

DESCRIPTION

Title of Invention:

DATA PROCESSING APPARATUS, PROGRAM, AND RECORDING MEDIUM

Technical Field

[0001]

The present invention relates to techniques for managing navigation of a ship.

Background Art

[0002]

Known in the art are techniques for managing information such as an amount of fuel consumed while navigating a ship. For example, Patent Literature 1 proposes a technique of generating navigation log data that varies over time, such as log data on a ship speed, and on a fuel consumption amount, based on measurement data acquired from a group of sensors provided on the ship, and managing ship navigation such that an amount of fuel consumed does not exceed a threshold value.

Citation List

Patent Literature

[0003]

Patent Literature 1:JP2015-44588A

Summary of Invention

Technical Problem

[0004]

A method of determining a fuel consumption amount of a ship includes, for example, a method based on an amount of fuel remaining in a fuel tank, and a method based on a flow rate of fuel flowing from the fuel tank into a main engine.

[0005]

The method based on a remaining amount of fuel in a fuel tank has long been in use, since it does not require employment of a complicated measuring apparatus. The fuel consumption amount determined by use of this method is commonly used for a navigation record referred to as a noon report, which a ship operator updates each day.

[0006]

On the other hand, use of the method based on a flow rate of fuel enables a fuel consumption amount to be continuously measured without need for manual intervention, although this method does require installation of a flowmeter. This method is suitable for application when it is desirable to know an amount of fuel consumed over a relatively short time period, such as, 10 minutes, or, for example, one hour.

[0007]

A long-term fuel consumption amount may be determined by accumulating short-term fuel consumption amounts that are continuously determined by use of the method based on the flow rate of the fuel. For example, if an amount of fuel used in a past hour is known every hour on the hour based on measurement by the flowmeter, an amount of fuel consumed in a past one day may be determined by adding up fuel consumption amounts every hour from a past noon time to a present time at each noon time.

[0008]

The fuel consumption amount determined based on the remaining amount of the

fuel in a predetermined time period should equal the fuel consumption amount determined based on the flow rate of the fuel in the same time period. However, in practice a difference often occurs between these fuel consumption amounts due to measurement error or other causes. As a result a disadvantage arises in that when using the fuel consumption amounts determined based on the flow rate of the fuel at short time intervals, these fuel consumption amounts tend not to be consistent with the fuel consumption amount recorded in the noon report.

[0009]

The foregoing problem may occur with regard not only to fuel consumption, but to any physical quantity that is accumulable and variable with ship navigation, such as a navigation distance and a navigation time.

[0010]

In light of the foregoing, it is an object of the present invention to provide a means for maintaining consistency between physical quantities that are accumulable and variable with ship navigation, and that are measured by use of different methods at different intervals.

Solution to Problem

[0011]

To solve the foregoing problem, a first aspect of the present invention provides a data processing apparatus that includes an acquisition unit that acquires first long-term physical quantity data indicative of a value in a first time period, and first short-term physical quantity data indicative of values in a plurality of second time periods included in the first time period, with regard to a first physical quantity accumulable and variable with a ship navigation; and a determination unit that determines a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data, closer to the value indicated by the first long-term physical quantity data, than a total value of the values indicated by the first short-term physical quantity data.

[0012]

In the data processing apparatus according to the first aspect, a configuration according to a second aspect may be employed in which the acquisition unit acquires second short-term physical quantity data indicative of values in the plurality of the second time periods, with regard to a second physical quantity having a predetermined relationship with the first physical quantity and variable with the ship navigation; and the acquisition unit acquires the first short-term physical quantity data by determining values of the first physical quantity in the plurality of the second time periods using the values indicated by the second short-term physical quantity data.

[0013]

In the data processing apparatus according to the first aspect, a configuration according to a third aspect may be employed in which a conversion unit is included that converts the values indicated by the first short-term physical quantity data in accordance with the conversion rule.

[0014]

In the data processing apparatus according to the third aspect, a configuration according to a fourth aspect may be employed in which the acquisition unit acquires second short-term physical quantity data indicative of values in the plurality of the second time periods, with regard to a second physical quantity having a predetermined relationship with the first physical quantity and variable with the ship navigation; and

the determination unit determines a relationship between the first physical quantity and the second physical quantity using the values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data, and the values indicated by the second short-term physical quantity data.

[0015]

In the data processing apparatus according to the first aspect, a configuration according to a fifth aspect may be employed in which a detection unit is included that detects an outlier included in the values in the plurality of the second time periods indicated by the first short-term physical quantity data; and the determination unit determines a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data in a time period, except for a time period in which the outlier is detected by the detection unit from among the plurality of the second time periods, closer to a value obtained by subtracting an amount in accordance with the time period, in which the outlier is detected by the detection unit, from the value indicated by the first long-term physical quantity data.

[0016]

In the data processing apparatus according to the first aspect, a configuration according to a sixth aspect may be employed in which the acquisition unit acquires the first long-term physical quantity data in the first time period, and the first short-term physical quantity data in the first time period, for each of a plurality of first time periods; and the determination unit calculates a total value of values indicated by the first short-term physical quantity data in the first time period, and determines a structure of a function indicative of the conversion rule based on the total value and a value indicated by the first long-term physical quantity data, for each of the plurality of the first time periods.

