

SPECIFICATION

TITLE OF INVENTION:

DEVICE, PROGRAM, RECORDING MEDIUM AND METHOD FOR
DETERMINING A SHIP SPEED

TECHNICAL FIELD

- [0001] The present invention pertains to a technique of determining a ship speed.
- [0002] A ship speed (for example, a ship speed over ground) varies depending on meteorological/hydrographic conditions (such as wind speed, wind direction, wave height, tidal conditions, etc.) that the ship encounters during a voyage. Accordingly, when a ship with a certain load takes a route, for example, under a constant power of a driving device (such as an engine) for driving a propeller of the ship or at a constant speed through water, time required for the ship to complete the whole route may vary.
- [0003] Accordingly, if the ship is required to arrive at a destination point at an estimated arrival time, a ship operator needs to navigate the ship while adjusting the ship speed according to meteorological/hydrographic conditions that the ship encounters during the voyage. Therefore, when the operator makes an incorrect judgment on the meteorological/hydrographic environment, the ship may fail to arrive at the destination point by the estimated arrival time, or the ship may arrive at the destination point much earlier than the estimated arrival time and the ship may be forced to anchor or drift for a long time off a port at the destination point.
- [0004] Some techniques for avoiding the above explained inconvenience have been proposed. For example, patent document 1 proposes a system that calculates ship speeds for each of plural sections of the route so that the ship arrives at the destination point at the estimated arrival time while satisfying a condition that the ship speed through water under tidal conditions forecasted for each of the plural sections of the route is constant by solving simultaneous equations, and automatically controls blade angle of the propeller to allow the ship be propelled at the calculated ship speeds.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0005] Patent Document 1: JP2004-025914

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] Fuel consumption required for a ship to complete a voyage varies depending on distribution of navigation speeds of the ship (ship speeds) for each section of the route. For example, when fuel consumption required for a ship to complete a voyage within a predetermined time period at a constant speed pertaining to the entire route and fuel consumption required for the ship to complete the voyage within the predetermined time period at a high speed pertaining to the first half of the voyage and at a low speed pertaining to the last half of the voyage are compared with each other, the latter is generally larger than the former.

[0007] Accordingly, when a ship speed is determined so that only a condition that the ship should arrive at a destination point at an estimated arrival time is met, fuel consumption may become higher than expected. Since crude oil prices have risen recently, this may cause a serious problem to management of a shipping company if fuel consumption for operation of the ship exceeds estimates.

[0008] In view of the foregoing circumstances, the purpose of the present invention is to provide a means for operating a ship to complete a voyage without exceeding planned fuel consumption for the voyage.

MEANS FOR SOLVING THE PROBLEM

[0009] To solve the above explained problem, this invention provides a device comprising: a means for obtaining planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point; a means for obtaining environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point; a means for obtaining actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and a means for determining ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned

fuel consumption data.

- [0010] In a preferred embodiment of the above mentioned device, the means for determining ship speed specifies plural values of estimated fuel consumption each of which is estimated to be required for the ship to sail from the current location of the ship to the destination point in the environment indicated by the environment data at a selected one of plural values of ship speed, and determines one of the plural values of ship speed that causes a value of estimated fuel consumption not exceeding a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data as the ship speed for the voyage of the ship from the current location of the ship to the destination point.
- [0011] In a preferred embodiment of the above mentioned device, the means for determining ship speed stores data indicating plural values of fuel consumption each of which is estimated to be required for the ship to sail in one of various conditions each of which is defined by a combination of environment and ship speed for the voyage; and the means for determining ship speed specifies plural values of fuel consumption each of which is estimated to be required for the ship to sail in the environment indicated by the environment data at a selected one of the plural values of ship speed on the basis of the stored data.
- [0012] In a preferred embodiment of the above mentioned device, the means for determining ship speed determines the estimated fuel consumption on the basis of the actual fuel consumption data.
- [0013] In a preferred embodiment of the above mentioned device, the means for determining ship speed assigns ship speed to each of plural sections divided from the route from the current location of the ship to the destination point, specifies fuel consumption that is estimated to be required for the ship to sail in a section sequentially selected from the plural sections at ship speed assigned to the selected section, and specifies a sum of plural values of fuel consumption each of which is specified for each of the plural sections as the estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point.
- [0014] In a preferred embodiment of the above mentioned device, the environment data indicating meteorological and/or hydrographic environment pertaining to each of plural timings; and the means for determining ship speed specifies fuel consumption that is estimated to be required for the ship to sail in a section sequentially selected from the plural sections in an environment indicated by the environment data

pertaining to a timing when the ship sails in the selected section at ship speed assigned to the selected section, and specifies a sum of plural values of fuel consumption each of which is specified for each of the plural sections as the estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point.

[0015] In a preferred embodiment of the above mentioned device, the means for determining ship speed repeatedly performs a process for specifying estimated fuel consumption that is estimated to be required for the voyage of the ship from the current location of the ship to the destination point in each of plural cases where ship speed assigned to one or more sections selected from the plural sections is changed in accordance with a predetermined rule, and a process for selecting a set of plural values of ship speed assigned to the plural sections, from among the sets of plural values of ship speed each of which is used for specifying the estimated fuel consumption, that causes a minimum estimated fuel consumption, until a set of plural values of ship speed that causes a minimum estimated fuel consumption not exceeding the value calculated by subtracting is selected, for determining the ship speed from the current location of the ship to the destination point.

[0016] In a preferred embodiment of the above mentioned device, the means for determining ship speed determines the ship speed from the current location of the ship to the destination point in a form of rotation speed of propeller used for the voyage of the ship.

[0017] In a preferred embodiment of the above mentioned device, the means for determining ship speed determines the ship speed from the current location of the ship to the destination point in a form of combination of rotation speed and blade angle of the propeller used for the voyage of the ship.

[0018] This invention also provides a program that causes a computer to execute: a process of obtaining planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point; a process of obtaining environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point; a process of obtaining actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and a process of determining ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the

ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.

[0019] This invention also provides a storage medium capable of reading from a computer that continuously stores the program that causes a computer to execute: a process of obtaining planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point; a process of obtaining environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point; a process of obtaining actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and a process of determining ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.

[0020] This invention also provides a method comprising: a step in which a device obtains planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point; a step in which the device obtains environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point; a step in which the device obtains actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and a step in which the device determines ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.

