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(54) SYSTEM AND METHOD FOR MONITORING SAFETY STATUS OF SHIP USING ROLL MOTION DATA

(57) Proposed are a system and a method for monitoring a safety status of a ship using roll motion data. The system and the method are configured as follows. Rolling period data, average list angle data, and significant rolling angle data are received from a rolling period computation part, an average list angle computation part, and a significant rolling angle computation part. It is determined whether the rolling period data is equal to or less than a maximum unique rolling period. On the basis of the maximum unique rolling period, a controller determines whether a rolling period is in a normal, caution, or danger state.

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present disclosure relates to a system and a method for monitoring a safety status of a ship using roll motion data. In particular, the present disclosure relates to a system and a method for monitoring a safety status of a ship using roll motion data, wherein a normal, caution, or danger state for each item of a rolling period, an average list angle, and a significant rolling angle of the ship is determined and displayed on the basis of the rolling period, the average list angle, and the significant rolling angle obtained by performing fast Fourier transform (FFT) analysis on data obtained through an electronic inclinometer.

Description of the Related Art

[0002] Currently, ships have undergone smartization as deeply as other types of transportation means. In particular, life in a ship requires relatively long human work hours compared to other transportation facilities and is a field that requires considerable expertise, so there have been rapid changes to smart ships, such as autonomous ships and unmanned ships that require relatively fewer workers.

[0003] Korean Patent No. 10-1880815 (hereinafter, referred to as the related art) discloses a system for providing a ship safety sailing monitoring and automatic avoidance service, wherein the system is equipped with various sensors including a ship tilt detection sensor and a distance detection sensor and computes an average value of sensing values to prevent warning malfunction caused by device malfunction and enable rapid automatic response in urgent situations where the navigator cannot respond.

[0004] However, in the related art, the degree of tilt is analyzed by comparing a tilt average value with a preset reference value, and when a result of the comparative analysis indicates exceeding a prestored threshold value, a notification signal is generated to a warning notification part provided in the ship. The related art does not provide specific criterion for generating an alarm signal and a detailed configuration of the alarm signal.

[0005] The foregoing is intended merely to aid in the understanding of the background of the present disclosure, and is not intended to mean that the present disclosure falls within the purview of the related art that is already known to those skilled in the art.

Document of Related Art

[0006] (Patent Document 1) Korean Patent No. 10-1880815 (titled: SYSTEM FOR PROVIDING SHIP SAFETY SAILING MONITORING AND AUTOMATIC AVOIDANCE SERVICE)

SUMMARY OF THE INVENTION

[0007] The present disclosure is directed to providing a system and a method for monitoring a safety status of a ship using roll motion data, the system and the method being capable of specifically providing criteria and configuration for generating an alarm signal that displays the safety status of the ship on the basis of roll motion data of the ship obtained from an electronic inclinometer.

[0008] According to an embodiment of the present disclosure, there is provided a system for monitoring a safety status of a ship using roll motion data, the system including: a rolling period computation part configured to compute rolling period data by performing fast Fourier transform (FFT) analysis on rolling angle data over time shown by an electronic inclinometer; an average list angle computation part configured to compute average list angle data by performing FFT analysis on the rolling angle data; a significant rolling angle computation part configured to compute significant rolling angle data by performing FFT analysis on the rolling angle data; a controller configured to receive the computed rolling period data, the computed average list angle data, and the computed significant rolling angle data, and perform comparative analysis on the rolling period data with a maximum unique rolling period and the maximum unique rolling period + 40 % of the maximum unique rolling period to determine a normal, caution, or danger state of a rolling period, and perform comparative analysis on the average list angle data with 50 % of a grade criterion and the grade criterion to determine a normal, caution, or danger state of an average list angle, and perform comparative analysis on the significant rolling angle data with 50 % of the grade criterion and the grade criterion to determine a normal, caution, or danger state of an average significant rolling angle, and output a display control signal corresponding to each of the determined states; and a display configured to receive the display control signal from the controller and display the display control signal.

[0009] In the system for monitoring the safety status of the ship using the roll motion data according to the embodiment,

the lesser of a limit inclination angle of the ship and 10 [deg] may be selected as the grade criterion.