[0017]

In the data processing apparatus according to the first aspect, a configuration according to a seventh aspect may be employed in which the acquisition unit acquires the first long-term physical quantity data, and the first short-term physical quantity data, for each of a plurality of first time periods; the acquisition unit acquires second long-term physical quantity data indicative of a value in each of the plurality of the first time periods, and second short-term physical quantity data indicative of values in the plurality of the second time periods included in each of the plurality of the first time periods, with regard to a second physical quantity having a predetermined relationship with the first physical quantity and variable with the ship navigation; and the determination unit determines, as a first relationship, a relationship between the first physical quantity and the second physical quantity using the first long-term physical quantity data and the second long-term physical quantity data, determines, as a second relationship, a relationship between the first physical quantity and the second physical quantity using the first short-term physical quantity data and the second short-term physical quantity data, and determines the conversion rule based on the first relationship and the second relationship.

[0018]

An eighth aspect of the present invention provides a program that causes a computer to execute a process of: acquiring first long-term physical quantity data indicative of a value in a first time period, and first short-term physical quantity data indicative of values in a plurality of second time periods included in the first time period, with regard to a first physical quantity accumulable and variable with ship navigation; and determining a conversion rule in such a manner as to bring a total value of values

converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data closer to the value indicated by the first long-term physical quantity data, than a total value of the values indicated by the first short-term physical quantity data.

[0019]

A ninth aspect of the present invention provides a non-transitory computer-readable recording medium for storing a program that causes a computer to execute process of: acquiring first long-term physical quantity data indicative of a value in a first time period, and first short-term physical quantity data indicative of values in a plurality of second time periods included in the first time period, with regard to a first physical quantity accumulable and variable with a ship navigation; and determining a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data closer to the value indicated by the first long-term physical quantity data, than a total value of the values indicated by the first short-term physical quantity data.

Advantageous Effects of Invention

[0020]

According to the present invention, consistency is maintained between physical quantities that are accumulable and variable with ship navigation, and that are measured by use of different methods at different intervals.

Brief Description of Drawings

[0021]

FIG. 1 is a diagram showing an overall configuration of a navigation data processing system according to an embodiment.

FIG. 2 is a diagram showing a configuration of a computer used as hardware for a terminal apparatus according to the embodiment.

FIG. 3 is a diagram showing a functional configuration of the terminal apparatus according to the embodiment.

FIG. 4 is a diagram showing a configuration of a computer used as hardware for a server apparatus according to the embodiment.

FIG. 5 is a diagram showing a functional configuration of the server apparatus according to the embodiment.

FIG. 6 is a diagram showing a data structure of a noon report table according to the embodiment.

FIG. 7 is a diagram showing a data structure of a navigation log table according to the embodiment.

FIG. 8 is an explanatory diagram of a relationship between short-term fuel consumption amounts, converted values of the amounts, and a long-term fuel consumption amount according to the embodiment.

FIG. 9 is an explanatory diagram of a relationship between short-term fuel consumption amounts, converted values of the amounts, and a long-term fuel consumption amount according to the embodiment.

FIG. 10 is an explanatory diagram of a method used by a determination unit for determining a relationship between ship speeds and fuel consumption amounts according to the embodiment.

FIG. 11 is an explanatory diagram of a method used by a determination unit for determining a structure of a function indicative of a conversion rule according to a

modification.

FIG. 12 is an explanatory diagram of a method used by a determination unit for determining a conversion rule according to a modification.

Description of Embodiments

[0022]

Embodiment

Navigation data processing system 1 according to an embodiment of the present invention is described below. FIG. 1 is a schematic diagram showing an overall configuration of navigation data processing system 1.

[0023]

Navigation data processing system 1 includes terminal apparatus 11 that is provided on ship 9 for operation by an operator of the ship, and server apparatus 12 that exchanges data with terminal apparatus 11 via communication satellite 8. It is of note that ship 9 navigates a route commencing from departure point S and arriving at destination point E.

[0024]

FIG. 2 is a diagram showing a configuration of computer 10 used as hardware for terminal apparatus 11. Computer 10 includes processor 101, memory 102, communication unit 103, and interface 104. Processor 101 performs data processing in accordance with a program stored in memory 102. Memory 102 stores a variety of data. Communication unit 103 communicates with server apparatus 12 via communication satellite 8. Interface 104 is connected to sensor group 61, operation apparatus 62 (e.g., a keyboard, a mouse, and the like), and display 63, and exchanges data between these apparatuses and processor 101 and memory 102.

[0025]

Sensor group 61 consists of a variety of sensors that are provided on ship 9. It is note that the types of sensors constituting sensor group 61 may vary. In the following description, sensor group 61 includes a Global Navigation Satellite System (GNSS) that measures a present position of ship 9, a speedometer that measures a navigation speed (ship speed) of ship 9, a compass that measures an orientation of ship 9, a flowmeter that measures a flow rate of fuel flowing from a fuel tank to a main engine, a horsepower meter that measures a horsepower of the main power, and a pressure gauge that measures a scavenging pressure of the main engine.

[0026]

FIG. 3 is a diagram showing a functional configuration of terminal apparatus 11. When processor 101 performs data processing upon execution of a program according to the present embodiment, computer 10 acts as a terminal apparatus 11 with the configuration shown in FIG. 3; namely terminal apparatus 11 including storage unit 111, measurement data acquisition unit 112, noon report acquisition unit 113, navigation log generation unit 114, display instruction unit 115, and transmission unit 116. The functional configuration of terminal apparatus 11 is described below.

[0027]

Storage unit 111 stores a variety of data. Measurement data acquisition unit 112 continuously acquires measurement data indicative of a measurement made by each sensor in sensor group 61. The measurement data acquired by measurement data acquisition unit 112 is stored in storage unit 111.