EFFECTS OF THE INVENTION

[0021] The present invention allows fuel consumption required for a ship to complete a voyage from a current location to a destination point to be estimated in accordance with predicted meteorological/hydrographic environment that the ship encounters during the voyage, and a target ship speed is determined so that a sum of actual fuel consumption pertaining to a part of the voyage that has already been completed and the estimated fuel consumption pertaining to a part of the voyage that is yet to be completed should not exceed a planned fuel consumption pertaining to the entire voyage. When the ship is operated to sail at the target ship speed, fuel consumption actually required for the entire voyage does not exceed the planned fuel consumption for the entire voyage (a predetermined threshold value).

BRIEF EXPLANATION OF THE DRAWINGS

[0022] [Fig. 1] A drawing illustrating an overall configuration of a ship speed determination system in one exemplary embodiment of the present invention.

[Fig. 2] A drawing illustrating a hardware configuration of a ship terminal device, a ship speed determination server device and meteorological/hydrographic forecast data distribution service device in one exemplary embodiment of the present invention.

[Fig. 3] A drawing illustrating a functional configuration of the ship terminal device in one exemplary embodiment of the present invention.

[Fig. 4] A drawing illustrating a functional configuration of the ship speed determination server device in one exemplary embodiment of the present invention.

[Fig. 5] A drawing illustrating a data configuration of a sample DB (database) in one exemplary embodiment of the present invention.

[Fig. 6] A drawing illustrating a flow of processes executed by the ship speed determination system before the ship departs in one exemplary embodiment of the present invention.

[Fig. 7] A drawing illustrating correspondences between legs used for determination of target ship speeds and parameters for each of the legs such as ship speeds in one exemplary embodiment of the present invention.

[Fig. 8] A drawing illustrating an example page shown on a display of the ship terminal device in one exemplary embodiment of the present invention.

[Fig. 9] A drawing illustrating a flow of processes executed by the ship speed determination system during a voyage in one exemplary embodiment of the present invention.

[Fig. 10] A drawing illustrating a relation between time and fuel consumption when the ship sails at a ship speed determined by the ship speed determination system in one exemplary embodiment of the present invention.

MODES FOR CARRYING OUT THE INVENTION

[0023] [1. Exemplary Embodiment]

Ship speed determination system (1) in one exemplary embodiment of the present invention will be explained hereafter. Ship speed determination system (1) is a system to inform a ship operator continuously of a desirable ship speed (navigation speed) when the ship departs on a voyage and while the ship sails so that fuel consumption required for the ship to sail from the departure point to the destination point should not exceed a predetermined amount.

[0024] [1.1. Configuration]

Firstly, the configuration of ship speed determination system (1) is explained. Fig. 1 is a drawing schematically illustrating the overall configuration of ship speed determination system (1). Ship speed determination system (1) is provided with ship terminal device (11) located on ship (9) and used by the operator of ship (9). Ship (9) takes a route from departure point (S) to destination point (E).

[0025] Ship speed determination system (1) is further provided with ship speed determination server device (12) that wirelessly communicates with ship terminal device (11) via communication satellite (8) and transmits target ship speed data indicating desirable ship speed for ship (9) (hereafter referred to as "target ship speed") to ship terminal device (11). Target ship speed is an estimated ship speed meeting the condition that fuel consumption pertaining to the entire voyage from departure point (S) to destination point (E) would not exceed the fuel consumption that is planned prior to the voyage (hereafter referred to as "planned fuel consumption") if ship (9) sails at the target ship speed. A method for determining the target ship speed will be explained in the latter section of this specification pertaining to operation of the system.

[0026] Ship speed determination system (1) is further provided with meteorological/hydrographic forecast data distribution service device (13) that distributes meteorological/hydrographic forecast data (functioning as environment data) to ship speed determination server

device (12). Meteorological/hydrographic forecast data is data indicating meteorological or hydrographic conditions that ship (9) encounters at various timings during the voyage, and is provided from a company that forecasts meteorological/hydrographic conditions in various areas in the world.

[0027] Each of ship terminal device (11), ship speed determination device (12) and meteorological/hydrographic forecast data distribution service device (13) is a general computer provided with a communication means for performing data communication with external information processing devices via a network. That is, each of ship terminal device (11), ship speed determination server device (12) and meteorological/hydrographic forecast data distribution service device (13), as illustrated in fig. 2, is provided with CPU (101) that processes various data in accordance with a program, ROM (102) that stores a basic program such as BIOS, RAM (103) that temporarily stores data and which CPU (101) uses as an operation region, HDD (104) that stores an OS, programs such as an application program or various other data, communication IF (interface) (105) that performs data communication with other external information processing devices, and an input/output IF (106) that performs input/output of various data with external devices such as a display device and a keyboard.

[0028] Fig. 3 is a drawing schematically illustrating a functional configuration of ship terminal device (11). That is, ship terminal device (11) functions as a device provided with functional configuration parts as illustrated in fig. 3 by executing a processing in accordance with an application program stored in HDD (104) of ship terminal device (11).

[0029] Ship terminal device (11) is provided with, as a functional configuration part, navigation log data receiving means (111) for receiving navigation log data from sensors (91) located on ship (9). Navigation log data is data indicating meteorological/hydrographic environment such as wind conditions that ship (9) actually encountered on the route from departure point (S) to the current location (hereafter referred to as "current point (K)"), the route on which ship (9) actually navigated, etc. Specifically, navigation log data includes several types of data such as data indicating current location of ship (9), data indicating ship speed over ground or ship speed through water, data indicating wind direction or wind speed, data indicating wave height, wave direction, or wave period, data indicating heading of ship (9), data indicating propeller rotating speed, data indicating fuel consumption (fuel flow rate) and the like.

[0030] Sensors (91) are located on ship (9) for generating the above-explained navigation log data. Sensors (91) include various types of sensors; for example, a GPS for specifying current location of ship (9), a ship speed sensor for measuring ship speed through water, a wind sensor for measuring wind direction and wind speed, a wave sensor for measuring wave height, wave direction and wave period, a heading sensor for measuring heading of ship (9), a fuel flow sensor for measuring fuel consumption, and the like.

[0031] Ship terminal device (11) is further provided with, as functional configuration parts, navigation log data transmission means (112) for transmitting navigation log data that navigation log data receiving means (111) received from sensors (91) to ship speed determination server device (12), target ship speed data receiving means (113) for receiving target ship speed data that is transmitted from ship speed determination server device (12) in response to the transmission of navigation log data transmission means (112), and notification means (114) for notifying a target ship speed indicated by the target ship speed data that target ship speed data receiving means (113) received to the operator of ship (9).

[0032] Fig. 4 is a drawing schematically illustrating a functional configuration of ship speed determination server device (12). That is, ship speed determination server device (12) functions as a device provided with functional configuration parts as illustrated in fig. 4 by executing a processing in accordance with an application program stored in HDD (104) of ship speed determination server device (12).

