to the

navigation speed input field in area A2, thus calculating the time required to navigate the designated section. Next, terminal apparatus 11 obtains the sum of the navigation times in the designated sections and the berthing periods at the ports along the designated section indicated by the ship route data, and specifies, as the arrival time, the time corresponding to the elapse of the sum time from the time that was input to the departure time input field in area A4. Terminal apparatus 11 then displays the thus specified arrival time in the arrival time input field in area A4.

[0051] Also, in the case where the constant navigation speed mode has been selected in area A2, if an arrival time is input to the arrival time input field in area A4, a navigation speed is automatically input to the navigation speed input field in area A2. When an arrival time is input to the arrival time input field in area A4, first, terminal apparatus 11 calculates, as a total required time, the length of time from the time that was input to the arrival time input field in area A4 to the time that was input to the departure time input field in area A4. Next, terminal apparatus 11 obtains the sum of the berthing periods at the ports along the designated section, which are indicated by the ship route data (see FIG. 7) that corresponds to the route name that was input in area A3, and subtracts the sum berthing period from the total required time, thus calculating the navigation time in the designated section. Next, terminal apparatus 11 divides the length of the designated section indicated by the ship route data by the navigation time in the designated section, thus calculating a navigation speed. Terminal apparatus 11 then displays the thus calculated navigation speed in the navigation speed input field in area A2.

[0052] Area A5 in the setting screen displays checkboxes for designating past time periods. The time periods designated in area A5 indicate

ranges of virtual departure times that can be used for calculating a sample (described later) of the time required for navigation or the fuel consumption amount in estimation processing. Hereinafter, the departure time that was input to the departure time input field in area A4 will be called the “designated departure time”, and a virtual departure time that is set for calculating a sample in a time period that was designated in area A5 will be called the “virtual departure time”.

[0053] Area A6 in the setting screen displays an input field for a loading amount. The user can enter a loading amount to the input field in area A6. Note that the data input to the input field in area A6 is loading amount data that is acquired by loading amount data acquisition unit 1115.

[0054] After completing the input of necessary parameters in the setting screen, the user clicks an “OK” button in area A7. In response to this operation, terminal apparatus 11 performs estimation processing. The estimation processing is performed by calculation unit 114, statistical processing unit 115, fuel consumption amount specification unit 116, time specification unit 117, and probability specification unit 118, which are included in terminal apparatus 11 (see FIG. 4). The description of configuration units of terminal apparatus 11 will continue with reference to FIG. 4 again.

[0055] Calculation unit 114 references the performance data included in the performance data group (see FIG. 5) and the weather/maritime condition data included in the weather/maritime condition table group (see FIG. 8), and, for each of the past times, calculates at least either the time or the fuel consumption amount required for navigation in a supposed case where the ship departs at that past time as the departure time and navigates the designated ship route while maintaining the designated navigation speed or the designated fuel consumption per unit time.

- [0056] For each past time, statistical processing unit 115 estimates the probability distribution of a population of samples of time or fuel consumption amount calculated by calculation unit 114.
- [0057] Using a fuel consumption amount-related probability distribution that was estimated by statistical processing unit 115, fuel consumption amount specification unit 116 specifies a fuel consumption amount that is estimated to be sufficient for navigating the entire ship route with a predetermined probability, that is to say the amount of fuel that the ship needs to hold.
- [0058] Using a time-related probability distribution that was estimated by statistical processing unit 115, time specification unit 117 specifies the time required for the ship to completely navigate the designated ship route with a predetermined probability.
- [0059] Using the probability distribution for the time that was estimated by statistical processing unit 115, probability specification unit 118 specifies the probability that the ship will completely navigate the designated ship route within a predetermined time.
- [0060] Details of the processing performed by calculation unit 114, statistical processing unit 115, fuel consumption amount specification unit 116, time specification unit 117, and probability specification unit 118 will be described in the later description of the estimation processing.
- [0061] Server apparatus 12 (see FIG. 1) is a server apparatus that accumulates weather/maritime condition data that indicates past weather/maritime conditions in each sea area, and distributes the accumulated weather/maritime condition data in accordance with a request from an external apparatus. Server apparatus 12 is an ordinary server apparatus that performs data distribution, and thus the function configuration thereof will not be described.

- [0062] Next, the estimation processing performed by terminal apparatus 11 will be described. While the estimation processing is performed, storage unit 112 temporarily stores an operation table for temporarily storing data that is generated by calculation unit 114 and a sample table.
- [0063] For each of various virtual departure times within the time periods designated by the user in area A5 of the setting screen (see FIG. 9), calculation unit 114 calculates a sample of the time and the fuel consumption amount required for navigation in a supposed case where the ship starts navigation at the virtual departure time. An operation table is temporarily generated for each virtual departure time, and is discarded when calculation unit 114 has completed calculation for a sample for one set of a time and a fuel consumption amount.
- [0064] FIG. 10 is a diagram showing the configuration of the operation table. The operation table has “port-to-port route”, “sea area name”, “section number”, “distance”, “start time”, “navigation speed”, “fuel consumption per unit time”, “end time”, and “fuel consumption amount” data fields.
- [0065] The data field “port-to-port route” stores data that indicates the names of the departure port and the destination port in the portion between adjacent ports in the ship route (hereinafter, this portion being called the “port-to-port route”). The data field “sea area name” stores data that indicates sea area names that identify the sea areas that are traversed along the port-to-port route, and this data is stored in order along the port-to-port route. The data field “section number” stores section numbers that identify sections obtained when the portion traversing the corresponding sea area in the port-to-port route is divided by a predetermined distance (e.g., 10 miles) beginning from the side nearest to the departure port. The data field “distance” stores data indicating the length of the corresponding section. Note that the length is the

predetermined distance (e.g., 10 miles) for all of the sections other than the last section for each sea area.

[0066] The data field “start time” stores data indicating the start time of navigation along the corresponding section. The data field “navigation speed” stores the navigation speed of the ship navigating the corresponding section. The data field “fuel consumption per unit time” stores the fuel consumption per unit time when the ship navigates the corresponding section. The data field “end time” stores data indicating the end time of navigation along the corresponding section. The data field “fuel consumption amount” stores the fuel consumption amount when the ship navigates the corresponding section.

[0067] FIG. 11 is a diagram showing the configuration of the sample table. The sample table is a table in which calculation unit 114 stores samples of times and fuel consumption amounts required for navigation that are calculated for respective virtual departure times. The sample table is a group of data records that respectively correspond to virtual departure times, and has “virtual departure time”, “virtual arrival time”, and “fuel consumption amount” data fields.