[0010] According to another embodiment of the present disclosure, there is provided a method for monitoring a safety status of a ship using roll motion data, the method including: receiving, by a controller, rolling period data, average list angle data, and significant rolling angle data from a rolling period computation part, an average list angle computation part, and a significant rolling angle computation part; determining, by the controller, whether the rolling period data is equal to or less than a maximum unique rolling period; determining, by the controller, that a rolling period is in a normal state and displaying a rolling period normal state through a display when the rolling period data is equal to or less than the maximum unique rolling period; determining, by the controller, that the rolling period is in a caution state and displaying a rolling period caution state through the display when the rolling period data is greater than the maximum unique rolling period and is equal to or less than the maximum unique rolling period + 40 % of the maximum unique rolling period; and determining, by the controller, that the rolling period is in a danger state and displaying a rolling period danger state through the display when the rolling period data is greater than the maximum unique rolling period + 40 % of the maximum unique rolling period.

[0011] The method for monitoring the safety status of the ship using the roll motion data according to the embodiment may, after the receiving, further include: determining, by the controller, whether the average list angle data is equal to or less than 50 % of a grade criterion; determining, by the controller, that an average list angle is in a normal state and displaying a list angle normal state through the display when the average list angle data is equal to or less than 50 % of the grade criterion; determining, by the controller, that the average list angle is in a caution state and displaying an average list angle caution state through the display when the average list angle data is greater than 50 % of the grade criterion and is equal to or less than the grade criterion; and determining, by the controller, that the average list angle is in a danger state and displaying an average list angle danger state through the display when the average list angle data is greater than the grade criterion.

[0012] The method for monitoring the safety status of the ship using the roll motion data according to the embodiment may, after the receiving, further include: determining, by the controller, whether the significant rolling angle data is equal to or less than 50 % of a grade criterion; determining, by the controller, that a significant rolling angle is in a normal state and displaying a significant rolling angle normal state through the display when the significant rolling angle data is equal to or less than 50 % of the grade criterion; determining, by the controller, that the significant rolling angle is in a caution state and displaying a significant rolling angle caution state through the display when the significant rolling angle data is greater than 50 % of the grade criterion and is equal to or less than the grade criterion; and determining, by the controller, that the significant rolling angle is in a danger state and displaying a significant rolling angle danger state through the display when the significant rolling angle data is greater than the grade criterion.

[0013] According to the system and the method for monitoring a safety status of a ship using roll motion data according to the embodiments of the present disclosure, the rolling period data, the average list angle data, and the significant rolling angle data are received from the rolling period computation part, the average list angle computation part, and the significant rolling angle computation part, and it is determined whether the rolling period data is equal to or less than the maximum unique rolling period. When the rolling period data is equal to or less than the maximum unique rolling period, it is determined that the rolling period is in the normal state and the rolling period normal state is displayed through the display. When the rolling period data is greater than the maximum unique rolling period and is equal to or less than the maximum unique rolling period + 40 % of the maximum unique rolling period, the controller determines that the rolling period is in the caution state and displays the rolling period caution state through the display. When the rolling period data is greater than the maximum unique rolling period + 40 % of the maximum unique rolling period, it is determined that the rolling period is in the danger state and the rolling period danger state is displayed through the display. Accordingly, the criteria and configuration for generating an alarm signal that displays the safety status of the ship on the basis of the roll motion data of the ship obtained from the electronic inclinometer can be specifically provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The above and other objectives, features, and other advantages of the present disclosure will be more clearly understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram illustrating a system for monitoring a safety status of a ship using roll motion data, according to an embodiment of the present disclosure; and

FIG. 2 is a flowchart illustrating a method for monitoring a safety status of a ship using roll motion data, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0015] In describing embodiments of the present disclosure, if it is decided that a detailed description of the known art

related to the present disclosure makes the subject matter of the present disclosure unclear, the detailed description will be omitted. Further, the terms described below are defined in consideration of the functions in the present disclosure, and may be changed depending on the intention of a user, an operator, or a usual practice. Therefore, the definition should be based on the contents throughout this specification. The terms used below are merely for describing the embodiments of the present disclosure, and should not be restrictively interpreted. Unless clearly used otherwise, a singular expression includes a plural meaning. In the description, the expression "include" or "have" is for indicating any features, numbers, steps, operations, elements, or a part or combination thereof, and should not be interpreted as excluding presence or possibility of one or more other features, numbers, steps, operations, elements, or a part or combination thereof other than the above.