[0033] Ship speed determination server device (12) is provided with, as a functional configuration part, navigation parameter obtaining means (121) (functioning as a means for obtaining planned fuel consumption data) for obtaining navigation parameter data. Navigation parameter data is data indicating parameters that are basically unchanged during the entire voyage of ship (9), and navigation parameter data includes data that is determined by a person such as route data indicating the route of ship (9), departure time data indicating the departure time, target arrival time data indicating a target arrival time and planned fuel consumption data indicating planned fuel consumption, data that indicates state of ship (9) (parameter affecting performance of the ship) such as draft data indicating draft of ship (9), trim data indicating trim (i.e. longitudinal lean) of ship (9), ship hull fouling data indicating degree of ship hull fouling and propeller fouling data indicating degree of propeller fouling, and other types of data such as data indicating propeller rotation speed.

[0034] Draft data and trim data may be data indicating values measured

visually by a person such as the ship operator when, for example, loading of ship (9) has been completed, and input by the person to ship terminal device (11), or data indicating values measured by a sensor included in sensors (91) such as a trim sensor and transmitted from the sensor to ship terminal device (11). Draft data and trim data may be transmitted from ship terminal device (11) to ship speed determination server device (12) via communication satellite (8) before initiation of the navigation. Some data indicating navigation parameters that are determined by a person such as route data may be determined by a shipping manager who manages the navigation of ship (9) on shore, and directly input to ship speed determination server device (12) by the shipping manager. Some data indicating navigation parameters that indicates states of ship (9) such as ship hull fouling data may be estimated by the shipping manager on shore on the basis of number of years of usage of ship (9) or the like, and directly input to ship speed determination server device (12) by the shipping manager.

[0035] Ship speed determination server device (12) is further provided with, as function configuration parts, meteorological/hydrographic forecast data receiving means (122) (functioning as a means for obtaining environment data) for receiving meteorological/hydrographic forecast data from meteorological/hydrographic forecast data distribution service device (13), and navigation log data receiving means (123) (functioning as a means for obtaining actual fuel consumption data) for receiving navigation log data transmitted from ship terminal device (11). Ship speed determination server device (12) is further provided with, as functional configuration parts, target ship speed determination means (124) (functioning as a means for determining ship speed) for determining target ship speed on the basis of navigation parameters, navigation log data and meteorological/hydrographic forecast data, and generating target ship speed data, and target ship speed data transmission means (125) for transmitting the target ship speed data to ship terminal device (11).

[0036] Target ship speed determination means (124) of ship speed determination server device (12) is provided with storage means (1241), and storage means (1241) stores sample DB (database) managing sample data (functioning as data indicating fuel consumption under each environment for each ship speed) indicating fuel consumption rate of ship (9) under each of various conditions. Fig. 5 is a drawing illustrating data configuration of sample DB. Sample data managed by sample DB has data fields storing parameters indicating conditions pertaining to the

voyage of ship (9) such as wind direction, wind speed, wave height, wave direction, wave period, tide speed, tide direction, draft, trim, ship hull fouling, propeller fouling, propeller rotating speed and ship speed over ground, and a data field storing fuel consumption rate when ship (9) sails under the conditions indicated by the parameters.

[0037] Sample data managed by sample DB may indicate parameters such as wind direction, ship speed over ground, etc. input to a physical simulation model (since the model is a known technique, explanation of the model is omitted) of ship (9) in a computer, and may indicate fuel consumption rate calculated by the computer.

[0038] [1.2. Operation]

Next, operation of ship speed determination system (1) is explained. Fig. 6 is a drawing illustrating a flow of processing executed by ship speed determination system (1) for determining target ship speed before ship (9) departs. The processing for determining target ship speed before the voyage of ship (9) may be triggered by a completion of input of navigation parameters to ship speed determination server device (12) performed by the shipping manager on shore. When the shipping manager on shore inputs navigation parameters to ship speed determination server device (12) and ship speed determination server device (12) obtains the navigation parameters (S001), ship speed determination server device (12) generates request data instructing transmission of meteorological/hydrographic forecast data, and transmits the request data to meteorological/hydrographic forecast data distribution service device (13) (S002). The request data contains the route data indicating the route included in the navigation parameters.

[0039] Meteorological/hydrographic forecast data distribution service device (13) extracts the latest meteorological/hydrographic forecast data pertaining to each of areas on the route indicated by the route data contained in the request data received from ship speed determination server device (12), and transmits the meteorological/hydrographic forecast data to ship speed determination server device (12) (S003).

[0040] When target ship speed determination means (124) of ship speed determination server device (12) obtains the meteorological/hydrographic forecast data transmitted from meteorological/hydrographic forecast data distribution service device (13), target ship speed determination means (124) initiates a series of processes for determining target ship speed. Target ship speed determination means (124) sets ship speed for each of plural sections (hereafter referred to as "legs") constituting the route from departure

point (S) to destination point (E) whose number is n , and calculates estimated fuel consumption when ship (9) sails at the set ship speed in each leg. Hereafter, the i^{th} leg (i is a natural number equal to or less than n) in the order on the route is referred to as "leg (i)."

[0041] Border points (starting point and ending point) of each leg on the route may be determined by the ship operator or the shipping manager on shore, and data indicating the determined border points of each leg may be input to ship speed determination server device (12) as a part of the route data.

[0042] Fig. 7 is a drawing illustrating correspondences between the legs and parameters for each of the legs such as ship speeds. A series of processes performed by target ship speed determination means (124) for determining target ship speed are explained below by referring to fig. 6 and fig. 7. Distance (l_i) - distance (l_n) are distances of leg (1) - leg (n) respectively, and they are fixed values specified by the data indicating the border points of each leg included in the route data.

[0043] Target ship speeds that target ship speed determination means (124) is required to determine are ship speed (v_1) - ship speed (v_n) that are desirable ship speeds over ground at which ship (9) should sail in leg (1) - leg (n) respectively. Desirable ship speed (v_1) - desirable ship speed (v_n) are ship speeds achieving a condition that fuel consumption pertaining to the entire voyage should not exceed the planned fuel consumption.

[0044] First, target ship speed determination means (124) sets ship speed (v_1) - ship speed (v_n) meeting the following conditions as initial values of provisional target ship speeds (S004). Provisional target ship speeds are ship speeds that are candidates of target ship speeds.
(Condition 1) Estimated arrival time (referred to as " t_n " in the latter part of this specification) matches the target arrival time.
(Condition 2) Provisional ship speed (v_1) - provisional ship speed (v_n) are constant. (Namely, $v_1 = v_2 = \dots = v_n$.)