[0068] The data field “virtual departure time” stores data indicating a virtual departure time. The data field “virtual arrival time” stores data indicating a time that is obtained by adding the time period from the virtual departure time to the designated departure time, to the time of arrival at the destination port in a supposed case where the ship starts navigation at the virtual departure time (hereinafter, the obtained time being called a “virtual arrival time”). In other words, the virtual arrival time is the time of arrival at the destination port in a supposed case of envisioning that the ship starts navigation at the designated departure time and encounters weather/maritime conditions similar to the case of starting navigation at the virtual departure time. The data

field “fuel consumption amount” stores data indicating the fuel consumption amount that is required to reach the destination port in a supposed case where the ship starts navigation at the virtual departure time.

[0069] The estimation processing overall includes processing in which calculation unit 114 generates a large number of samples of times and fuel consumption amounts required for navigation, processing in which statistical processing unit 115 estimates a probability distribution with use of the samples generated by calculation unit 114, and processing in which fuel consumption amount specification unit 116, time specification unit 117, and probability specification unit 118 respectively specify fuel consumption amounts, times, and probabilities with use of the probability distribution estimated by statistical processing unit 115.

[0070] FIGS. 12A and 12B are diagrams showing a flow of processing in which calculation unit 114 generates a large number of samples of times and fuel consumption amounts required for navigation. When the user clicks the “OK” button in area A7 in the setting screen (see FIG. 9), a sample table (see FIG. 11) is generated by calculation unit 114 (step S001). Note that the sample table generated in step S001 is an empty table that does not include data records.

[0071] Next, calculation unit 114 reads, from the ship route table (see FIG. 7), ship route data that corresponds to the route name that was input to the input field in area A3 of the setting screen (step S002).

[0072] Next, calculation unit 114 selects one day in order of the oldest day in the time periods corresponding to the checkboxes that are checked in area A5 in the setting screen, and sets a virtual departure time by replacing the date of the departure time that was input in the input field in area A4 (the designated departure time) with the selected date (step

S003).

[0073] Next, calculation unit 114 generates an operation table (see FIG. 10) for a portion from the departure port to the destination port that was input to the input field in area A4 of the setting screen out of the ship route indicated by the ship route data that was read out in step S002 (step S004). In step S004, calculation unit 114 stores the data corresponding to the data fields “sea area name”, “section number”, and “distance” in the operation table. Also, in step S004, calculation unit 114 stores data indicating the virtual departure time that was set in step S003 in the data field “start time” that corresponds to the first section in the operation table. In other words, the virtual departure time is set as the start time for navigation of the first section.

[0074] Next, calculation unit 114 selects the highest one of the sections that are identified by the section number stored in the data field “section number” in the operation table (step S005). Hereinafter, the section that is selected in step S005 will be called the “selected section”.

[0075] Next, calculation unit 114 reads out, from the weather/maritime condition table group (see FIG. 8), the weather/maritime condition table that corresponds to the sea area that includes the selected section, and reads out, from the read weather/maritime condition table, the weather/maritime condition data that corresponds to the time period that includes the start time of navigation in the selected section (step S006).

[0076] Next, calculation unit 114 reads out, from the performance data group (see FIG. 5), the performance data that corresponds to a combination of the ship name that was input to the input field in area A1 of the setting screen, the loading amount that was input to the input field in area A6, and the weather/maritime conditions indicated by the weather/maritime condition data that was read out in step S006 (step S007).

[0077] Next, calculation unit 114 determines whether the constant navigation

speed mode or the constant fuel consumption amount mode was selected in area A2 in the setting screen (step S008).

[0078] If the constant navigation speed mode has been selected (“1” in step S008), calculation unit 114 stores data indicating the navigation speed that was input to the input field in area A2 of the setting screen, in the data field “navigation speed” that corresponds to the selected section in the operation table. In other words, calculation unit 114 sets the navigation speed that was designated by the user as the navigation speed in the selected section (step S009).

[0079] Next, calculation unit 114 specifies a fuel consumption per unit time that corresponds to the navigation speed that was set in step S009, in accordance with the relationship between navigation speed and fuel consumption per unit time that is indicated by the performance data that was read out in step S007. Calculation unit 114 stores data indicating the specified fuel consumption per unit time in the data field “fuel consumption per unit time” that corresponds to the selected section in the operation table. In other words, calculation unit 114 sets the fuel consumption per unit time that corresponds to the navigation speed that was set by the user, as the fuel consumption per unit time required for navigation in the selected section (step S010).

[0080] If the constant fuel consumption amount mode has been selected (“2” in step S008), calculation unit 114 stores data indicating the fuel consumption per unit time that was input to the input field in area A2 of the setting screen, in the data field “fuel consumption per unit time” that corresponds to the selected section in the operation table. In other words, calculation unit 114 sets the fuel consumption per unit time that was designated by the user, as the fuel consumption per unit time required for navigation in the selected section (step S011).

[0081] Next, calculation unit 114 specifies a navigation speed that

corresponds to the fuel consumption per unit time that was set in step S011, in accordance with the relationship between navigation speed and fuel consumption per unit time that is indicated by the performance data that was read out in step S007. Calculation unit 114 stores data indicating the specified navigation speed in the data field “navigation speed” that corresponds to the selected section in the operation table. In other words, calculation unit 114 sets the navigation speed that corresponds to the fuel consumption per unit time that was set by the user as the navigation speed in the selected section (step S012).

[0082] After step S010 or S012, calculation unit 114 calculates the time required for navigation in the selected section by dividing the length of the selected section by the navigation speed of the selected section (step S013). Next, calculation unit 114 specifies the end time of navigation in the selected section by adding the time calculated in step S013 to the start time of the selected section (step S014). Calculation unit 114 stores data indicating the specified end time in the data field “end time” that corresponds to the selected section in the operation table.

[0083] Next, calculation unit 114 calculates the fuel consumption amount required for navigation in the selected section by multiplying the fuel consumption per unit time of the selected section by the time that was calculated in step S013 (step S015). Calculation unit 114 stores data indicating the calculated fuel consumption amount in the data field “fuel consumption amount” that corresponds to the selected section in the operation table.

[0084] Next, calculation unit 114 determines whether or not the selected section is the last section in the operation table, that is to say the last section in the entire ship route (step S016). If the selected section is not the last section in the entire ship route (“No” in step S016), calculation unit 114 determines whether the selected section is the last

section of the port-to-port route (step S017).

[0085] If the selected section is the last section of the port-to-port route (“Yes” in step S017), calculation unit 114 specifies the start time of navigation in the section after the selected section by adding the berthing period of the destination port of the port-to-port route that includes the selected section, which is indicated by the ship route data that was read out in step S002, to the end time of navigation of the selected section. Calculation unit 114 stores data indicating the specified start time in the data field “start time” that corresponds to the section following the selected section in the operation table. In other words, calculation unit 114 sets the time corresponding to the elapse of the berthing period at the port from the end time of navigation of the last section in the port-to-port route, as the start time of navigation of the next section (step S018).