[0028]

Noon report acquisition unit 113 acquires noon report data that constitutes content of a noon report that is input by the operator of the ship by use of operation

apparatus 62. In the following description, the noon report is indicative of a fuel consumption amount (an example of a first physical quantity in Claim 1), an average ship speed, and a travel distance in a past one day (an example of a first time period in Claim 1) for each noon time corresponding to a local time relative to a location of ship 9. The noon report acquired by noon report acquisition unit 113 is stored in storage unit 111.

[0029]

It is of note that a period of one day according to the present embodiment is a period from noon time at local time relative to the location of ship 9 to a subsequent noon time, also relative to the location of ship 9. Since ship 9 may move between time zones, a period of one day according to the present embodiment need not necessarily be a period of 24 hours.

[0030]

Based on the measurement data, navigation log generation unit 114 generates navigation log data that sequentially indicates a value of a physical quantity that varies with navigation of ship 9. In the following description, the navigation log data is indicative of a fuel consumption amount, average ship speed, travel distance, average horsepower, and average scavenging pressure in an immediately prior one hour period (an example of a second time period in Claim 1) every hour on the hour. The navigation log data generated by navigation log generation unit 114 is stored in storage unit 111.

[0031]

Display instruction unit 115 instructs display 63 to display an input screen for the noon report.

[0032]

Transmission unit 116 transmits to server apparatus 12 the navigation log data and the noon report data stored in storage unit 111.

[0033]

FIG. 4 is a diagram showing a configuration of computer 20 used as hardware for server apparatus 12. Computer 20 includes processor 201, memory 202, communication unit 203, and interface 204. Processor 201 performs data processing in accordance with a program stored in memory 202. Memory 202 stores a variety of data. Communication unit 203 communicates with terminal apparatus 11 via communication satellite 8. Interface 204 is connected to operation apparatus 71 (e.g., a keyboard, a mouse, and the like) and display 72, and exchanges data between these apparatuses and processor 201 and memory 202.

[0034]

FIG. 5 is a diagram showing a functional configuration of server apparatus 12. Processor 201 performs data processing upon execution of the program according to the present embodiment, and computer 20 acts as server apparatus 12 with the configuration shown in FIG. 5; namely, server apparatus 12 including storage unit 121, reception unit 122, detection unit 123, determination unit 124, and conversion unit 125. The functional configuration of server apparatus 12 is described below.

[0035]

Storage unit 121 stores a variety of data. The data stored in storage unit 121 includes a noon report table in which the noon report data received by reception unit 122 from terminal apparatus 11 is stored, and a navigation log table in which the navigation log data received by reception unit 122 from terminal apparatus 11 is stored.

[0036]

FIG. 6 is a diagram showing a data structure of the noon report table. The

noon report table is a collection of data records for storing the noon report data that is transmitted from terminal apparatus 11 at each noon time. In the noon report table, each of the data records stores date data, fuel consumption amount data (an example of first long-term physical quantity data in Claim 1), ship speed data, and travel distance data.

[0037]

The date data is indicative of a date of a target period when measurement of the fuel consumption amount or other measurements are taken. The fuel consumption amount data is indicative of a fuel consumption amount of the main engine in the target time period (one day). The ship speed data is indicative of an average navigation speed of ship 9 in the target time period (one day). The travel distance data is indicative of a travel distance of ship 9 in the target time period (one day).

[0038]

In the following description, to distinguish the fuel consumption amount data stored in the noon report table from the short-term fuel consumption amount stored in the noon report table, the fuel consumption amount data stored in the noon report table is referred to as “long-term fuel consumption amount data,” and the fuel consumption amount indicated by the long-term fuel consumption amount data is referred to as a “long-term fuel consumption amount.”

[0039]

FIG. 7 is a diagram showing a data structure of the navigation log table. The navigation log table is a collection of data records for storing the navigation log data that is transmitted from terminal apparatus 11 every hour on the hour. In the navigation log table, each of the data records stores date data, time number data, fuel consumption amount data (an example of first short-term physical quantity data in Claim 1), ship speed data (an example of second short-term physical quantity data in Claim 4), travel distance data, horsepower data, scavenging pressure data, an outlier flag, and converted value data.

[0040]

The date data is indicative of a date when measurement of the fuel consumption amount or other measurements are taken. The time number data is indicative of an ordinal number of an hour in one day corresponding to the target time period when measurement of the fuel consumption amount or other measurements are taken. The fuel consumption amount data is indicative of the fuel consumption amount of the main engine in the target time period (one hour).

[0041]

In the following description, to distinguish the fuel consumption amount data stored in the navigation log table from the fuel consumption amount stored in the noon report table described later, the fuel consumption amount data stored in the navigation log table is referred to as “short-term fuel consumption amount data,” and the fuel consumption amount indicated by the short-term fuel consumption amount data is referred to as a “short-term fuel consumption amount.”

[0042]

The ship speed data is indicative of an average navigation speed (an example of a second physical quantity in Claim 4) of ship 9 in the target time period (one hour). The travel distance data is indicative of a travel distance of ship 9 in the target time period (one hour). The horsepower data is indicative of an average horsepower of the main engine in the target time period (one hour). The scavenging pressure data is indicative of an average scavenging pressure of the main engine in the target time period (one hour). The outlier flag indicates whether the short-term fuel consumption amount

is an outlier. In the present embodiment, the outlier flag of one is indicative that short-term fuel consumption amount is an outlier. The converted value data is indicative of a value (converted value) converted from the short-term fuel consumption amount by conversion unit 125 (described later).

[0043]

Referring once more to FIG. 5, the functional condition of server apparatus 12 will now be described. Reception unit 122 (an example of acquisition unit in Claim 1) receives the navigation log data and noon report data transmitted from terminal apparatus 11. The navigation log data and noon report data received by reception unit 122 is stored in the navigation log table and noon report table, respectively.