[0045] Provisional ship speed (v_1) - provisional ship speed (v_n) meeting the above mentioned conditions 1 and 2 are calculated, for example, by the formula like $v_1 = v_2 = \dots = v_n = (\text{total distance of the route}) / ((\text{target arrival time}) - (\text{departure time}))$.

[0046] Next, target ship speed determination means (124) calculates voyage time (T_1) - voyage time (T_n) for leg (1) - leg (n) respectively by the below formula.

[Equation 1]

$$T_i = \frac{l_i}{v_i}$$

(i is a natural number equal to or less than n.)

- [0047] Next, target ship speed determination means (124) calculates time (t_1) - time (t_n) that are estimated times when ship (9) arrives at the ending points of leg (1) - leg (n) respectively by the below formula.
[Equation 2]

$$t_i = t_0 + \sum_{j=1}^i T_j$$

(t_0 is departure time when ship (9) leaves the departure point (S).)

- [0048] Next, target ship speed determination means (124) specifies parameters indicating meteorological/hydrographic conditions that ship (9) will probably encounter when ship (9) sails each of leg (1) - leg (n) on the basis of the meteorological/hydrographic forecast data. The parameters indicating meteorological/hydrographic conditions are, for example, values of wind direction, wind speed, wave height, wave direction, wave period, tide speed, tide direction and the like. Hereafter, the parameters specified for leg (i) are referred to as "parameters (E_i)."

- [0049] Areas for which the meteorological/hydrographic forecast data indicates the parameters such as wind direction and legs do not necessarily correspond to each other. Namely, some parameters indicated by the meteorological/hydrographic forecast data may be values of wind directions, etc. pertaining to an area covering plural legs. Moreover, plural parameters of one type of meteorological/hydrographic condition such as wind direction may be obtained for one leg. In this case, target ship speed determination means (124) may specify the parameter for the leg by, for example, calculating a weighted average in accordance with coverage ratios of the plural areas corresponding to the plural parameters.

- [0050] Next, target ship speed determination means (124) specifies fuel consumption rate (e_i) when ship (9) sails leg (i) by referring to sample DB (fig. 5). Specifically, when parameters pertaining to draft and trim included in the navigation parameters are referred to as "parameters (S)" and parameters pertaining to ship hull fouling and propeller fouling included in the navigation parameters are referred to as "parameters (D)," target ship speed determination means (124) extracts, from sample DB, sample data that meets all of the below conditions, and specifies fuel

consumption rate (e_i) by a known interpolation processing on the basis of plural fuel consumption rates indicated by the extracted plural data sets of sample data.

The extracted sample data should contain parameters pertaining to wind direction - tide direction each of which is close to a corresponding parameter of parameters (E_i). (Specifically, a value of the parameter contained in the extracted sample data should fall in a range of a predetermined width whose middle value is a value of the corresponding parameter of parameters (E_i).)

The extracted sample data should contain parameters pertaining to draft and trim each of which is close to corresponding parameter of parameters (S). (Specifically, a value of the parameter contained in the extracted sample data should fall in a range of a predetermined width whose middle value is a value of the corresponding parameter of parameters (S).)

The extracted sample data should contain parameters pertaining to ship hull fouling and propeller fouling each of which is close to corresponding parameter of parameters (D). (Specifically, a value of the parameter contained in the extracted sample data should fall in a range of a predetermined width whose middle value is a value of the corresponding parameter of parameters (D).)

[0051] Next, target ship speed determination means (124) calculates estimated fuel consumption-per-leg (f_1) - estimated fuel consumption-per-leg (f_n) that are estimated fuel consumptions when ship (9) navigates in each of leg (1) - leg (n) at provisional target ship speed (v_1) - provisional target ship speed (v_n) respectively by the below formula.

[Equation 3]

$$f_i = e_i \times T_i$$

[0052] Next, target ship speed determination means (124) calculates provisional estimated fuel consumption (F_F) that is estimated fuel consumption when ship (9) sails on the route from current location (K) (in this case, departure point (S)) to destination point (E) at provisional target speed (v_i) - provisional target speed (v_n) by the below formula (S005).

[Equation 4]

$$F_F = \sum_{i=1}^n f_i$$

[0053] After target ship speed determination means (124) calculates provisional estimated fuel consumption (F_F) that is estimated fuel

consumption when ship (9) sails at the provisional target ship speeds in each of the legs as explained above, target ship speed determination means (124) judges whether calculated provisional estimated fuel consumption (F_F) is equal to or less than planned fuel consumption (F_{MAX}) (S006). Planned fuel consumption (F_{MAX}) is indicated by the planned fuel consumption data included in the navigation parameters.

[0054] When it is judged in step S006 that provisional estimated fuel consumption (F_F) exceeds planned fuel consumption (F_{MAX}) (S006; No), target ship speed determination means (124) sequentially selects provisional target ship speed (v_i) from among provisional target ship speed (v_1) - provisional target ship speed (v_n) that are currently set, calculates provisional estimated fuel consumption (F_F) when selected provisional target ship speed (v_i) is decreased by a predetermined ratio (or changed by a value determined by a certain rule like decreased by a predetermined value), and specifies the minimum value of provisional estimated fuel consumption (F_F) from among the plural values of provisional estimated fuel consumption (F_F) calculated pertaining to each selected provisional target ship speed (v_i).

[0055] Specifically, first, target ship speed determination means (124) substitutes "1" for the variable "i" (S007). Next, target ship speed determination means (124) multiplies " v_i " by "c" ($c < 1$) that is a predetermined constant (S008). Next, target ship speed determination means (124) calculates provisional estimated fuel consumption ($F_F(i)$) corresponding to a set of provisional target ship speed (v_1) - provisional target ship speed (v_n) including provisional target ship speed (v_i) decreased by being multiplied by "c" in step S008 (S009). Target ship speed determination means (124) calculates provisional estimated fuel consumption ($F_F(i)$) in step S009 in the same way as it calculates provisional estimated fuel consumption (F_F) in step S005.

[0056] Next, target ship speed determination means (124) temporarily stores provisional estimated fuel consumption ($F_F(i)$) calculated in step S009 in storage means (1241) (S010), and restores provisional target ship speed (v_i) that is decreased by being multiplied by "c" to its original value by, for example, dividing the decreased value by "c" (S011). Next, target ship speed determination means (124) judges whether the current variable "i" is equal to "n" (S012). When the current variable "i" is not equal to "n" (S012; No), target ship speed determination means (124) increases "i" by "1" (S013), and repeats a series of processes in step S008 - step S012. As a result, provisional estimated fuel consumption ($F_F(1)$) - provisional estimated fuel consumption ($F_F(n)$) are temporarily stored in

storage means (1241).