[0016] In each system shown in the drawings, elements in some cases may have same or different reference numerals to suggest that the elements could be different or similar. However, elements may have different implementations and work with some or all of the systems shown or described in the specification. The various elements shown in the drawings may be the same or different. It is random which one is referred to as a first element and which one is referred to as a second element.

[0017] In the specification, when one element "transmits", "transfers", or "provides" data or a signal to another element, it means that the element transmits the data or signal directly to the other element or the element transmits the data or signal to the other element via at least one another element.

[0018] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

[0019] FIG. 1 is a block diagram illustrating a system for monitoring a safety status of a ship using roll motion data, according to an embodiment of the present disclosure.

[0020] The system for monitoring the safety status of a ship using roll motion data according to the embodiment of the present disclosure is provided in the ship and is executed by receiving measured data from an electronic inclinometer 100. A rolling period computation part 200, an average list angle computation part 210, a significant rolling angle computation part 220, a controller 300, and a display 400 are in an on-board form.

[0021] The rolling period computation part 200 computes rolling period data by performing fast Fourier transform (FFT) analysis on rolling angle data over time shown by the electronic inclinometer 100. A rolling period refers to the time that it takes for a ship to tilt from its maximum inclination on one side to the opposite side and return to its original position. In other words, the rolling period refers to the time required to heel from the starboard rolling angle to the port rolling angle and back to the starboard rolling angle, and the unit is [sec] .

[0022] The average list angle computation part 210 computes average list angle data by performing FFT analysis on rolling angle data over time shown by the electronic inclinometer 100. A list angle refers to the angle of a ship when the ship is tilted laterally and remains in a parallel state in still water. The list angle is an indicator that there is a possibility that a ship may tilt to one side when the ship is damaged and flooded. Small fishing boats, for example, may be observed to be at anchor or to sail while tilted rather than upright during anchoring or sailing due to a lopsided load when fishing gear is loaded onto the boats. This indicates that the list angle is not upright. In particular, since it is difficult to intuitively compute the list angle of a ship at sea, the average list angle is a main safety factor that can be used to determine whether the ship is upright through an average value of rolling angles for the port and the starboard by using the electronic inclinometer 100 in order to quantitatively observe the upright state of the ship for the safety of the ship. The average list angle is shown by computing an average value of port and starboard rolling angles for each FFT analysis and averaging the average values for the total number (n) of trials.

[0023] The significant rolling angle computation part 220 computes significant rolling angle data by performing FFT analysis on rolling angle data over time shown by the electronic inclinometer 100. A rolling angle refers to the maximum angle at which a ship is tilted due to the roll of the ship. A list angle refers to a static angle, while the rolling angle refers to a dynamic angle caused by the roll of a ship. The rolling angle is a factor that may occur independently depending on the sea and sailing conditions regardless of damage or flooding of the ship. The electronic inclinometer 100 expresses the port rolling angle as a negative number (-) and the starboard rolling angle as a positive number (+). An average value of top 1/3 of rolling angles (for the port and the starboard each) of a ship is defined as a significant rolling angle. The significant rolling angle may be used as a main indicator to know a significant value of an inclination angle due to roll. In order to compute the significant rolling angle, the maximum rolling angle for the port and the starboard each is derived for each FFT analysis and a significant value is computed so that the significant rolling angle is computed when a unique rolling period is computed. Since it is a significant value, the average value of 1/3 of the data is computed, and the computed significant rolling angles are averaged for the total number (n) of trials.

[0024] The controller 300 is a microcomputer that controls all elements. The controller 300 receives rolling period data, average list angle data, and significant rolling angle data computed by the rolling period computation part 200, the average list angle computation part 210, and significant rolling angle computation part 220, and performs comparative analysis to determine a normal, caution, or danger state of the rolling period, the average list angle, and the significant rolling angle, and outputs and displays a display control signal corresponding to each determined state to the display 400. The controller

300 performs comparative analysis on the input rolling period data with the maximum unique rolling period and the maximum unique rolling period + 40 % of the maximum unique rolling period to determine the normal, caution, or danger state of the rolling period. The controller 300 performs comparative analysis of average list angle data with 50 % of a grade criterion and the grade criterion to determine the normal, caution, or danger state of the average list angle. The controller 300 performs comparative analysis of significant rolling angle data with 50 % of the grade criterion and the grade criterion to determine the normal, caution, or danger state of an average significant rolling angle. The lesser of the limit inclination angle of the ship and 10 [deg] may be selected as the grade criterion.