[0044]

Detection unit 123 detects an outlier in the short-term fuel consumption amount indicated by the short-term fuel consumption amount data, which is stored in the navigation log table. Upon detecting the short-term fuel consumption amount data indicative of the outlier, detection unit 123 rewrites to one the outlier flag that is included in a data record in which the short-term fuel consumption amount data are stored.

[0045]

Detection unit 123 may use any known method of detecting the outlier in the short-term fuel consumption amount, such as a method of detecting a value greater than a threshold as the outlier, and a method of detecting the outlier using statistical processing, such as the Smirnov-Grubbs test and t-test. In the present embodiment, when the ratio of the short-term fuel consumption amount to the horsepower that are respectively indicated by the short-term fuel consumption amount data and the horsepower data in the same data record in the navigation log table, exceeds a predetermined upper threshold, or when the ratio falls below a predetermined lower threshold, detection unit 123 detects this short-term fuel consumption amount as the outlier.

[0046]

Determination unit 124 determines a converted value in a such a manner as to bring a total value of values (converted values) converted by use of the conversion rule from a plurality of short-term fuel consumption amounts indicated by a plurality of short-term fuel consumption amount data on the target day stored in the navigation log table, closer to the long-term fuel consumption amount indicated by the long-term fuel consumption amount data on the same target day stored in the noon report table, than a total value of these short-term fuel consumption amounts.

[0047]

In the present embodiment, determination unit 124 determines the conversion rule by a procedure described below. Firstly, determination unit 124 retrieves a data record on the target day from the noon report table, and then substitutes, into variable F_1 , a long-term fuel consumption amount indicated by long-term fuel consumption amount data stored in the retrieved data record.

[0048]

Determination unit 124 subsequently extracts data records on a target day from data records stored in the navigation log table, counts the number of the extracted data records, and then substitutes this number into variable p . Determination unit 124 subsequently counts the number of data records that include the outlier flag of one from among the data records extracted from the navigation log table, counts the number of data records that include the outlier flag of one, and then substitutes this number into variable q .

[0049]

Determination unit 124 subsequently calculates a total value of short-term fuel consumption amounts indicated by short-term fuel consumption amount data stored in a data record including the outlier flag that is not one, from among the data records extracted from the navigation log table, and then substitutes this total value into variable F_2 .

[0050]

Determination unit 124 subsequently calculates coefficient “a” using Equation 1 described below.

Equation 1

$$a = \frac{(p-q)}{p} \times F_1 \div F_2 \dots \text{(Equation 1)}$$

[0051]

Determination unit 124 subsequently determines Equation 2 described below, in which coefficient “a” is used, as a function equation that expresses a conversion rule.

Equation 2

$$g' = a \times g \dots \text{(Equation 2)}$$

where g is a short-term fuel consumption amount indicated by short-term fuel consumption amount data stored in the navigation log table, and g' is a converted short-term fuel consumption amount (a value converted from the short-term fuel consumption amount).

[0052]

The data indicative of the conversion rule (for example, data indicative of a value of coefficient “a”) determined by determination unit 124 is stored in storage unit 121.

[0053]

The total value of the converted values that are calculated from the short-term fuel consumption amounts by use of the conversion rule determined in the above method, equals a value obtained by subtracting an amount in accordance with a time period in which the short-term fuel consumption amount data in the navigation log data is indicative of an outlier (a time period in which detection unit 123 detects an outlier), from long-term fuel consumption amount F_1 indicated by long-term fuel consumption amount data in the target time period included in the noon report data.

[0054]

FIG. 8 is an explanatory diagram of a relationship between the short-term fuel consumption amounts, converted values of the amounts, and the long-term fuel consumption amount.

[0055]

The bar graph shown in FIG. 8(A) represents short-term fuel consumption amounts on the target day for each time number. In this example, the target day includes 25 hours. Accordingly, p in Equation 1 is 25. The short-term fuel consumption amounts shown in the bar graph in FIG. 8 includes no outlier. Accordingly, q in Equation 1 is zero.

[0056]

The height of line segment A_1 shown in FIG. 8(A) is indicative of a value of a long-term fuel consumption amount per hour on the target day; namely, a value expressed by Equation 3 described below.

Equation 3

$$\frac{F_1}{p} = \frac{F_1}{25} \dots \text{(Equation 3)}$$

[0057]

The area of a rectangle between line segment A₁ and the x-axis is indicative of long-term fuel consumption amount F₁.

[0058]

The height of line segment A₂ shown in FIG. 8(A) is indicative of the average value of short-term fuel consumption amounts shown in the bar graph in FIG. 8(A); namely, a value expressed by Equation 4 described below.

Equation 4

$$\frac{F_2}{p} = \frac{F_2}{25} \dots (\text{Equation 4})$$

[0059]

The area of a rectangle between line segment A₂ and the x-axis is indicative of total value F₂ of short-term fuel consumption amounts on the target day.

[0060]

As shown in FIG. 8(A), long-term fuel consumption amount F₁ on the target day is not equal to total value F₂ of short-term fuel consumption amounts on the same target day.

[0061]

The bar graph shown in FIG. 8(B) shows converted values calculated by multiplying the short-term fuel consumption amounts shown in the bar graph in FIG. 8(A) by coefficient “a.” The height of line segment A₃ shown in FIG. 8(B) is indicative of the average value of the converted values shown in the bar graph in FIG. 8(B). The area of a rectangle between line segment A₃ and the x-axis is indicative of total value (a × F₂) of the converted values shown in the bar graph in FIG. 8(B).