- [0057] Next, target ship speed determination means (124) specifies provisional estimated fuel consumption ($F_F(j)$) (j is a natural number equal to or less than n) that indicates the minimum value among provisional estimated fuel consumption ($F_F(1)$) - provisional estimated fuel consumption ($F_F(n)$) (S014). Next, target ship speed determination means (124) multiplies provisional target ship speed (v_j), that is restored to the original value in step S001, by "c" so that provisional target ship speed (v_j) becomes the value used for calculation of provisional estimated fuel consumption ($F_F(j)$) that indicates the minimum value (S015). Next, target ship speed determination means (124) repeats the process in step S006 treating provisional estimated fuel consumption ($F_F(j)$) specified in step S014 as new provisional estimated fuel consumption (F_F). Namely, target ship speed determination means (124) judges whether new provisional estimated fuel consumption (F_F) is equal to or less than planned fuel consumption (F_{MAX}).
- [0058] Next, target ship speed determination means (124) repeats the series of processes in step S006 - step S015 until it is judged that provisional estimated fuel consumption (F_F) is equal to or less than planned fuel consumption (F_{MAX}). When it is judged that provisional estimated fuel consumption (F_F) is equal to or less than planned fuel consumption (F_{MAX}) in step S006 (S006; Yes), target ship speed determination means (124) determines ship speed (v_1) - ship speed (v_n) that are currently set as provisional target ship speed (v_1) - provisional target ship speed (v_n) as target ship speed (v_1) - target ship speed (v_n) (S016).
- [0059] After target ship speed determination means (124) determines target ship speed (v_1) - target ship speed (v_n) as explained above, ship speed determination server device (12) transmits target ship speed data indicating target ship speed (v_1) - target ship speed (v_n) to ship terminal device (11) (S017). Ship terminal device (11) instructs a display connected to ship terminal device (11) to show target ship speed (v_1) for the first leg, i.e. leg (1), indicated by the target ship speed data received from ship speed determination server device (12) (S018).
- [0060] Fig. 8 is a drawing schematically illustrating an example of a page shown on the display connected to ship terminal device (11) in step S018. The ship operator is notified of a desirable ship speed at which ship (9) should sail in leg (1) by referring to the page illustrated in fig. 8. The ship speed notified to the ship operator is a ship speed for the leg that ship (9) is about to enter or on which ship (9) is currently sailing. Accordingly, the target ship speed data transmitted from ship speed

determination server device (12) to ship terminal device (11) in step S017 does not need to indicate all of target ship speed (v_1) - target ship speed (v_n) determined in step S016, and it is only required that the target ship speed data should indicate at least target ship speed (v_1) for leg (1).

[0061] An explanation of a series of processes that are performed by ship speed determination system (1) before ship (9) departs is as described above. It should be noted that ship (9) is not required to arrive at the destination point (E) by the target arrival time when ship (9) sails at the target ship speed determined by ship speed determination system (1). Accordingly, ship speed determination system (1) is useful when the condition that fuel consumption that is actually required for the voyage should not exceed the planned fuel consumption is a top priority, and the target arrival time may be changed because of meteorological/hydrographic conditions that ship (9) encounters during the voyage.

[0062] The ship operator operates ship (9) to start the voyage from departure point (S), i.e. the starting point of leg (1), at the target ship speed shown in the page illustrated in fig. 8. Ship speed determination system (1) continuously updates the target ship speed at regular intervals during the voyage of ship (9). Next, a series of processes performed by ship speed determination system (1) while ship (9) sails are explained.

[0063] Fig. 9 is a drawing illustrating a flow of processes executed by ship speed determination system (1) for updating the target ship speed while ship (9) sails. Most of the processes in the flow illustrated in fig. 9 (the processes executed during the voyage) are the same as or similar to the processes in the flow illustrated in fig. 6 (the processes executed before the voyage). Accordingly, the processes illustrated in fig. 9 that are the same as or similar to the processes illustrated in fig. 6 are specified by step numbers used in fig. 6 for the corresponding processes with an apostrophe ('). For example, a process in step S002' in fig. 9 is the same as or similar to the process in step S002 in fig. 6. Hereafter, it is assumed that current location (K) of ship (9) during the voyage is in leg (k) (k is a natural number that is equal to or less than n), and distance between the starting point of leg (k) and current location (K) is as assumed to be distance (l_k) of entire leg (k) multiplied by a (a is zero or positive real number less than 1).

[0064] Ship terminal device (11) generates navigation log data by use of data continuously received from sensors (91) of ship (9), and transmits the newly generated navigation log data to ship speed determination server device (12) at regular intervals (S101). As already described, the

navigation log data contains data indicating fuel consumption that ship (9) actually used for the voyage (fuel flow rate). Ship speed determination server device (12) stores the navigation log data received from ship terminal device (11) in storage means (1241) (S102).

[0065] Target ship speed determination means (124) of ship speed determination server device (12) initiates a series of processes for updating the target ship speed each time the navigation log data is received from ship terminal device (11) and stored in storage means (1241) at regular intervals. First, target ship speed determination means (124) specifies actual fuel consumption (F_P) that is required for the navigation of ship (9) from departure point (S) to current location (K) on the basis of the navigation log data (specifically data indicating fuel flow rate) stored in storage means (1241) pertaining to the navigation from departure point (S) to current location (K) (S103).

[0066] Next, target ship speed determination means (124) transmits request data for meteorological/hydrographic forecast data pertaining to the areas covering the route from current location (K) to destination point (E) to meteorological/hydrographic forecast data distribution service device (13) (S002'). Meteorological/hydrographic forecast data distribution service device (13) transmits the latest meteorological/hydrographic forecast data in response to the request data to ship speed determination server device (12) (S003')

[0067] Next, target ship speed determination means (124) calculates provisional estimated fuel consumption (F_F) by treating target ship speed (v_k) - target ship speed (v_n) that are currently set as the provisional target ship speeds by use of the latest meteorological/hydrographic forecast data received in step S003' (S005').

[Equation 5]

$$F_F = f_k \times (1 - a) + \sum_{i=k+1}^n f_i$$

[0068] Namely, in step S005', target ship speed determination means (124) calculates a sum of estimated fuel consumption required for ship (9) to sail the remaining part of leg (k) where ship (9) is currently sailing (the first term of the above formula) and estimated fuel consumption required for ship (9) to sail leg (k+1) - leg (n) (the second term of the above formula) as provisional estimated fuel consumption (F_F) pertaining to current location (K).