[0025] The same grade criterion may be applied to the average list angle and the significant rolling angle for grade classification. In the meantime, in addition to applying 50 % of the grade criterion in the caution grade, an experience point of a crew member based on long experience may be manually received and applied.

[0026] Based on [Table 1] and [Table 2] below, the characteristics of each element will be described as follows.

[0027] Referring to the rolling period, there is a clear distinction between "caution" and "danger" using the top of a unique rolling period range of each ship as a criterion and 40 % of the value as a criterion. In particular, considering that ship H and ship I, which are ships for passengers and cars, have flat surfaces and are much less sensitive to changes in the marine environment than training ships or passenger ships, the fact that the rolling periods of the ships exceed 7 seconds directly indicates that the marine environment is very unstable. From the same perspective, for the average list angle and the significant rolling angle, even if the ships for passengers and cars have a slightly larger change in the inclination angles than other ships, this indicates that the ships for passengers and cars are in a very dangerous condition. That is, it is well demonstrated that ship G having an inclination angle of about 5 degrees is in a normal range while ship I having an inclination angle of 5 degrees is in a very dangerous condition. Most training ships and passenger ships ensure safety even when the extent of the limit inclination angle exceeds 10 degrees, so there is no problem in applying a criterion of 10 degrees to secure sufficient universality for the risk.

[Table 1]

	Types of ships	LBP [m]	Breadth [m]	Unique rolling period range [sec]	Limit inclination angle extent and designation [deg]
A	Training ships	120.0	19.4	9.6 ~ 11.7	11.6 ~ 16.0 / 10
B		104.0	25.0	10.1 ~ 13.7	11.6 ~ 16.0 / 10
C	Passenger ships	148.0	24.8	10.6 ~ 13.0	11.3 ~ 16.0 / 10
D		175.0	27.0	11.6 ~ 18.9	10.8 ~ 13.9 / 10
E		171.0	27.0	14.3 ~ 17.1	11.4 ~ 12.4 / 10
F		102.0	17.8	10.4 ~ 14.6	10.8 ~ 13.2 / 10
G		147.0	25.0	11.0 ~ 19.1	11.3 ~ 16.0 / 10
H	Ships for passengers and cars	47.0	12.0	4.6 ~ 5.1	5.9 ~ 8.9 / 5.9
I		55.0	13.0	4.9 ~ 5.2	4.4 ~ 8.1 / 4.4

[Table 2]

Classification	Determination	Rolling period [sec]	Average list angle/significant rolling angle [deg]
Ship A	Normal	≤ 11.7	≤ 5.0
	Caution	≤ 16.4	≤ 10.0
	Danger	> 16.4	> 10.0
Ship B	Normal	≤ 13.7	≤ 5.0
	Caution	≤ 19.2	≤ 10.0
	Danger	> 19.2	> 10.0
Ship C	Normal	≤ 13.0	≤ 5.0
	Caution	≤ 18.2	≤ 10.0
	Danger	> 18.2	> 10.0
Ship D	Normal	≤ 18.9	≤ 5.0
	Caution	≤ 26.5	≤ 10.0
	Danger	> 26.5	> 10.0
Ship E	Normal	≤ 17.1	≤ 5.0
	Caution	≤ 23.9	≤ 10.0
	Danger	> 23.9	> 10.0
Ship F	Normal	≤ 14.6	≤ 5.0
	Caution	≤ 20.4	≤ 10.0
	Danger	> 20.4	> 10.0
Ship G	Normal	≤ 19.1	≤ 5.0
	Caution	≤ 26.7	≤ 10.0
	Danger	> 26.7	> 10.0
Ship H	Normal	≤ 5.1	≤ 3.0
	Caution	≤ 7.1	≤ 5.9
	Danger	> 7.1	> 5.9
Ship I	Normal	≤ 5.2	≤ 2.2
	Caution	≤ 7.3	≤ 4.4
	Danger	> 7.3	> 4.4

[0028] The display 400 receives a display control signal from the controller 300 and displays the normal, caution, or danger state for the rolling period, the average list angle, and the significant rolling angle of the ship. As the display 400, an output device, such as a PDP, LCD, LED, or OLED display, may be used.