[0062]

Line segment A₁ and line segment A₃ have an equal height. Accordingly, long-term fuel consumption amount F₁ equals total value (a × F₂) of the converted values from the short-term fuel consumption amounts. Thus, the long-term fuel consumption amount indicated by the long-term fuel consumption amount data included in the noon report data is consistent with the values converted from the short-term fuel consumption amounts indicated by the short-term fuel consumption amount data stored in the navigation log table.

[0063]

FIG. 9 is an explanatory diagram of a relationship between short-term fuel consumption amounts, converted values of the amounts, and a long-term fuel consumption amount, similar to FIG. 8. However in the case shown in FIG. 9, short-term fuel consumption amounts in accordance with time numbers 5 and 17 are outliers among short-term fuel consumption amounts on the target day. Accordingly, p in Equation 1 is 25, and q is 2 in this case.

[0064]

The bar graph shown in FIG. 9(A) represents short-term fuel consumption amounts for each time number. The bar graph shown in FIG. 8(B) is obtained by removing bars that shows the outliers from the bar graph shown in FIG. 9(A).

[0065]

In the FIG. 9(B), the area of a rectangle between line segment B₁ and the x-axis is indicative of a value obtained by subtracting amounts in accordance with time periods, in which short-term fuel consumption amounts are outliers on the target day (in this case, two hours among 25 hours), from a long-term fuel consumption amount in the same target day. Specifically, the area of the rectangle between line segment B₁ and the x-axis is indicative of a value expressed by Equation 5 described below.

Equation 5

$$\frac{p-q}{p} \times F_1 = \frac{23}{25} \times F_1 \dots (\text{Equation 5})$$

[0066]

The height of line segment B₂ shown in FIG. 9(B) is indicative of an average value of short-term fuel consumption amounts shown in the bar graph in FIG. 9(B); namely, a value expressed by Equation 6 described below. However, F₂ is a total value of fuel consumption amounts obtained by excluding the outliers from short-term fuel consumption amounts on the target day.

Equation 6

$$\frac{F_2}{p-q} = \frac{F_2}{23} \dots (\text{Equation 6})$$

[0067]

The area of a rectangle between line segment B₂ and the x-axis is indicative of F₂.

[0068]

The bar graph shown in FIG. 9(C) represents converted values calculated by multiplying short-term fuel consumption amounts shown in the bar graph in FIG. 9(B) by coefficient “a.” The height of line segment B₃ shown in FIG. 9(C) is indicative of the average value of the converted values shown in the bar graph in FIG. 9(C). The area of a rectangle between line segment B₃ and the x-axis is indicative of a total value (a × F₂) of converted values shown in the bar graph in FIG. 9(C).

[0069]

Line segment B₁ and line segment B₃ have an equal height. Accordingly, the value (values expressed by Equation 5) obtained by subtracting amounts in accordance with time periods, in which short-term fuel consumption amounts are outliers on the target day, from long-term fuel consumption amount F₁ in the same target day equals the total value (a × F₂) of converted values from short-term fuel consumption amounts except for the outliers in the same target day. Thus, if the short-term fuel consumption amounts include outliers, the long-term fuel consumption amount except for an amount in accordance with the outliers is consistent with the converted values from short-term fuel consumption amounts except for the outliers.

[0070]

Referring again to FIG. 5, the functional condition of server apparatus 12 is described in the following. Conversion unit 125 converts the short-term fuel consumption amounts indicated by the short-term fuel consumption amount data in the target time period stored in the navigation log table, in accordance with the conversion rule determined by determination unit 124 for the target time period. The converted value data indicative of the converted values from short-term fuel consumption amounts calculated by conversion unit 125 is stored in the corresponding data record in the navigation log table.

[0071]

In addition to the determination of the foregoing conversion rule, determination unit 124 determines a relationship between ship speeds and fuel consumption amounts. FIG. 10 is an explanatory diagram of a method used by determination unit 124 for determining the relationship between the ship speeds and the fuel consumption amounts. FIG. 10 is a scatter diagram in which a coordinate plane is defined using the horizontal axis indicative of ship speeds and the vertical axis indicative of converted values from the short-term fuel consumption amounts. On the coordinate plane, plots are placed that are each indicative of a combination of a ship speed indicated by the ship speed

data that is stored in a data record with the outlier flag that is not one from among data records of the past predetermined time period (for example, the most recent one month) in the navigation log table, and a converted value indicated by the converted value data. In FIG. 10, curve S is added that approximates the relationship between the ship speeds and the converted values that are represented by the plots.

[0072]

Determination unit 124 determines coefficient b of curve S expressed by Equation 7 described below, using the least-square method.

Equation 7

$$g' = b \times v^3 \dots (\text{Equation 7})$$

wherein g' is a converted value from a short-term fuel consumption amount, and v is a ship speed.

[0073]

The data indicative of the relationship between the ship speeds and the converted values from the short-term fuel consumption amounts (for example, data indicative of a value of coefficient b) determined by determination unit 124 are stored in storage unit 121.

[0074]

According to navigation data processing system 1 described above, the short-term fuel consumption amounts indicated by the short-term fuel consumption amount data stored in the navigation log table are converted for each target time period so as to be consistent with the long-term fuel consumption amount indicated by the long-term fuel consumption amount data included in the noon report. The converted values from short-term fuel consumption amounts are consistent with the long-term fuel consumption amount, and are also acquired at intervals (one hour) shorter than the measurement interval of the long-term fuel consumption amount (one day). Accordingly, it is possible to know a short-term variation in the fuel consumption amount, and which cannot be found from the noon report, by viewing a sequential variation in the converted values.