[0069] Next, target ship speed determination means (124) judges whether provisional estimated fuel consumption (F_F) is equal to or less than a

value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}) (i.e. F_F is equal to or less than ($F_{MAX} - F_P$)) (S006').

[0070] When it is judged that provisional estimated fuel consumption (F_F) exceeds the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}) in step S006' (S006'; No), target ship speed determination means (124) executes processes in step S007' - step S015' that are almost the same as the processes in step S007 - step S015 in fig. 6. The processes in step S007' - step S015' only differ from the processes in step S007 - step S015 in the point that provisional target ship speed (v_k) - provisional target ship speed (v_n) are used in step S007' - step S015' instead of provisional target ship speed (v_1) - provisional target ship speed (v_n) used in step S007 - step S015.

[0071] Next, target ship speed determination means (124) repeats the series of processes in step S006' - step S015' until provisional estimated fuel consumption (F_F) becomes equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}). When it is judged that provisional estimated fuel consumption (F_F) is equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}) in step S006' (S006'; Yes), target ship speed determination means (124) determines ship speed (v_k) - ship speed (v_n) that are currently set as provisional target ship speed (v_k) - provisional target ship speed (v_n) as target ship speed (v_k) - target ship speed (v_n) (S016').

[0072] Fig. 10 is a drawing illustrating a relation between time and fuel consumption pertaining to the entire voyage from departure point (S) to destination point (E) when ship (9) sails at target ship speed (v_k) - target ship speed (v_n) determined in step S016'. As shown in fig. 10, target ship speed determination means (124) specifies provisional estimated fuel consumption (F_F) so that the sum of actual fuel consumption (F_P) that is fuel consumption required for the voyage from departure point (S) to current location (K) and provisional estimated fuel consumption (F_F) that is estimated fuel consumption required for the voyage from current location (K) to destination point (E) does not exceed planned fuel consumption (F_{MAX}) that is fuel consumption allowed for the entire voyage from departure point (S) to destination point (E). Then, target ship speed determination means (124) determines provisional target ship speed (v_k) - provisional target ship speed (v_n) that cause the specified provisional estimated fuel consumption (F_F) as updated target ship speed (v_k) - target ship speed (v_n).

[0073] When target ship speed determination means (124) determines updated target ship speed (v_k) - target ship speed (v_n) as described above, ship speed determination server device (12) transmits updated target ship speed data indicating updated target ship speed (v_k) - target ship speed (v_n) to ship terminal device (11) (S017'). Ship terminal device (11) instructs the display to update information shown on the page illustrated in fig. 8 in accordance with the updated target ship speed data received from ship speed determination server device (12) (S018').

[0074] While ship (9) is sailing, the series of processes in step S101 - step S018' as described above are repeatedly executed at regular intervals, and the target ship speed is updated on the basis of latest actual fuel consumption (F_p) and the latest meteorological/hydrographic forecast data. An explanation of a series of processes that are performed by ship speed determination system (1) while ship (9) sails is as described above.

[0075] By use of ship speed determination system (1), when the ship operator operates ship (9) so that ship (9) sails at the target ship speed shown by the display, fuel consumption actually required for the entire navigation from departure point (S) to destination point (E) is controlled not to exceed the fuel consumption that is planned before the voyage is started (the planned fuel consumption).

[0076] [2. Modifications]

The embodiment described above is one specific example of the present invention, and can be modified within the scope of the technical ideas of the present invention. Examples of modifications are indicated below.

[0077] (1) In the embodiment described above, as illustrated in fig. 1, ship speed determination server device (12) is located on shore, and performs data communication with ship terminal device (11) via communication satellite (8). In place of the foregoing, ship speed determination server device (12) may be located on board ship (9). Moreover, ship terminal device (11) and ship speed determination server device (12) may be arranged inside one casing (specifically, for example, a single computer may execute the application program for ship terminal device (11) and the application program for ship speed determination server device (12)). In such a case, ship terminal device (11) and ship speed determination server device (12) do not need to perform data communication via communication satellite (8). Namely, when these devices are arranged in different casings from each other, they may perform data communication via a LAN provided in ship (9), and when they are arranged inside one casing, they may exchange data via a data bus. Moreover, when ship

speed determination server device (12) is located on board ship (9), ship speed determination server device (12) may perform data communication with meteorological/hydrographic forecast data distribution service device (13) via communication satellite (8).

[0078] (2) In the embodiment described above, processes for generating sample data (fig. 5), i.e. calculation of fuel consumption rate corresponding to each of various combinations of parameters (wind direction - ship speed over ground) by use of physical simulation model of ship (9) in a computer, are executed prior to the voyage, and the generated sample data is stored in storage means (1241) prior to the voyage. In place of the foregoing, when sample data is required for determining target ship speeds while ship (9) sails the required sample data may be generated by use of the physical simulation model.

[0079] Moreover, in place of using sample data generated by use of the physical simulation model for determining target ship speeds, a function formula expressing a relation between the parameters and fuel consumption rate may be specified prior to the voyage on the basis of sample data generated by use of the physical simulation model, and fuel consumption rate corresponding to the given parameters may be calculated in accordance with the function formula for determining target ship speeds.

[0080] (3) In the embodiment described above, sample data used for determining target ship speeds is generated by calculating fuel consumption rate corresponding to each of various combinations of parameters (wind direction - ship speed over ground) by use of physical simulation model of ship (9) in a computer. In addition to or in place of the foregoing, sample data indicating correspondence between parameters (wind direction - ship speed over ground) indicated by navigation log data obtained during a voyage that ship (9) performed in the past and fuel consumption rate (actual measured value) may be stored in sample DB, and the sample data obtained as described above may be used for the determination of target ship speeds.

[0081] In the modified embodiment described above, sample data generated from navigation log data pertaining to the current voyage of ship (9) may be preferentially used for determining target ship speeds compared to the other sample data (namely, sample data generated by use of the physical simulation model and sample data generated from navigation log data pertaining to a voyage that is different from the current voyage). In such a case, sample data indicating the actual conditions of ship (9) that is more accurate than sample data generated by use of the physical

simulation model in general is continuously stored in sample DB during the voyage, and the sample data stored in sample DB during the voyage is used for determining target ship speeds pertaining to the remaining part of the voyage. Accordingly, in such a case, ship (9) can perform better than in the other case, where sample data generated from navigation log data obtained in the current voyage is not preferentially used, such that ship (9) can arrive at the destination point (E) at a timing closer to the target arrival time than in the other case, without increase of fuel consumption.