[0086] If the selected section is not the last section in the port-to-port route (“No” in step S017), calculation unit 114 stores data indicating the end time of navigation of the selected section in the data field “start time” that corresponds to the section after the selected section in the operation table. In other words, calculation unit 114 sets the end time of navigation of the intermediate section in the port-to-port route as the start time of navigation of the next section (step S019).

[0087] After step S018 or S019, calculation unit 114 returns the processing to step S005, selects the next section in the operation table, and repeats the processing from step S006.

[0088] If it was determined in step S016 that the selected section is the last section in the entire ship route (“Yes” in step S016), calculation unit 114 specifies the virtual arrival time by calculating the time period from the virtual departure time that was set in step S003 to the departure time that was input to the input field in area A4 of the setting screen

(designated departure time), and adding the calculated time period to the end time of navigation of the selected section, which is the last section in the entire ship route (step S020).

[0089] Next, calculation unit 114 calculates the fuel consumption amount required for navigation of the entire ship route by obtaining the sum of all of the fuel consumption amounts indicated by the data pieces stored in the data field “fuel consumption amount” in the operation table (step S021).

[0090] Next, calculation unit 114 adds one new data record to the sample table, and stores data indicating the virtual departure time set in step S003 to the data field “virtual departure time” in the added data record, as well as data indicating the virtual arrival time specified in step S020 to the data field “virtual arrival time”, and data indicating the fuel consumption amount calculated in step S021 to the data field “fuel consumption amount” (step S022).

[0091] Next, calculation unit 114 discards the operation table (step S023). Next, calculation unit 114 determines whether or not the virtual departure time that was set in step S003 is the virtual departure time that was set when selecting the last day in the time periods that correspond to the checkboxes that are checked in area A5 of the setting screen, that is to say the last virtual departure time (step S024).

[0092] If the virtual departure time that was set in step S003 is not the last virtual departure time (“No” in step S024), calculation unit 114 returns the processing to step S003, selects the next day in the time periods that correspond to the checkboxes that are checked in area A5 of the setting screen and sets a new virtual departure time, and then repeats the processing from step S004.

[0093] If the virtual departure time that was set in step S003 is the last virtual departure time (“Yes” in step S024), calculation unit 114 ends

this processing.

[0094] When the above-described processing by calculation unit 114 is ended, statistical processing unit 115 estimates probability distributions with use of the data stored in the sample table (see FIG. 11) stored in storage unit 112.

[0095] The probability distribution that is estimated by statistical processing unit 115 is different depending on the mode that has been selected in area A2 of the setting screen. If the constant fuel consumption amount mode has been selected, statistical processing unit 115 estimates a probability distribution for a population of samples of the fuel consumption amounts indicated by the data pieces stored in the data field “fuel consumption amount” in the sample table (hereinafter, called the “fuel consumption amount-related probability distribution”), and a probability distribution for a population of samples of the virtual arrival times indicated by the data pieces stored in the data field “virtual arrival time” in the sample table (hereinafter, called the “time-related probability distribution”). On the other hand, if the constant navigation speed mode has been selected, the virtual arrival time is constant, and therefore statistical processing unit 115 estimates only a fuel consumption amount-related probability distribution, and does not estimate a time-related probability distribution.

[0096] In the present embodiment, statistical processing unit 115 estimates a fuel consumption amount-related probability distribution or time-related probability distribution based on the assumption that the population of samples indicated by the data stored in the sample table follows a normal distribution. However, statistical processing unit 115 may estimate a probability distribution other than a normal distribution. Note that methods for estimating the probability distribution of a given population of samples are known, and therefore will not be described.

[0097] FIGS. 13 and 14 are diagrams showing result display screens that include graphs of probability distributions estimated by statistical processing unit 115. FIG. 13 shows a result display screen in the case where the constant navigation speed mode has been selected in the setting screen, and FIG. 14 shows a result display screen in the case where the constant fuel consumption amount mode has been selected in the setting screen.

[0098] Area B1 in the result display screen for the constant navigation speed mode shown in FIG. 13 displays a graph of a fuel consumption amount-related probability distribution estimated by statistical processing unit 115. The graph illustrated as an example in FIG. 13 shows that the fuel consumption amount required for the ship to navigate the entire ship route will be less than or equal to 1568.2 tons (value that is $+3\sigma$ from the average) with a 99.73% probability.

[0099] Using the fuel consumption amount-related probability distribution that was estimated by statistical processing unit 115, fuel consumption amount specification unit 116 specifies a fuel consumption amount that is estimated to be sufficient for navigating the entire ship route with a 99.73% probability, that is to say the amount of fuel that needs to be held by the ship in order to navigate the entire ship route. The graph displayed in area B1 of the result display screen for the constant navigation speed mode indicates the fuel amount that was specified by fuel consumption amount specification unit 116.

[0100] Area B2 in the result display screen for the constant navigation speed mode displays a navigation speed, an arrival time, and a fuel consumption amount margin. The navigation speed and the arrival time that are displayed in the result display screen for the constant navigation speed mode are the navigation speed that was designated by the user in area A2 of the setting screen and the arrival time that was

automatically set according to that navigation speed, or are the arrival time that was set by the user in area A4 and the navigation speed that was automatically set according to that arrival time.

[0101] The fuel consumption amount margin is a value that is calculated by $(Y-X)/X \times 100(\%)$, where X (ton) is the fuel consumption amount required for the entire ship route in the case of a Beaufort number used as a reference for weather/maritime conditions encountered during navigation of the ship (e.g., Beaufort number 0), and Y (ton) is the fuel consumption amount that is estimated to be required with a 99.73% probability according to the probability distribution (in the example in FIG. 13, 1568.2 tons).

[0102] Using the estimated fuel consumption amount-related probability distribution, statistical processing unit 115 calculates the fuel consumption amount margin in accordance with the aforementioned calculation expression. Area B2 in the result display screen for the constant navigation speed mode displays the fuel consumption amount margin that is calculated by statistical processing unit 115 in this way.

[0103] In area C1 in the result display screen for the constant fuel consumption amount mode shown in FIG. 14, a graph of a time-related probability distribution estimated by statistical processing unit 115 is displayed. Also, in area C2, a graph of a fuel consumption amount-related probability distribution estimated by statistical processing unit 115 is displayed.

[0104] The graph illustrated as an example in area C1 in FIG. 14 shows that the ship will arrive at the destination port by 13:15 on 12 October 2016 (value that is $+3 \sigma$ from the average) with a 99.73% probability. Using the time-related probability distribution that was estimated by statistical processing unit 115, time specification unit 117 specifies the time of arrival at the destination port with a 99.73% probability (in the example

in FIG. 14, 13:15 on 12 October 2016) in a supposed case where the ship starts navigation at the departure time that was designated by the user in area A4 of the setting screen. The graph displayed in area C1 of the result display screen for the constant fuel consumption amount mode displays the time that is specified by the time specification unit 117 in this way.