[0075]

When the converted values from short-term fuel consumption amounts are used, a relationship is determined between a fuel consumption amount and another physical quantity having a certain relationship with the fuel consumption amount, similar to the relationship between the ship speeds and the fuel consumption amounts, from measurement data in a shorter time period, compared to a case where the long-term fuel consumption amount is used.

[0076]

For example, to determine curve S indicative of the relationship between the ship speeds and the fuel consumption amounts with sufficient accuracy for actual use from the scatter diagram as shown in FIG. 10, at least about ten plots are required that are spaced apart from each other. Accordingly, when the long-term fuel consumption amount is used, measurement data for a period of about several months are required to determine curve S. On the other hand, when the short-term fuel consumption amounts are used, it is possible to determine curve S by use of the measurement data for a time period of about several days.

[0077]

Modifications

The foregoing embodiment may be modified in various manners. Some examples of the modifications are described below. It is of note that the foregoing embodiment and the following modifications may be combined as appropriate.

[0078]

(1) In the foregoing embodiment, the value indicated by the data stored in the navigation log table with regard to the fuel consumption amount is converted in such a manner as to maintain consistency between the value indicated by the data stored in the noon report table and the value indicated by data stored in the navigation log table with regard to the fuel consumption amount. However, the physical quantity to be converted may be a physical quantity other than the fuel consumption amount if the physical quantity is accumulable and variable with ship 9. Such a physical quantity includes, for example, a navigation distance or a navigation time.

[0079]

(2) In the foregoing embodiment, determination unit 124 determines the conversion rule for the short-term fuel consumption amounts in such a manner as to equalize the long-term fuel consumption amount in the target time period with the total value of the converted values from the short-term fuel consumption amounts in the same target time period. However, the total value of the converted values from the short-term fuel consumption amounts need not be equal to the long-term fuel consumption amount if the conversion rule is determined in such a manner as to bring the total value of the converted valued from the short-term fuel consumption amounts in target time period closer to the long-term fuel consumption amount in the same target time period, than a total value of pre-conversion short-term fuel consumption amounts.

[0080]

(3) In the foregoing embodiment, reception unit 122, which is an example of an acquisition unit, acquires the short-term fuel consumption amount data indicative of the measurement of the flowmeter in sensor group 61. However, the method used by the acquisition unit for acquiring the short-term fuel consumption amount data is not limited to this method. For example, the acquisition unit may acquire data indicative of the measurement every hour (hereafter, referred to as “short-term physical quantity data”) with regard to a physical quantity that is variable with navigation of ship 9, and may then determine the short-term fuel consumption amount data by use of the physical quantity indicated by the short-term physical quantity data. For example, if a relationship between the horsepower (an example of a second physical quantity in Claim 2) of ship 9 and the fuel consumption amount is known, the acquisition unit may receive the navigation log data including horsepower data from terminal apparatus 11, and may acquire the short-term fuel consumption amount data by determining the short-term fuel consumption amount by use of the horsepower indicated by the horsepower data (an example of second short-term fuel physical quantity data in Claim 2). Instead of the horsepower, a scavenging pressure or other measurement may be used.

[0081]

(4) In the foregoing embodiment, as shown in Equation 2, the function indicative of the conversion rule for the short-term fuel consumption amounts determined by determination unit 124, has a structure indicative of a proportional relationship. However, the structure of the function indicative of the conversion rule for the short-term fuel consumption amounts determined by determination unit 124, is not limited to the structure indicative of the proportional relationship. The structure of the function indicative of the conversion rule may be selected from among a variety of structures, such as a liner structure or a nonlinear structure.

[0082]

Determination unit 124 may determines the structure of the function indicative of the conversion rule based on the long-term fuel consumption amount and also the short-term fuel consumption amounts for each of a plurality of days. FIG. 11 is an

explanatory diagram of a method used by determination unit 124 for determining the structure of the function indicative of the conversion rule according to this modification. FIG. 11 is a scatter diagram in which a coordinate plane is defined using the horizontal axis (x-axis) indicative of a total value of short-term fuel consumption amounts in one day and the vertical axis (y-axis) indicative of a long-term fuel consumption amount. On the coordinate plane, plots are placed that are each indicative of a combination of a total value of short-term fuel consumption amounts (non-outlier) on a target day and a long-term fuel consumption amount (a value obtained by subtracting an amount in accordance with a time period in which a short-term fuel consumption amount is an outlier) in the same target day. In FIG. 11, straight line N is added that approximates a relationship between the total value of the short-term fuel consumption amounts and the long-term fuel consumption amount that are represented by the plots.

[0083]

Determination unit 124 calculates a total value of the short-term fuel consumption amounts indicated by the short-term fuel consumption amount data included in a data record with the outlier flag that is not one from among data records in the navigation log table for each of the plurality of the target days included in the past predetermined time period (for example, three months). Determination unit 124 calculates a value obtained by subtracting an amount in accordance with a time period, in which a short-term fuel consumption amount is an outlier, from a long-term fuel consumption amount indicated by long-term fuel consumption amount data included in the noon report table for each of the plurality of the target days.

[0084]

Determination unit 124 subsequently determines coefficients m and n of straight line N expressed by Equation 8 described below, using a least-square method.

Equation 8

$$y = m \times x + n \quad \dots \text{(Equation 8)}$$

[0085]

For example, intercept n of straight line N may indicate a fixed difference (offset) between the long-term fuel consumption amount and the short-term fuel consumption amounts. Thus, determination unit 124 uses Equation 9 described below as a function indicative of the conversion rule, instead of Equation 2.