[0082] (4) In the embodiment described above, target ship speed is determined for each of n sections (legs) divided from the route. Length of each of the legs may be selected in accordance with the purpose. For example, when a length of each leg is comparatively short, such as in a range from 0.1 nautical miles (185.2 meters) to 1 nautical mile (1852 meters), target ship speed is updated substantially in real time. If fuel efficiency decreases when ship speed is frequently changed, it may be preferable for a length of each leg to be comparatively long so that frequency of changing ship speed does not affect fuel efficiency.

[0083] Moreover, it is not necessarily required to divide the route into legs for determining target ship speed. For example, when a function formula is used for calculating fuel consumption rate in accordance with given parameters (wind direction - ship speed over ground) in place of using sample data for determining target ship speed (as in the modified embodiment (2) described above), provisional estimated fuel consumption (F_F) may be calculated by integrating values of the function formula pertaining to the remaining part of the voyage, and ship speed that causes provisional estimated fuel consumption (F_F) to be equal to or less than fuel consumption calculated by subtracting actual fuel consumption F_P from planned fuel consumption (F_{MAX}) may be determined as target ship speed, for example, at regular intervals. In such a case, target ship speed is determined at regular intervals, not for each of the legs. Moreover, the present invention may be used for determining target ship speed pertaining to only a partial section of the entire route of the voyage. In such a case, a selected point on the route is used instead of departure point or destination point.

[0084] (5) In the embodiment described above, ship terminal device (11) notifies the ship operator of target ship speed by instructing the display to show the target ship speed indicated by target ship speed data obtained from ship speed determination server device (12). In addition to or in place of the foregoing, ship terminal device (11) may calculate target

propeller rotation speed and/or target blade angle of propeller (when ship (9) is provided with a variable pitch propeller) for achieving the target ship speed, and instruct a control device for controlling propeller rotation speed and/or blade angle to achieve the target propeller rotation speed and/or the target blade angle by outputting instruction data to the control device.

[0085] (6) In the embodiment described above, ship speed determination server device (12) determines target ship speed (v_k) - target ship speed (v_n) in the form of speed. When ship (9) is provided with a fixed pitch propeller, ship speed (ship speed through water) of ship (9) is a monotonically increasing function of propeller rotation speed in general. Accordingly, ship speed determination server device (12) may determine target ship speed in the form of propeller rotation speed like target ship speed (r_k) - target ship speed (r_n) (r_k - r_n are propeller rotation speeds pertaining to leg (k) - leg (n) respectively) in place of target ship speed (v_k) - target ship speed (v_n).

[0086] When ship (9) is provided with a variable pitch propeller, ship speed (ship speed through water) of ship (9) is specified by a combination of propeller rotation speed and blade angle of propeller. Accordingly, ship speed determination server device (12) may determine target ship speed in the form of a combination of propeller rotation speed and blade angle like target ship speed (r_k, p_k) - target ship speed (r_n, p_n) (r_k - r_n are propeller rotation speeds pertaining to leg (k) - leg (n) respectively, and p_k - p_n are blade angles pertaining to leg (k) - leg (n) respectively) in place of target ship speed (v_k) - target ship speed (v_n). In such a case, sample data (fig. 5) may include propeller rotation speed and blade angle in addition to or in place of ship speed through water, and target ship speed determination means (124) may use propeller rotation speed and blade angle contained in sample data as parameters indicating provisional target ship speed for determining target ship speed.

[0087] (7) In the embodiment described above, the series of processes for updating target ship speed performed while ship (9) sails (fig. 9) are initiated each time that navigation log data that is transmitted from ship terminal device (11) at regular intervals is received by ship speed determination server device (12). The series of processes for updating target ship speed performed while ship (9) sails may be initiated by another type of event. For example, the series of processes for updating target ship speed may be initiated at regular intervals by ship speed determination server device (12) independently from the transmission of navigation log data from ship terminal device (11) to ship speed

determination server device (12). When meteorological/hydrographic forecast data distribution service device (13) periodically transmits the latest meteorological/hydrographic forecast data to ship speed determination server device (12) without receiving any request from ship speed determination server device (12), ship speed determination server device (12) may initiate the series of processes for updating target ship speed each time that the latest meteorological/hydrographic forecast data is received.

[0088] (8) In the embodiment described above, each of ship terminal device (11) and ship speed determination server device (12) are implemented by executing a process according to an application program on a general computer. In place of the foregoing, at least one of ship terminal device (11) and ship speed determination server device (12) may implement the functional configuration units schematically illustrated in figs. 3 and 4 using hardware, that is, a so-called dedicated device.

[0089] (9) In the embodiment described above, when target ship speed determination means (124) determines target ship speed, target ship speed determination means (124) does not further seek a more desirable value of provisional estimated fuel consumption (F_F) after one value of provisional estimated fuel consumption (F_F) that is equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}) is found (S006 or S006'). In place of the foregoing, target ship speed determination means (124) may specify plural values of provisional estimated fuel consumption (F_F) each of which is equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}), and select the most desirable value according to a predetermined criterion from among the plural values of provisional estimated fuel consumption (F_F) (for example, select a value of provisional estimated fuel consumption (F_F) whose corresponding estimated arrival time (t_n) is the closest to the target arrival time, select the smallest value of provisional estimated fuel consumption (F_F), etc.) as the value of provisional estimated fuel consumption (F_F) used for determining target ship speed.

[0090] (10) In the embodiment described above, when target ship speed is determined before the voyage is started, ship speed (v_1) - ship speed (v_n) that are constant and cause estimated arrival time (t_n) to match the target arrival time are used as the initial provisional target ship speeds (S004). When target ship speed is updated during the voyage, ship speeds that are currently set as the target ship speeds are used as provisional target ship speeds. Provisional target ship speeds may be determined in accordance

with other rules. For example, ship speeds that were actually adopted in a voyage performed in the past under a similar condition to the condition that ship (9) encounters in the current voyage may be specified for each of the legs on the basis of sample data, and the specified ship speeds may be used as, for example, the initial provisional target ship speed.

[0091] In the embodiment described above, when target ship speed is determined before the voyage is started, target ship speed determination means (124) repeats decreasing a provisional target ship speed pertaining to a selected leg by a predetermined ratio, calculating provisional estimated fuel consumption (F_F) by use of the decreased provisional target ship speed, and selecting the smallest value from among the calculated values of provisional estimated fuel consumption (F_F) (S006 - S015 or S006' - S015') to seek provisional estimated fuel consumption (F_F) that is equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}). Provisional estimated fuel consumption (F_F) that is equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}) may be sought in accordance with another method. For example, target ship speed determination means (124) may randomly select plural provisional target ship speeds from the current provisional target ship speeds, change the selected provisional target ship speeds by a value randomly determined within a predetermined range, and calculate provisional estimated fuel consumption (F_F) by use of the changed plural provisional target ship speeds to seek provisional estimated fuel consumption (F_F) that is equal to or less than the value calculated by subtracting actual fuel consumption (F_P) from planned fuel consumption (F_{MAX}).