[0105] The graph illustrated as an example in area C2 in FIG. 14 shows that the fuel consumption amount required for the ship to navigate the entire ship route is less than 1526.8 tons (value that is $+3\sigma$ from the average) with a 99.73% probability.

[0106] Using the fuel consumption amount-related probability distribution that was estimated by statistical processing unit 115, fuel consumption amount specification unit 116 specifies a fuel consumption amount that is estimated to be sufficient for navigating the entire ship route with a 99.73% probability, that is to say the amount of fuel that needs to be held in order to navigate the entire ship route. The graph displayed in area C2 of the result display screen for the constant navigation speed mode indicates the fuel amount that is specified by fuel consumption amount specification unit 116 in this way.

[0107] Area C3 in the result display screen for the constant fuel consumption amount mode displays a fuel consumption per unit time, a fuel consumption amount margin, and an arrival probability. The fuel consumption per unit time that is displayed in the result display screen for the constant fuel consumption amount mode is the fuel consumption per unit time that was designated by the user in area A2 of the setting screen. The fuel consumption amount margin that is displayed in the result display screen for the constant fuel consumption amount mode is the value calculated by statistical processing unit 115, similarly to the fuel consumption amount margin displayed in the result display screen

for the constant navigation speed mode. The arrival probability that is displayed in the result display screen for the constant fuel consumption amount mode is the probability that the ship will arrive at the destination port by the arrival time that was designated by the user in area A4 of the setting screen.

[0108] Using the time-related probability distribution that was estimated by statistical processing unit 115, probability specification unit 118 specifies the probability that the ship will arrive at the destination port by the arrival time that was designated by the user in area A4 of the setting screen in a supposed case where the ship starts navigation at the departure time that was designated by the user in area A4 of the setting screen (in the example in FIG. 14, this probability is 65.2%). Area C3 in the result display screen for the constant fuel consumption amount mode displays the probability that is estimated by probability specification unit 118 in this way as the arrival probability.

[0109] As described above, according to system 1, the user can learn the time and the fuel consumption amount that would be necessary, with a predetermined probability, for the ship to navigate a ship route. Also, according to system 1, the user can learn the probability of arrival (arrival probability) at a destination port by a designated arrival time in a supposed case where the ship starts navigation at a designated departure time. The time, the fuel consumption amount, and the arrival probability that system 1 presents to the user have been specified in accordance with probability distributions that were estimated based on past weather/maritime conditions. Accordingly, the time, the fuel consumption amount, and the arrival probability that system 1 presents to the user are reasonable estimated values that give consideration to the influence of weather/maritime conditions on ship navigation. Accordingly, the user can utilize this information presented by system 1

in order to determine a navigation speed or a fuel consumption per unit time for ship navigation, determine whether or not the ship should navigate to a destination, an arrival time of which is designated, and so on.

[0110] [Modifications]

The above-described embodiment can be modified in various ways within the scope of the technical idea of the present invention. Examples of such variations are shown below.

[0111] (1) In the embodiment described above, in the case where the constant fuel consumption amount mode has been designated, terminal apparatus 11 specifies a time by which the ship can arrive at one destination designated by the user with a predetermined probability (e.g., 99.73%) and displays the specified time as the arrival time. Alternatively, a configuration may be employed in which terminal apparatus 11 specifies a time by which the ship can arrive at each of a plurality of ports with a predetermined probability (e.g., 99.73%) in a supposed case where the ship departs from a designated departure port at a designated departure time and navigates with a designated fuel consumption per unit time, and terminal apparatus 11 displays the specified time as an arrival time for the ports.

[0112] FIG. 15 is a diagram showing a screen displayed by terminal apparatus 11 according to this variation. In area D1 of screen in FIG. 15, the user inputs a ship name, a departure port name, a departure time, a fuel consumption per unit time, and a loading amount. Then, when the user clicks an "OK" button in area D2, area D3 displays the times at which the ship can arrive with a 99.73% probability as arrival times for each of the destination ports. In this variation, statistical processing unit 115 estimates a probability distribution for each of the ship routes from the departure port to the destination port by performing processing

similar to the processing for the constant fuel consumption amount mode in the above-described embodiment. Then, with use of the probability distributions estimated by statistical processing unit 115, time specification unit 117 specifies the arrival times that are to be displayed in area D3 for each of the ship routes by performing processing similar to the processing in the above-described embodiment.

[0113] (2) In the embodiment described above, the loading amount data indicates the percentage (%) of the loading amount relative to the maximum loading amount. Alternatively, the loading amount data may indicate the weight (ton) of the load. The loading amount data may also indicate the draft of the ship.

[0114] (3) In the embodiment described above, the sections, that are obtained by dividing a portion traversing a sea area in the port-to-port route by a predetermined distance (e.g., 10 miles) beginning from the side nearest to the departure port, are used by calculation unit 114 as a unit for specifying a navigation speed or a fuel consumption per unit time in accordance with the performance data. The method for determining the sections is not limited to this. For example, in the constant fuel consumption amount mode, a portion of the ship route that is navigated by the ship in a predetermined time period (e.g., 15 minutes) may be used by calculation unit 114 as the unit for specifying a navigation speed in accordance with the performance data. In this case, the locations and the lengths of the sections in the port-to-port route vary depending on the weather/maritime conditions encountered by the ship. Accordingly, the locations and lengths of the sections in the port-to-port route change according to various virtual departure times.

[0115] (4) In the embodiment described above, fuel consumption amount specification unit 116 specifies the fuel consumption amount required to

navigate the entire ship route. Alternatively, or additionally, a configuration may be employed in which fuel consumption amount specification unit 116 specifies a fuel bunkering amount. In this variation, acquisition unit 111 acquires remaining fuel amount data that indicates the remaining fuel amount of the ship upon arriving at a fuel bunkering port. Fuel consumption amount specification unit 116 specifies the fuel consumption amount required to navigate from the fuel bunkering port to the destination port, and calculates a fuel bunkering amount by subtracting the remaining fuel amount indicated by the remaining fuel amount data from the specified fuel consumption amount. Display unit 113 displays the fuel bunkering amount calculated by fuel consumption amount specification unit 116 in the result display screen. According to this variation, the user can easily learn the amount of fuel that needs to be bunkered at the fuel bunkering port.

[0116] (5) In the embodiment described above, the performance data indicates the relationship between navigation speed and fuel consumption per unit time in a table format. Alternatively, a configuration may be employed in which the performance data indicates the relationship between navigation speed and fuel consumption per unit time with use of an equation.