Equation 9

$$g' = a \times g + n \quad \dots \text{(Equation 9)}$$

[0086]

In this case, determination unit 124 calculates coefficient “a” using the Equation 10 described below, instead of Equation 1.

Equation 10

$$a = \left\{ \frac{(p-q)}{p} \times F_1 - (p-q) \times n \right\} \div \{F_2 - (p-q) \times n\} \quad \dots \text{(Equation 10)}$$

[0087]

Using coefficient “a” determined using Equation 10, determination unit 124 calculates converted value g’ from short-term fuel consumption amount g using Equation 9.

[0088]

(5) In the foregoing embodiment, determination unit 124 determines the conversion rule directly from the long-term fuel consumption amount and the short-term fuel consumption amounts using Equation 1. Instead of this method, determination unit 124 may determine the conversion rule indirectly based on a relationship between the fuel consumption amount and the physical quantity having a

predetermined relationship with the fuel consumption amount for a long time period and a relationship between the fuel consumption amount and this physical quantity for a short time period.

[0089]

FIG. 12 is an explanatory diagram of a method used by determination unit 124 for determining the conversion rule according to this modification. It is of note that in an example of FIG. 12 a ship speed (an example of a second physical quantity in Claim 7) is used as the physical quantity that has the predetermined relationship with the fuel consumption amount.

[0090]

FIG. 12(A) is a scatter diagram in which a coordinate plane is defined using the horizontal axis (x-axis) indicative of average ship speeds (long-term ship speed) in one day and the vertical axis (y-axis) indicative of long-term fuel consumption amounts. On the coordinate plane, a plot is placed that is indicative of a combination of the long-term ship speed indicated by ship speed data on the target day (an example of second long-term physical quantity data in Claim 7) stored in the noon report table, and the long-term fuel consumption amount indicated by long-term fuel consumption amount data in the same target day for each of the plurality of the target days in a predetermined time period (for example, three months). In FIG. 12(A), curve P is added that approximates the relationship between the long-term ship speed and the long-term fuel consumption amount that are represented by the plots.

[0091]

Determination unit 124 determines coefficient j of curve P expressed by the Equation 11 described below, using the least-square method.

Equation 11

$$y = j \times x^3 \dots \text{(Equation 11)}$$

[0092]

FIG. 12(B) is a scatter diagram in which a coordinate plane is defined using the horizontal axis (x-axis) indicative of average ship speeds in one hour (short-term ship speed) and the vertical axis (y-axis) indicative of short-term fuel consumption amounts. On the coordinate plane, a plot is placed that is indicative of a combination of the short-term ship speed indicated by ship speed data in the target time (an example of second short-term physical quantity data in Claim 7) stored in the navigation log table, and the short-term fuel consumption amount indicated by short-term fuel consumption amount data in the same target time, for each of the plurality of the target times in the same predetermined time period. In FIG. 12(B) curve Q is added that approximates the relationship between the long-term ship speed and the long-term fuel consumption amount that are represented by the plots. In addition, in FIG. 12(B) curve P (shown by a dashed line) shown in FIG. 12(A) is added to compare with curve Q.

[0093]

Determination unit 124 determines coefficient k of curve Q expressed by the Equation 12 described below, using the least-square method.

Equation 12

$$y = k \times x^3 \dots \text{(Equation 12)}$$

[0094]

Here, the long-term ship speed and the short-term ship speed are each a ship speed determined based on the measurement of the same speedometer in sensor group 61.

[0095]

Determination unit 124 determines Equation 13 described below as the

conversion rule in such a manner as to bring the total value of the converted values from the short-term fuel consumption amounts calculated using Equation 12 for the target time period, closer to a long-term fuel consumption amount calculated using Equation 11 for the same target time period. In the Equation 13, g is the short-term fuel consumption amount, and g' is converted value of the amount.

Equation 13

$$g' = \frac{j}{k} \times g \dots \text{(Equation 13)}$$

[0096]

Conversion unit 125 calculates the converted value from the short-term fuel consumption amount using Equation 13, instead of Equation 2 used in the foregoing embodiment.

[0097]

(6) In the foregoing embodiment, the function that approximates the relationship between the ship speeds and the fuel consumption amounts is a cubic function. However, the function that approximates the relationship between the ship speeds and the fuel consumption amounts is not limited to the cubic function; and a higher order polynomial or non-integer function may be used as a function that approximates the relationship between the ship speeds and the fuel consumption amounts.

[0098]

(7) In the foregoing embodiment, the least-square method is used as a method of determining the function that approximates the relationship between two physical quantities. However, other methods, such as a spline interpolation, may be used as the method.

[0099]

(8) In the foregoing embodiment, server apparatus 12 acquires the navigation log data and the noon report data from terminal apparatus 11 via communication satellite 8. However, the method used by server apparatus 12 for acquiring the navigation log data and the noon report data is not limited to the method using communication via communication satellite 8. For example, while ship 9 is anchored at a port, the navigation log data and the noon report data may be transmitted from terminal apparatus 11 to server apparatus 12 via an access point for wireless communication available at the port. Alternatively, the navigation log data and the noon report data may be read by server apparatus 12 from a recording medium, such as a memory card, to which the navigation log data and the noon report data are copied from terminal apparatus 11.

[0100]

(9) In the foregoing embodiment, server apparatus 12 performs the determination of the conversion rule and the conversion of the short-term fuel consumption amounts. However, terminal apparatus 11 may perform at least one of these processes. For example, terminal apparatus 11 may include detection unit 123, determination unit 124, and conversion unit 125, and may transmit the converted value data indicative of the converted values to server apparatus 12 by using transmission unit 116.