[0092] (11) In the embodiment described above, sample data (fig. 5) includes data indicating tide speed and tide direction, and data indicating ship speed over ground. In place of the foregoing, sample data may not include data indicating tide speed and tide direction, and may include data indicating ship speed through water instead of ship speed over ground. In such a case, when target ship speed determination means (124) determines target ship speed, target ship speed determination means (124) may calculate ship speed through water corresponding to provisional target ship speed, which is given in a form of ship speed over ground, on the basis of navigation direction indicated by the route data and tide speed and tide direction indicated by meteorological/hydrographic forecast data, and extract sample data from sample DB corresponding to the calculated ship speed through water.

[0093] The present invention is implemented by a device exemplified by ship terminal device (11) or ship speed determination server device (12), a system exemplified by ship speed determination system (1), a computer program for ship terminal device (11) or ship speed determination server device (12), a storage medium capable of reading from a computer that continuously stores the program, or processing method executed by each device that configures ship speed determination system (1) (ship terminal device (11), ship speed determination server device (12) and meteorological/hydrographic forecast data distribution service device (13)).

DESCRIPTION OF REFERENCE NUMERALS

[0094] 1...ship speed determination system, 8...communication satellite, 9...ship, 11...ship terminal device, 12...ship speed determination server device, 13...meteorological/hydrographic forecast data distribution service device, 91...sensors, 101...CPU, 102...ROM, 103...RAM, 104...HDD, 105...communication IF, 106...input/output IF, 111...navigation log data receiving means, 112...navigation log data transmission means, 113...target ship speed data receiving means, 114...notification means, 121...navigation parameter obtaining means, 122...meteorological/hydrographic forecast data receiving means, 123...navigation log data receiving means, 124...target ship speed determination means, 125...target ship speed data transmission means, 1241...storage means

CLAIMS

- [Claim 1] A device comprising:
- a means for obtaining planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point;
 - a means for obtaining environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point;
 - a means for obtaining actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and
 - a means for determining ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.
- [Claim 2] The device according to claim 1, in which:
- the means for determining ship speed specifies plural values of estimated fuel consumption each of which is estimated to be required for the ship to sail from the current location of the ship to the destination point in the environment indicated by the environment data at a selected one of plural values of ship speed, and determines one of the plural values of ship speed that causes a value of estimated fuel consumption not exceeding a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data as the ship speed for the voyage of the ship from the current location of the ship to the destination point.
- [Claim 3] The device according to claim 2, in which:
- the means for determining ship speed stores data indicating plural values of fuel consumption each of which is estimated to be required for the ship to sail in one of various conditions each of which is defined by a combination of environment and ship speed for the voyage; and
 - the means for determining ship speed specifies plural values of

fuel consumption each of which is estimated to be required for the ship to sail in the environment indicated by the environment data at a selected one of the plural values of ship speed on the basis of the stored data.

[Claim 4] The device according to any one of claims 1 to 3, in which:
the means for determining ship speed determines the estimated fuel consumption on the basis of the actual fuel consumption data.

[Claim 5] The device according to any one of claims 1 to 4, in which:
the means for determining ship speed assigns ship speed to each of plural sections divided from the route from the current location of the ship to the destination point, specifies fuel consumption which is estimated to be required for the ship to sail in a section sequentially selected from the plural sections at ship speed assigned to the selected section, and specifies a sum of plural values of fuel consumption each of which is specified for each of the plural sections as the estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point.

[Claim 6] The device according to claim 5, in which:
the environment data indicating meteorological and/or hydrographic environment pertaining to each of plural timings; and
the means for determining ship speed specifies fuel consumption which is estimated to be required for the ship to sail in a section sequentially selected from the plural sections in an environment indicated by the environment data pertaining to a timing when the ship sails in the selected section at ship speed assigned to the selected section, and specifies a sum of plural values of fuel consumption each of which is specified for each of the plural sections as the estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point.

[Claim 7] The device according to claim 5 or 6, in which:
the means for determining ship speed repeatedly performs a process for specifying estimated fuel consumption which is estimated to be required for the voyage of the ship from the current location of the ship to the destination point in each of plural cases where ship speed assigned to one or more sections selected from the plural sections is changed in accordance with a predetermined rule, and a process for selecting a set of plural values of ship speed assigned to the plural sections, from among the sets of plural values of ship speed each of which is used for specifying the estimated fuel consumption, which causes a minimum estimated fuel consumption,

until a set of plural values of ship speed that causes a minimum estimated fuel consumption not exceeding the value calculated by subtracting is selected, for determining the ship speed from the current location of the ship to the destination point.

[Claim 8] The device according to any one of claims 1 to 7, in which:
 the means for determining ship speed determines the ship speed from the current location of the ship to the destination point in a form of rotation speed of propeller used for the voyage of the ship.

[Claim 9] The device according to claim 8, in which:
 the means for determining ship speed determines the ship speed from the current location of the ship to the destination point in a form of combination of rotation speed and blade angle of the propeller used for the voyage of the ship.

[Claim 10] A program that causes a computer to execute:
 a process of obtaining planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point;
 a process of obtaining environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point;
 a process of obtaining actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and
 a process of determining ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.

[Claim 11] A storage medium capable of reading from a computer that continuously stores the program that causes a computer to execute:
 a process of obtaining planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point;
 a process of obtaining environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point;

a process of obtaining actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and

a process of determining ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.

[Claim 12]

A method comprising:

a step in which a device obtains planned fuel consumption data indicating fuel consumption that is planned to be used for a voyage of a ship from a departure point to a destination point;

a step in which the device obtains environment data indicating meteorological and/or hydrographic environment on a route from the departure point to the destination point;

a step in which the device obtains actual fuel consumption data indicating fuel consumption that was required for a voyage of the ship from the departure point to a current location of the ship while the ship sails on the route; and

a step in which the device determines ship speed for a voyage of the ship from the current location of the ship to the destination point so that estimated fuel consumption for the voyage of the ship from the current location of the ship to the destination point in the environment indicated by the environment data does not exceed a value calculated by subtracting the fuel consumption indicated by the actual fuel consumption data from the fuel consumption indicated by the planned fuel consumption data.