[0117] (6) In the embodiment described above, consideration is not given to the amount of fuel that is consumed by the ship while anchored. Alternatively, a configuration may be employed in which terminal apparatus 11 gives consideration to the amount of fuel that is consumed by the ship while anchored. In this variation, acquisition unit 111 acquires data indicating an anchoring fuel consumption per unit time. Calculation unit 114 calculates an anchoring fuel consumption amount by multiplying the berthing period by the anchoring fuel consumption

per unit time indicated by the data acquired by acquisition unit 111, for each of the ports of call. Calculation unit 114 adds the thus calculated anchoring fuel consumption amounts to the navigation fuel consumption amount, thus calculating the fuel consumption amount that is required for navigating the entire ship route with consideration given to the anchoring fuel consumption amount. According to this variation, an even more realistic fuel consumption amount is estimated.

[0118] (7) In the embodiment described above, calculation unit 114 sets virtual departure times that are different by units of one day when calculating samples of the arrival time or the fuel consumption amount. The time interval between virtual departure times set by calculation unit 114 is not limited to being one day, and it is possible to set virtual departure times that are different by units of 12 hours, for example.

[0119] (8) In the embodiment described above, the variables designated by the user, that is to say the navigation speed (constant navigation speed mode) and the fuel consumption per unit time (constant fuel consumption amount mode) are constant throughout the entire ship route. Alternatively, the user may be able to designate different variables for each port-to-port route or sea area, for example.

[0120] (9) In the embodiment described above, weather/maritime conditions and the loading amount are taken into consideration as parameters that influence the relationship between navigation speed and fuel consumption per unit time during navigation of the ship. Another parameter such as trim may also be taken into consideration as a parameter that influences the relationship between navigation speed and fuel consumption per unit time during navigation of the ship. In this case, performance data acquisition unit 1111 acquires performance data that corresponds to the parameter such as trim, and calculation unit 114 uses the performance data corresponding to the designated parameter

such as trim to calculate the navigation speed or the fuel consumption amount during the navigation of sections.

[0121] (10) In the embodiment described above, the performance data indicates the relationship between navigation speed and fuel consumption per unit time. As long as the performance data indicates the relationship between a first variable that is correlated with navigation speed and a second variation that is correlated with fuel consumption per unit time, there is no limitation to the aforementioned variables. For example, the performance data may indicate the relationship between navigation speed and horsepower, the relationship between propeller rotation speed and load, or the like.

[0122] (11) In the embodiment described above, the ship route that terminal apparatus 11 subjects to estimation processing regarding a fuel consumption amount and an arrival time is the entire ship route from the departure port to the destination port of the ship route designated by the user. Alternatively, terminal apparatus 11 may perform estimation processing regarding the ship route from the current position of the ship to the destination port. In this case, acquisition unit 111 of terminal apparatus 11 acquires location data that indicates the current location of the ship specified by a GNSS (Global Navigation Satellite System) or the like implemented in the ship, for example. Terminal apparatus 11 then performs estimation processing for the ship route from the current location indicated by the acquired location data to the destination port (the remaining route).

[0123] (12) In the embodiment described above, calculation unit 114 calculates a sample of the fuel consumption amount required for navigation (constant navigation speed mode and constant fuel consumption amount mode) or the arrival time (constant fuel consumption amount mode) for each of various virtual departure times. Alternatively, or additionally,

calculation unit 114 may calculate a sample of the fuel consumption per unit time (constant navigation speed mode) or the navigation speed (constant fuel consumption amount mode) for each of various virtual departure times. In this case, statistical processing unit 115 estimates a probability distribution of the fuel consumption per unit time (constant navigation speed mode) or a probability distribution of the navigation speed (constant fuel consumption amount mode).

[0124] (13) In the embodiment described above, an operation table (see FIG. 10) is generated each time estimation processing is performed, and the operation table is discarded when estimation processing ends. In other words, calculation unit 114 repeatedly calculates a navigation speed (constant fuel consumption amount mode) or a fuel consumption per unit time (constant navigation speed mode) for each section each time estimation processing is performed. Alternatively, for each of various virtual departure times, calculation unit 114 may calculate a navigation speed for each section in correspondence with various fuel consumption per unit times (constant fuel consumption amount mode) or calculate a fuel consumption per unit time for each section in correspondence with various navigation speeds (constant navigation speed mode), and store the calculated results in storage unit 112.

[0125] FIG. 16 is a diagram illustrating an example of the configuration of a table (hereinafter, called a “navigation speed table”) storing the navigation speeds of sections calculated by calculation unit 114 in this variation.

[0126] In the navigation speed table illustrated as an example in FIG. 16, a navigation speed calculated by calculation unit 114 is stored for each section of 3 hours of navigation in a supposed case where a certain ship with a certain loading amount starts to navigate along a certain ship route at the virtual departure time “12:00 1 Jan 2010” with the fuel

consumption per unit time “50 (ton/day)”. The navigation speed table has “time period”, “section start point”, “section end point”, and “navigation speed” data fields. The data field “time period” stores data indicating the navigation time period. In this case, the duration of the time period indicated by the data stored in the data field “time period” is always 3 hours.

[0127] The data field “section start point” stores data that indicates the location of the start point of the section navigated by the ship in the time period indicated by the data stored in the data field “time period”. Also, the data field “section end point” stores data that indicates the location of the end point section navigated by the ship in the time period indicated by the data stored in the data field “time period”.

[0128] The data field “navigation speed” stores data that indicates the navigation speed that is calculated by calculation unit 114 in accordance with the performance data, based on the weather/maritime condition data that corresponds to the time period indicated by the data stored in the data field “time period” and the sea area indicated by the data stored in the data fields “section start point” and “section end point”.

[0129] The navigation speed table having the data configuration shown in FIG. 16 is stored in storage unit 112 for each of various combinations of ships, loading amounts, ship routes, virtual departure times, and amounts of fuel consumption per unit time.

[0130] FIG. 17 is a diagram illustrating an example of the configuration of a table (hereinafter, called the “fuel consumption table”) storing the fuel consumption per unit time for each section calculated by calculation unit 114 in this variation.

[0131] In the fuel consumption table illustrated as an example in FIG. 17, a fuel consumption per unit time calculated by calculation unit 114 is stored for each section of 3 hours of navigation in a supposed case

where a certain ship with a certain loading amount starts to navigate along a certain ship route at the virtual departure time “12:00 1 Jan 2010” at the navigation speed of “15 (knot)”. The fuel consumption table includes “time period”, “section start point”, “section end point”, and “fuel consumption per unit time” data fields. The data stored in the “time period”, “section start point”, and “section end point” data fields of the fuel consumption table are the same as the data stored in the data fields having the same names in the navigation speed table.

[0132] The data field “fuel consumption per unit time” stores data that indicates the fuel consumption per unit time that is calculated by calculation unit 114 in accordance with the performance data, based on the weather/maritime condition data that corresponds to the time period indicated by the data stored in the data field “time period” and the sea area indicated by the data stored in the data fields “section start point” and “section end point”.

[0133] The fuel consumption table having the data configuration shown in FIG. 17 is stored in storage unit 112 for each of various combinations of ships, loading amounts, ship routes, virtual departure times, and navigation speeds.