[0029] A method for monitoring a safety status of a ship by using the system for monitoring the safety status of the ship using roll motion data according to the embodiment of the present disclosure configured as described above will be described.

[0030] FIG. 2 is a flowchart illustrating a method for monitoring a safety status of a ship using roll motion data, according to an embodiment of the present disclosure. Herein, S denotes a step.

[0031] First, the controller 300 receives rolling period data, average list angle data, and significant rolling angle data from the rolling period computation part 200, the average list angle computation part 210, and the significant rolling angle computation part 220 in step S100.

[0032] Next, the controller 300 determines whether the rolling period data is equal to or less than the maximum unique rolling period in step S200.

[0033] When the rolling period data is equal to or less than the maximum unique rolling period in step S200 (Y), the controller 300 determines that the rolling period is in the normal state and displays a rolling period normal state through the display 400 in step S230.

[0034] When the rolling period data is greater than the maximum unique rolling period in step S200 (N), the controller 300 determines whether the rolling period data is equal to or less than the maximum unique rolling period + 40 % of the maximum unique rolling period in step S210.

[0035] When the rolling period data is equal to or less than the maximum unique rolling period + 40 % of the maximum unique rolling period in step S210 (Y), the controller 300 determines that the rolling period is in the caution state and displays a rolling period caution state through the display 400 in step S240.

[0036] When the rolling period data is greater than the maximum unique rolling period + 40 % of the maximum unique rolling period in step S210, the controller 300 determines that the rolling period is in the danger state and displays a rolling period danger state through the display 400 in step S220.

[0037] In the meantime, after step S100, the controller 300 determines whether the average list angle data is equal to or less than 50 % of the grade criterion in step S300.

[0038] When the average list angle data is equal to or less than 50 % of the grade criterion in step S300, the controller 300 determines that the average list angle is in the normal state and displays a list angle normal state through the display 400 in

step S330.

[0039] When the average list angle data is greater than 50 % of the grade criterion in step S300 (N), the controller 300 determines whether the average list angle data is equal to or less than the grade criterion in step S310.

[0040] When the average list angle data is equal to or less than the grade criterion in step S310 (Y), the controller 300 determines that the average list angle is in the caution state and displays an average list angle caution state through the display 400 in step S340.

[0041] In the meantime, when the average list angle data is greater than the grade criterion in step S310 (N), the controller 300 determines that the average list angle is in the danger state and displays an average list angle danger state through the display 400 in step S320.

[0042] In the meantime, after step S100, the controller 300 determines whether the significant rolling angle data is equal to or less than 50 % of the grade criterion in step S400.

[0043] When the significant rolling angle data is equal to or less than 50 % of the grade criterion in step S400 (Y), the controller 300 determines that the significant rolling angle is in the normal state and displays a significant rolling angle normal state through the display 400 in step S430.

[0044] When the significant rolling angle data is greater than 50 % of the grade criterion in step S400 (N), the controller 300 determines whether the significant rolling angle data is equal to or less than the grade criterion in step S410.

[0045] When the significant rolling angle data is equal to or less than the grade criterion in step S410 (Y), the controller 300 determines that the significant rolling angle is in the caution state and displays a significant rolling angle caution state through the display 400 in step S440.

[0046] When the significant rolling angle data is greater than the grade criterion in step S410 (N), the controller 300 determines that the significant rolling angle is in the danger state and displays a significant rolling angle danger state through the display 400 in step S420.

[0047] According to the system and the method for monitoring a safety status of a ship using roll motion data according to the embodiments of the present disclosure, the rolling period data, the average list angle data, and the significant rolling angle data are received from the rolling period computation part, the average list angle computation part, and the significant rolling angle computation part, and it is determined whether the rolling period data is equal to or less than the maximum unique rolling period. When the rolling period data is equal to or less than the maximum unique rolling period, it is determined that the rolling period is in the normal state and the rolling period normal state is displayed through the display. When the rolling period data is greater than the maximum unique rolling period and is equal to or less than the maximum unique rolling period + 40 % of the maximum unique rolling period, the controller determines that the rolling period is in the caution state and displays the rolling period caution state through the display. When the rolling period data is greater than the maximum unique rolling period + 40 % of the maximum unique rolling period, it is determined that the rolling period is in the danger state and the rolling period danger state is displayed through the display. Accordingly, the criteria and configuration for generating an alarm signal that displays the safety status of the ship on the basis of the roll motion data of the ship obtained from the electronic inclinometer can be specifically provided.