[0101]

(10) In the foregoing embodiment, the time period in which the long-term fuel consumption amount is measured is one day, and the time period in which the short-term fuel consumption amount is measured is one hour. However, different time periods may be used.

[0102]

(11) In the foregoing embodiment, the conversion rule is expressed by the function. However, a form for expressing the conversion rule is not limited to the function. For example, the conversion rule may be expressed by a conversion table that is indicative of a combination of a pre-conversion value and a post-conversion value.

[0103]

(12) In the foregoing embodiment, the hardware for server apparatus 12 is the computer, and also processor 201 enables the apparatus to include the configuration shown in FIG. 5 by performing a processing in accordance with a program. Instead of this configuration, server apparatus 12 may be a dedicated device that includes the configuration shown in FIG. 5.

[0104]

(13) A non-transitory computer-readable for storing a program to enable server apparatus 12 to include functions according to the foregoing embodiment, may be distributed.

Reference Signs List

[0105]

1...navigation data processing system, 8...communication satellite, 9...ship, 10...computer, 11...terminal apparatus, 12...server apparatus, 20...computer, 61...sensor group, 62...operation apparatus, 63...display, 71...operation apparatus, 72...display, 101...processor, 102...memory, 103...communication unit, 104...interface, 111...storage unit, 112...measurement data acquisition unit, 113...noon report acquisition unit, 114...navigation log generation unit, 115...display instruction unit, 116...transmission unit, 121...storage unit, 122...reception unit, 123...detection unit, 124...determination unit, 125...conversion unit, 201...processor, 202...memory, 203...communication unit, 204...interface

CLAIMS

1. A data processing apparatus comprising:
 - an acquisition unit that acquires first long-term physical quantity data indicative of a value in a first time period, and first short-term physical quantity data indicative of values in a plurality of second time periods included in the first time period, with regard to a first physical quantity accumulable and variable with a ship navigation; and
 - a determination unit that determines a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data, closer to the value indicated by the first long-term physical quantity data, than a total value of the values indicated by the first short-term physical quantity data.
2. The data processing apparatus according to Claim 1, wherein
 - the acquisition unit acquires second short-term physical quantity data indicative of values in the plurality of the second time periods, with regard to a second physical quantity having a predetermined relationship with the first physical quantity and variable with the ship navigation; and
 - the acquisition unit acquires the first short-term physical quantity data by determining values of the first physical quantity in the plurality of the second time periods using the values indicated by the second short-term physical quantity data.
3. The data processing apparatus according to Claim 1, further comprising a conversion unit that converts the values indicated by the first short-term physical quantity data in accordance with the conversion rule.
4. The data processing apparatus according to Claim 3, wherein
 - the acquisition unit acquires second short-term physical quantity data indicative of values in the plurality of the second time periods, with regard to a second physical quantity having a predetermined relationship with the first physical quantity and variable with the ship navigation; and
 - the determination unit determines a relationship between the first physical quantity and the second physical quantity using the values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data, and the values indicated by the second short-term physical quantity data.
5. The data processing apparatus according to Claim 1 further comprising a detection unit that detects an outlier included in the values in the plurality of the second time periods indicated by the first short-term physical quantity data;
 - wherein the determination unit determines a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data in a time period, except for a time period in which the outlier is detected by the detection unit from among the plurality of the second time periods, closer to a value obtained by subtracting an amount in accordance with the time period, in which the outlier is detected by the detection unit, from the value indicated by the first long-term physical quantity data.
6. The data processing apparatus according to Claim 1, wherein
 - the acquisition unit acquires the first long-term physical quantity data in the first time period, and the first short-term physical quantity data in the first time period,

for each of a plurality of first time periods; and

the determination unit calculates a total value of values indicated by the first short-term physical quantity data in the first time period, and determines a structure of a function indicative of the conversion rule based on the total value and a value indicated by the first long-term physical quantity data, for each of the plurality of the first time periods.

7. The data processing apparatus according to Claim 1, wherein

the acquisition unit acquires the first long-term physical quantity data, and the first short-term physical quantity data, for each of a plurality of first time periods;

the acquisition unit acquires second long-term physical quantity data indicative of a value in each of the plurality of the first time periods, and second short-term physical quantity data indicative of values in the plurality of the second time periods included in each of the plurality of the first time periods, with regard to a second physical quantity having a predetermined relationship with the first physical quantity and variable with the ship navigation; and

the determination unit determines, as a first relationship, a relationship between the first physical quantity and the second physical quantity using the first long-term physical quantity data and the second long-term physical quantity data, determines, as a second relationship, a relationship between the first physical quantity and the second physical quantity using the first short-term physical quantity data and the second short-term physical quantity data, and determines the conversion rule based on the first relationship and the second relationship.

8. A program that causes a computer to execute processing of:

acquiring first long-term physical quantity data indicative of a value in a first time period, and first short-term physical quantity data indicative of values in a plurality of second time periods included in the first time period, with regard to a first physical quantity accumulable and variable with ship navigation; and

determining a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data closer to the value indicated by the first long-term physical quantity data, than a total value of the values indicated by the first short-term physical quantity data.

9. A non-transitory computer-readable recording medium for storing a program that causes a computer to execute processing of:

acquiring first long-term physical quantity data indicative of a value in a first time period, and first short-term physical quantity data indicative of values in a plurality of second time periods included in the first time period, with regard to a first physical quantity accumulable and variable with a ship navigation; and

determining a conversion rule in such a manner as to bring a total value of values converted in accordance with the conversion rule from the values indicated by the first short-term physical quantity data closer to the value indicated by the first long-term physical quantity data, than a total value of the values indicated by the first short-term physical quantity data.