[0134] Calculation unit 114 extracts, from among the navigation speed tables stored in storage unit 112, the navigation speed table that corresponds to a virtual departure time that is in the time periods designated by the user in area A5 in the setting screen (see FIG. 9). Next, calculation unit 114 calculates a navigation time and an arrival time at the destination port with use of the navigation speeds stored in the extracted navigation speed table. Statistical processing unit 115 then estimates the probability distribution (time-related probability distribution) for a population of samples of arrival times calculated by calculation unit 114 in this way.

- [0135] Calculation unit 114 also extracts, from among the fuel consumption tables stored in storage unit 112, the fuel consumption table that corresponds to a virtual departure time that is in the time periods designated by the user in area A5 in the setting screen (see FIG. 9). Next, calculation unit 114 calculates a fuel consumption amount required for navigation of the entire ship route with use of the amounts of fuel consumption per unit time stored in the extracted fuel consumption table. Statistical processing unit 115 then estimates the probability distribution (fuel consumption amount-related probability distribution) for a population of samples of fuel consumption amounts calculated by calculation unit 114 in this way.
- [0136] (14) Statistical processing unit 115 of terminal apparatus 11 may use data stored in the navigation speed table (see FIG. 16) or the fuel consumption table (see FIG. 17) stored in storage unit 112 in the above-described variation to calculate a statistical value related to the navigation speed in a supposed case where the ship navigates with a designated fuel consumption per unit time or calculate a statistical value related to the fuel consumption per unit time in a supposed case where the ship navigates at a designated navigation speed, for example.
- [0137] FIG. 18 is a diagram illustrating an example of a screen displayed by display unit 113 in a supposed case where the constant fuel consumption amount mode has been designated in this variation. The screen illustrated as an example in FIG. 18 displays a statistical value related to the navigation speed in a supposed case where the ship designated by the user navigates the ship route designated by the user with the loading amount and the fuel consumption per unit time that were designated by the user.
- [0138] The graph shown in the left side in FIG. 18 shows values (knot) comparing the average value of the navigation speed of the ship in each

month from January to December in a supposed case where the ship navigates under conditions designated by the user, with the navigation speed in a supposed case where the ship navigates in the environment corresponding to the Beaufort number that was designated as the reference by the user. For example, in accordance with the performance data that corresponds to the ship, the loading amount, and the reference Beaufort number that were designated by the user, calculation unit 114 specifies, as a reference navigation speed W , the navigation speed that corresponds to the fuel consumption per unit time designated by the user.

[0139] Next, statistical processing unit 115 extracts the data records that correspond to January from among the data records included in the navigation speed tables that correspond to the combination of the ship, the ship route, the loading amount, and the fuel consumption per unit time that were designated by the user, and calculates average value V of the navigation speeds indicated by the data stored in the extracted data records. Statistical processing unit 115 then subtracts reference navigation speed W calculated by calculation unit 114 from average value V of the navigation speed calculated for January, and specifies the result $(V-W)$ as the navigation speed margin (knot) for January. Statistical processing unit 115 similarly calculates the navigation speed margin for February to December as well. The graph shown on the left side in FIG. 18 shows the navigation speed margins that were calculated in this way.

[0140] The right side of FIG. 18 displays the median value and the average value of the navigation speed for one or more months designated by the user. Statistical processing unit 115 extracts the data records that correspond to the months designated by the user from among the data records included in the navigation speed tables that correspond to the

combination of the ship, the ship route, the loading amount, and the fuel consumption per unit time that were designated by the user, and calculates the median value and the average value of the navigation speeds indicated by the data stored in the extracted data records. The median value and the average value that are shown in the right side in FIG. 18 are the statistical values that were calculated in this way.

[0141] FIG. 19 is a diagram showing another example of a screen displayed by display unit 113 in the case where the constant navigation speed mode has been designated in this variation. The screen illustrated as an example in FIG. 19 displays a statistical value related to the fuel consumption per unit time in a supposed case where the ship designated by the user navigates the ship route designated by the user with the loading amount and the navigation speed that were designated by the user.

[0142] The graph shown in the left side in FIG. 19 shows values (%) comparing the average value of the fuel consumption per unit time of the ship in each month from January to December in a supposed case where the ship navigates under conditions designated by the user, with the fuel consumption per unit time in a supposed case where the ship navigates in the environment corresponding to the Beaufort number that was designated as the reference by the user. For example, in accordance with the performance data that corresponds to the ship, the loading amount, and the reference Beaufort number that were designated by the user, calculation unit 114 specifies, as a reference fuel consumption per unit time M , the fuel consumption per unit time that corresponds to the navigation speed designated by the user.

[0143] Next, statistical processing unit 115 extracts the data records that correspond to January from among the data records included in the fuel consumption tables that correspond to the combination of the ship, the

ship route, the loading amount, and the navigation speed that were designated by the user, and calculates average value N of the amounts of fuel consumption per unit time indicated by the data stored in the extracted data records. Statistical processing unit 115 then subtracts reference fuel consumption per unit time M calculated by calculation unit 114 from average value N of the fuel consumption per unit time calculated for January, divides the resulting value (N-M) by the reference fuel consumption per unit time, multiplies the resulting value by 100, and specifies the result $((N-M)/M \times 100)$ as the fuel consumption per unit time margin (%) for January. Calculation unit 114 similarly calculates the fuel consumption per unit time margin for February to December as well. The graph shown on the left side in FIG. 19 shows the fuel consumption per unit time margins that were calculated in this way.

[0144] The right side of FIG. 19 displays the median value and the average value of the fuel consumption per unit time for one or more months designated by the user. Statistical processing unit 115 extracts the data records that correspond to the months designated by the user from among the data records included in the fuel consumption tables that correspond to the combination of the ship, the ship route, the loading amount, and the navigation speed that were designated by the user. Next, statistical processing unit 115 calculates the above-described fuel consumption per unit time margin for each fuel consumption per unit time indicated by the data stored in the extracted data records. Statistical processing unit 115 then calculates the median value and the average value for the fuel consumption per unit time margins calculated in this way. The median value and the average value that are shown in the right side in FIG. 19 are the statistical values that were calculated in this way.

[0145] (15) Terminal apparatus 11 may specify a fuel consumption per unit time that corresponds to a ship, a ship route, a loading amount, a navigation time, and an arrival probability that were designated by the user. The arrival probability is the probability that the ship will arrive at the destination port of the ship route by the arrival time. In this variation, the user designates the ship, the ship route, the loading amount, the departure time, the arrival time, and the arrival probability.

[0146] FIG. 20 is a diagram showing the flow of operations of terminal apparatus 11 in this variation. First, variable data acquisition unit 1114 sets an initial value of the fuel consumption per unit time “0.1 ton/day” as the fuel consumption per unit time in the constant fuel consumption amount mode (step S101).