[0048] The optimum exemplary embodiments have been disclosed and the specific terms are used in the drawings and the specification, but the exemplary embodiments and the terms are used just for the purpose of describing the exemplary embodiments of the present disclosure, but not used to limit meanings or restrict the scope of the present disclosure disclosed in the claims. Therefore, those skilled in the art will understand that various modifications of the exemplary embodiment and any other exemplary embodiments equivalent thereto are available. Accordingly, the true technical protection scope of the present disclosure should be determined by the technical idea of the appended claims.

Claims

1. A system for monitoring a safety status of a ship using roll motion data, the system comprising:

a rolling period computation part (200) configured to compute rolling period data by performing fast Fourier transform (FFT) analysis on rolling angle data over time shown by an electronic inclinometer (100);

an average list angle computation part (210) configured to compute average list angle data by performing FFT analysis on the rolling angle data;

a significant rolling angle computation part (220) configured to compute significant rolling angle data by performing FFT analysis on the rolling angle data;

a controller (300) configured to receive the computed rolling period data, the computed average list angle data, and the computed significant rolling angle data, and perform comparative analysis on the rolling period data with a maximum unique rolling period and the maximum unique rolling period + 40 % of the maximum unique rolling period to determine a normal, caution, or danger state of a rolling period, and perform comparative analysis on the average list angle data with 50 % of a grade criterion and the grade criterion to determine a normal, caution, or

danger state of an average list angle, and perform comparative analysis on the significant rolling angle data with 50 % of the grade criterion and the grade criterion to determine a normal, caution, or danger state of an average significant rolling angle, and output a display control signal corresponding to each of the determined states; and a display (400) configured to receive the display control signal from the controller and display the display control signal.

2. The system of claim 1, wherein as the grade criterion, the lesser of a limit inclination angle of the ship and 10 [deg] is selected.

3. A method for monitoring a safety status of a ship by using a system for monitoring the safety status of the ship using roll motion data, the method comprising:

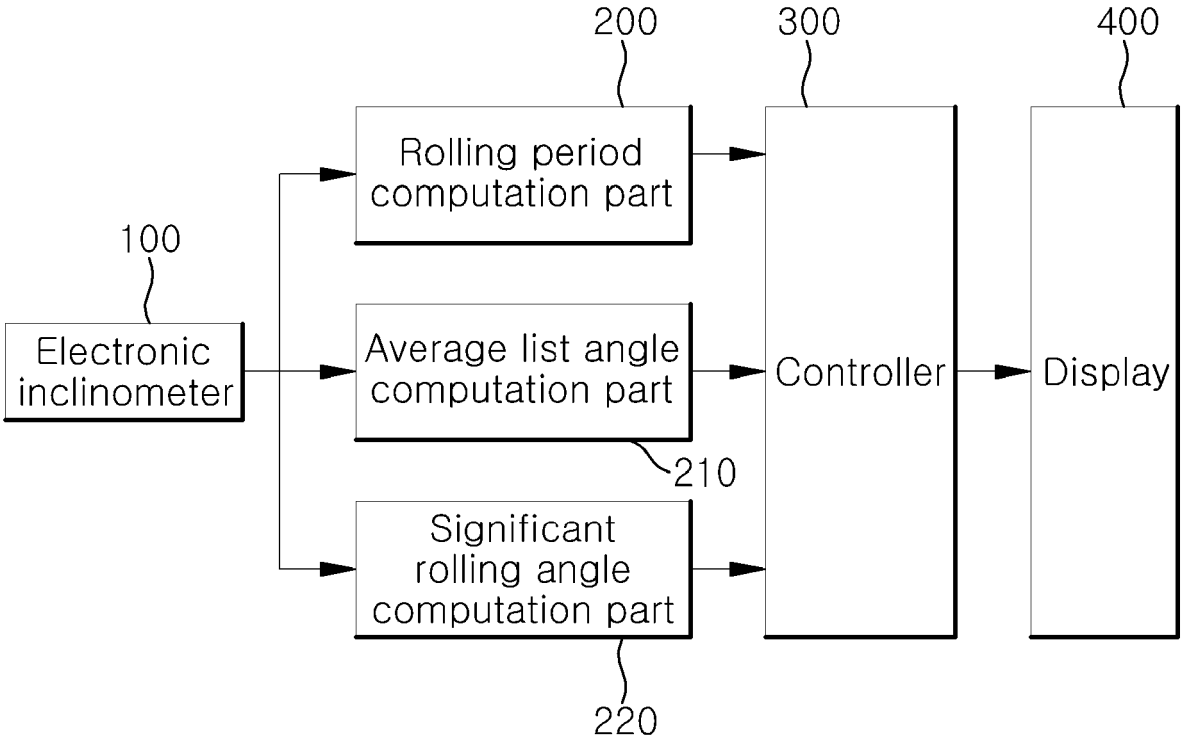
receiving, by a controller (300), rolling period data, average list angle data, and significant rolling angle data from a rolling period computation part (200), an average list angle computation part (210), and a significant rolling angle computation part (220);
determining, by the controller, whether the rolling period data is equal to or less than a maximum unique rolling period;
determining, by the controller, that a rolling period is in a normal state and displaying a rolling period normal state through a display (400) when the rolling period data is equal to or less than the maximum unique rolling period;
determining, by the controller, that the rolling period is in a caution state and displaying a rolling period caution state through the display when the rolling period data is greater than the maximum unique rolling period and is equal to or less than the maximum unique rolling period + 40 % of the maximum unique rolling period; and
determining, by the controller, that the rolling period is in a danger state and displaying a rolling period danger state through the display when the rolling period data is greater than the maximum unique rolling period + 40 % of the maximum unique rolling period.