[0147] Next, using the ship, the ship route, and the loading amount that were designated by the user and the fuel consumption per unit time that was set in step S101, calculation unit 114 performs processing similar to the processing in the constant fuel consumption amount mode in the above-described embodiment, and thus calculates samples of times required for navigation corresponding to various virtual departure times (step S102).

[0148] Next, statistical processing unit 115 estimates a probability distribution (time-related probability distribution) of a population of the samples that were calculated by calculation unit 114 in step S102 (step S103). Next, in accordance with the probability distribution that was estimated in step S103, time specification unit 117 specifies the time by which the ship will arrive at the destination port with the arrival probability designated by the user (step S104).

[0149] Next, storage unit 112 stores the time that was specified by time specification unit 117 in step S104 in association with the fuel consumption per unit time and the probability distribution that were

used to specify the time (step S105).

[0150] Next, time specification unit 117 determines whether or not the fuel consumption per unit time that is set at that time is the maximum value of the fuel consumption per unit time for the ship (step S106). If the set fuel consumption per unit time is not the maximum value (No in step S106), variable data acquisition unit 1114 adds a predetermined amount (e.g., 0.1 ton/day) to the fuel consumption per unit time that is set at that time (step S107). Terminal apparatus 11 then repeats the processing from step S102.

[0151] If the set fuel consumption per unit time is the maximum value (Yes in step S106), time specification unit 117 specifies the fuel consumption per unit time that is stored in association with the time that is closest to the arrival time set by the user (step S108) from among various times stored in storage unit 112 (the times specified in step S104). The fuel consumption per unit time specified in this way is the fuel consumption per unit time according to which the ship will arrive at the destination port by the arrival time designated by the user with the arrival probability designated by the user.

[0152] Display unit 113 displays the screen shown in FIG. 21 (hereinafter, called the “result display screen”) for example, with use of the data that was stored in storage unit 112 in step S105. Area E1 in result display screen displays the arrival probability and the like that were designated by the user. Area E2 displays a fuel consumption per unit time and a fuel consumption amount for navigation of the ship under conditions designated by the user.

[0153] Note that the fuel consumption per unit time displayed in area E2 is the fuel consumption per unit time that was specified in step S108. Also, the fuel consumption amount displayed in area E2 is calculated by multiplying the fuel consumption per unit time displayed in area E2 by

the navigation time, which is the result of subtracting the berthing periods at ports from the duration of time from the departure time to the arrival time that were designated by the user.

[0154] Area E3 displays a graph that shows the relationship between fuel consumption per unit time and arrival time. The graph in area E3 shows the relationship between the amount of fuel consumption per unit time and the times that are indicated by the data that was stored by storage unit 112 in step S105. Area E4 displays a graph that shows the probability distribution of arrival times in cases where the ship navigates with the fuel consumption per unit time displayed in area E2. The graph in area E4 shows the probability distribution that is stored in association with the fuel consumption per unit time that was specified in step S108.

[0155] In the above-described processing of terminal apparatus 11, the time specified by time specification unit 117 is compared with the arrival time designated by the user. Alternatively, the probability specified by probability specification unit 118 may be compared with the arrival probability designated by the user. FIG. 22 shows the flow of processing performed by terminal apparatus 11 in this case. Processing shown in FIG. 22 that is the same as processing shown in FIG. 20 is denoted with the same step numbers as in FIG. 20. The following describes the processing shown in FIG. 22 that is different from the processing shown in FIG. 20.

[0156] Instead of step S104 in the flow in FIG. 20, in accordance with the probability distribution that was estimated in step S103, probability specification unit 118 specifies the probability that the ship will arrive at the destination port by the arrival time designated by the user (step S204).

[0157] Next, storage unit 112 stores the probability that was estimated by

probability specification unit 118 in step S204 in association with the fuel consumption per unit time and the probability distribution that were used to specify the probability (step S205).

[0158] Next, probability specification unit 118 determines whether or not the fuel consumption per unit time that is set at that time is the maximum value of the fuel consumption per unit time for the ship (step S106). If the set fuel consumption per unit time is not the maximum value (No in step S106), variable data acquisition unit 1114 adds a predetermined amount (e.g., 0.1 ton/day) to the fuel consumption per unit time that is set at that time (step S107). Terminal apparatus 11 then repeats the processing from step S102.

[0159] If the set fuel consumption per unit time is the maximum value (Yes in step S106), probability specification unit 118 specifies the fuel consumption per unit time that is stored in association with the probability that is closest to the arrival probability set by the user (step S208) from among various probabilities stored in storage unit 112 (the probabilities specified in step S204). The fuel consumption per unit time specified in this way is the fuel consumption per unit time according to which the ship will arrive at the destination port by the arrival time designated by the user with the arrival probability designated by the user.

[0160] Display unit 113 displays the result display screen shown in FIG. 23 for example, with use of the data that was stored in storage unit 112 in step S205. In the result display screen of FIG. 23, the graph in area E3 is different from the result display screen in FIG. 21. In this case, area E3 displays a graph that shows the relationship between fuel consumption per unit time and arrival probability. This graph shows the relationship between the amount of fuel consumption per unit time and the probabilities that are indicated by the data that was stored by

storage unit 112 in step S205.

- [0161] According to this variation, the user can learn the minimum fuel consumption per unit time required for ship navigation in order for the ship to arrive at the destination by the arrival time with the designated arrival probability.
- [0162] (16) The load may be used instead of the fuel consumption per unit time in the embodiment described above. In this case, terminal apparatus 11 stores a correspondence table or a conversion expression that shows the relationship between fuel consumption per unit time and load in storage unit 112, and performs conversion between fuel consumption per unit time and load as necessary, for example.
- [0163] (17) In the embodiment described above, the time handled by terminal apparatus 11 may be expressed as a duration from the departure time. For example, when calculating time-related samples, calculation unit 114 may calculate a navigation time instead of an arrival time. The arrival time is the time at which the sum of the navigation time and the berthing periods has elapsed from the departure time, and therefore either the navigation time or the arrival time may be used. Accordingly, time specification unit 117 may specify a navigation time instead of specifying an arrival time. Also, instead of specifying the probability of the ship arriving at the destination port by the arrival time designated by the user, probability specification unit 118 may specify the probability of the ship arriving at the destination port within the navigation time designated by the user (the time obtained by subtracting the berthing periods from the time period from the departure time to the arrival time).
- [0164] (18) In the embodiment described above, terminal apparatus 11 and server apparatus 12 may be realized by processing corresponding to a program being executed by an ordinary computer. Alternatively, at

least a portion of terminal apparatus 11 and server apparatus 12 may be configured as a so-called dedicated apparatus.

[0165] (19) A program according to the present invention, that is to say a program that is an example of a program executed by computer 10 to realize terminal apparatus 11 in the embodiment described above, may be provided in the state of being stored on a computer-readable storage medium such as an optical storage medium or a semiconductor memory, or may be provided via a communication network such as the Internet. In the case where the program according to the present invention is provided in a state of being stored on a storage medium, computer 10 reads the program from the storage medium in order to use the program. Also, in the case where the program according to the present invention is provided via a communication network, the computer 10 receives the program from a distribution source apparatus in order to use the program.

DESCRIPTION OF REFERENCE NUMERALS

[0166] 1 ... System, 10 ... Computer, 11 ... Terminal apparatus, 12 ... Server apparatus, 20 ... Computer, 101 ... Memory, 102 ... Processor, 103 ... Communication IF, 104 ... Display apparatus, 105 ... Operation apparatus, 111 ... Acquisition unit, 112 ... Storage unit, 113 ... Display unit, 114 ... Calculation unit, 115 ... Statistical processing unit, 116 ... Fuel consumption amount specification unit, 117 ... Time specification unit, 118 ... Probability specification unit, 201 ... Memory, 202 ... Processor, 203 ... Communication IF, 1111 ... Performance data acquisition unit, 1112 ... Ship route data acquisition unit, 1113 ... Weather/maritime condition data acquisition unit, 1114 ... Variable data acquisition unit, 1115 ... Loading amount data acquisition unit

CLAIMS

- [Claim 1] A data processing apparatus comprising:
- a performance data acquisition unit that acquires performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment;
 - a weather/maritime condition data acquisition unit that acquires weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period;
 - a variable data acquisition unit that acquires variable data that indicates a designated value related to the first variable in a case where the ship navigates a ship route that passes through the one or more sea areas;
 - a calculation unit that, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, calculates a value that indicates one of a value related to the second variable and a fuel consumption amount required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data acquired by the variable data acquisition unit; and
 - a statistical processing unit that performs statistical processing on the values calculated by the calculation unit for the plurality of past times.

- [Claim 2] The data processing apparatus according to claim 1,

wherein the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit for the plurality of past times.

[Claim 3]

The data processing apparatus according to claim 2,

further comprising a fuel consumption amount specification unit that, with use of the probability distribution estimated by the statistical processing unit, specifies a fuel consumption amount that is sufficient, with a predetermined probability, in order for the ship to navigate the ship route at a navigation speed that corresponds to the value indicated by the variable data acquired by the variable data acquisition unit.

[Claim 4]

A data processing apparatus comprising:

a performance data acquisition unit that acquires performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment;

a weather/maritime condition data acquisition unit that acquires weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period;

a variable data acquisition unit that acquires variable data that indicates a designated value related to the second variable in a case where the ship navigates a ship route that passes through the one or more sea areas;

a calculation unit that, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, calculates a value that indicates one of a value related to the

first variable and a time required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data acquired by the variable data acquisition unit; and

a statistical processing unit that performs statistical processing on the values calculated by the calculation unit for the plurality of past times.

[Claim 5] The data processing apparatus according to claim 4, wherein the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit for the plurality of past times.

[Claim 6] The data processing apparatus according to claim 5, further comprising a time specification unit that, with use of the probability distribution estimated by the statistical processing unit, specifies a time that is required in order for the ship to completely navigate the ship route with a predetermined probability.

[Claim 7] The data processing apparatus according to claim 6, wherein the variable data acquisition unit acquires a plurality of pieces of the variable data,

the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit, for each of the plurality of pieces of the variable data, and

the time specification unit specifies a second variable according to which the ship completely navigates the ship route within a predetermined time with a predetermined probability, with use of the probability distributions estimated by the statistical processing unit for the plurality of pieces of the variable data.

[Claim 8] The data processing apparatus according to claim 5,

further comprising a probability specification unit that, with use of the probability distribution estimated by the statistical processing unit, specifies a probability that the ship completely navigates the ship route within a predetermined time.

[Claim 9] The data processing apparatus according to claim 8,
 wherein the variable data acquisition unit acquires a plurality of pieces of the variable data,

 the statistical processing unit estimates a probability distribution of a population of samples that are the values calculated by the calculation unit, for each of the plurality of pieces of the variable data, and

 the probability specification unit specifies a second variable according to which the ship completely navigates the ship route within a predetermined time with a predetermined probability, with use of the probability distributions estimated by the statistical processing unit for the plurality of pieces of the variable data.

[Claim 10] The data processing apparatus according to any one of claims 1 to 9,

 further comprising a loading amount data acquisition unit that acquires loading amount data that indicates a loading amount in navigation of the ship along the ship route,

 wherein for each of a plurality of the loading amounts, the performance data acquisition unit acquires the performance data that indicates a relationship between the first variable and the second variable in a case where the ship navigates while carrying cargo corresponding to the loading amount, and

 the calculation unit performs the calculation with use of the performance data regarding the loading amount indicated by the loading amount data.

- [Claim 11] A program for causing a computer to execute processing of:
- acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment;
 - acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period;
 - acquiring variable data that indicates a designated value related to the first variable in a case where the ship navigates a ship route that passes through the one or more sea areas;
 - calculating, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the second variable and a fuel consumption amount required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and
 - calculating a statistical value of the values that are related to the second variable or the fuel consumption amount and were calculated for the plurality of past times.

- [Claim 12] A computer-readable storage medium permanently storing a program for causing a computer to perform processing of:
- acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment;

acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period;

acquiring variable data that indicates a designated value related to the first variable in a case where the ship navigates a ship route that passes through the one or more sea areas;

calculating, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the second variable and a fuel consumption amount required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and

calculating a statistical value of the values that are related to the second variable or the fuel consumption amount and were calculated for the plurality of past times.

[Claim 13] A program for causing a computer to execute processing of:

acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment;

acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period;

acquiring variable data that indicates a designated value related to the second variable in a case where the ship navigates a ship route that passes through the one or more sea areas;

calculating, with use of the performance data and the

weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the first variable and a time required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and

calculating a statistical value of the values that are related to the first variable or the time and were calculated for the plurality of past times.

[Claim 14] A computer-readable storage medium permanently storing a program for causing a computer to perform processing of:

acquiring performance data that, for each of a plurality of weather/maritime environments, indicates a relationship between a first variable correlated with a navigation speed and a second variable correlated with a fuel consumption per unit time in a case where a ship navigates in the environment;

acquiring weather/maritime condition data that, for each of a plurality of past time periods, indicates a weather/maritime condition in one or more sea areas in the time period;

acquiring variable data that indicates a designated value related to the second variable in a case where the ship navigates a ship route that passes through the one or more sea areas;

calculating, with use of the performance data and the weather/maritime condition data, for each of a plurality of past times, a value that indicates one of a value related to the first variable and a time required for navigation in a case where the ship navigates the ship route from the time as a departure time while maintaining the value indicated by the variable data; and

calculating a statistical value of the values that are related to the first variable or the time and were calculated for the plurality of

past times.