4. The method of claim 3, after the receiving, further comprising:

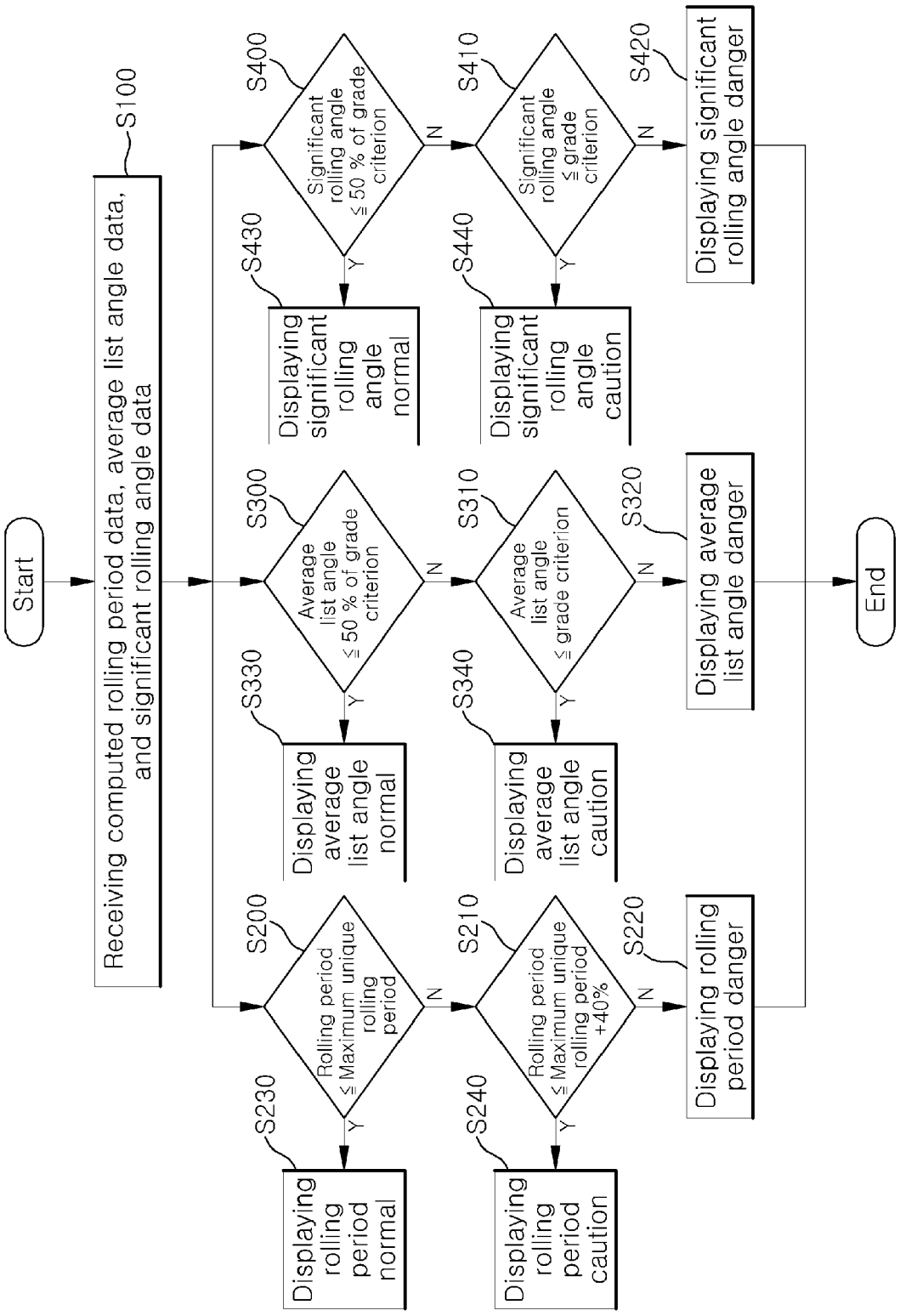
determining, by the controller, whether the average list angle data is equal to or less than 50 % of a grade criterion;
determining, by the controller, that an average list angle is in a normal state and displaying a list angle normal state through the display (400) when the average list angle data is equal to or less than 50 % of the grade criterion;
determining, by the controller, that the average list angle is in a caution state and displaying an average list angle caution state through the display when the average list angle data is greater than 50 % of the grade criterion and is equal to or less than the grade criterion; and
determining, by the controller, that the average list angle is in a danger state and displaying an average list angle danger state through the display when the average list angle data is greater than the grade criterion.

5. The method of claim 3, after the receiving, further comprising:

determining, by the controller, whether the significant rolling angle data is equal to or less than 50 % of a grade criterion;
determining, by the controller, that a significant rolling angle is in a normal state and displaying a significant rolling angle normal state through the display when the significant rolling angle data is equal to or less than 50 % of the grade criterion;
determining, by the controller, that the significant rolling angle is in a caution state and displaying a significant rolling angle caution state through the display when the significant rolling angle data is greater than 50 % of the grade criterion and is equal to or less than the grade criterion; and
determining, by the controller, that the significant rolling angle is in a danger state and displaying a significant rolling angle danger state through the display when the significant rolling angle data is greater than the grade criterion.


200
300
400
Rolling period computation part
100
Electronic inclinometer
Average list angle computation part
Controller
Display
210
Significant rolling angle computation part
220

[FIG. 1]


Start
S100
Receiving computed rolling period data, average list angle data, and significant rolling angle data
S200
Rolling period ≤ Maximum unique rolling period
Y
N
S210
Rolling period ≤ Maximum unique rolling period +40%
Y
N
S220
Displaying rolling period danger
S230
Displaying rolling period normal
S240
Displaying rolling period caution
S300
Average list angle ≤ 50 % of grade criterion
Y
N
S310
Average list angle ≤ grade criterion
Y
N
S320
Displaying average list angle danger
S330
Displaying average list angle normal
S340
Displaying average list angle caution
S400
Significant rolling angle ≤ 50 % of grade criterion
Y
N
S410
Significant rolling angle ≤ grade criterion
Y
N
S420
Displaying significant rolling angle danger
S430
Displaying significant rolling angle normal
S440
Displaying significant rolling angle caution
End

[FIG. 2]

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EUROPEAN SEARCH REPORT

Application Number
EP 24 16 3211

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2016/114867 A1 (NICOL PETER JAMES [CA]) 28 April 2016 (2016-04-28) * paragraph [0017] - paragraph [0020] * * paragraph [0030] * * paragraph [0033] * * paragraph [0036] - paragraph [0040] * * paragraph [0041] - paragraph [0048] * * claims 1-5,7 * * figures *	1-5	INV. B63B39/14 B63B79/10 B63B79/30
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X	US 4 918 628 A (GRIFFIN MICHAEL J [GB] ET AL) 17 April 1990 (1990-04-17) * column 2, line 30 - column 4, line 9 * * column 5, line 35 - column 6, line 5 * * claims * * figures *	1,3	
			TECHNICAL FIELDS SEARCHED (IPC) B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17 September 2024	Barré, Vincent

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 16 3211

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17-09-2024

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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