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(54) METHOD AND SYSTEM FOR CALCULATING NAVIGATION SAFETY SCORE

(57) An embodiment of the present disclosure discloses a navigation safety score calculation method.

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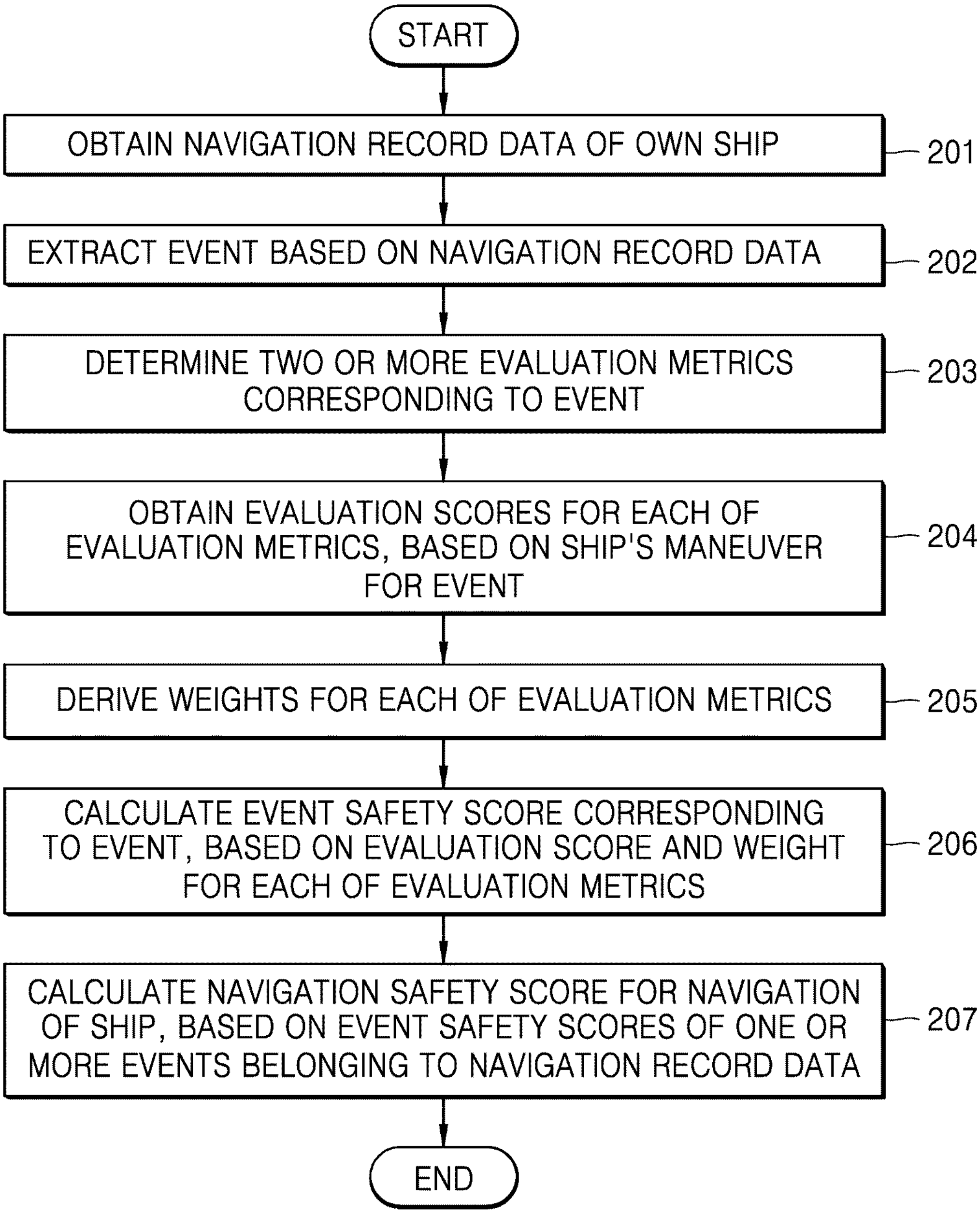
FIG. 2


START
OBTAIN NAVIGATION RECORD DATA OF OWN SHIP
201
EXTRACT EVENT BASED ON NAVIGATION RECORD DATA
202
DETERMINE TWO OR MORE EVALUATION METRICS CORRESPONDING TO EVENT
203
OBTAIN EVALUATION SCORES FOR EACH OF EVALUATION METRICS, BASED ON SHIP'S MANEUVER FOR EVENT
204
DERIVE WEIGHTS FOR EACH OF EVALUATION METRICS
205
CALCULATE EVENT SAFETY SCORE CORRESPONDING TO EVENT, BASED ON EVALUATION SCORE AND WEIGHT FOR EACH OF EVALUATION METRICS
206
CALCULATE NAVIGATION SAFETY SCORE FOR NAVIGATION OF SHIP, BASED ON EVENT SAFETY SCORES OF ONE OR MORE EVENTS BELONGING TO NAVIGATION RECORD DATA
207
END

Description

Technical Field

[0001] Embodiments below relate to a navigation safety score calculation method and system.

Background Art

[0002] In the modern maritime industry, it has become an important issue to evaluate and manage the navigation safety of ships in complicated maritime traffic situations. As maritime traffic increases, the risk of collisions between ships increases, requiring an accurate evaluation of hazardous situations that occur during ship navigation. In particular, various factors, such as encounters with other ships on the route, weather conditions, or the state of the ship itself, may interact in a complicated manner to cause a hazardous situation, and the ship's response thereto may be an important factor in the safety evaluation.

[0003] In the past, compliance with regulations such as the International Regulations for Preventing Collisions at Sea (COLREGS) has been used as an evaluation criterion to prevent collisions between ships, but in many cases, it is difficult to sufficiently evaluate the navigational safety of ships in complicated maritime situations based solely on compliance with such regulations. Therefore, there is a need for a precise safety evaluation method.

Disclosure of Invention

Technical Problem

[0004] An object of the present disclosure is to calculate a safety score for each event through various evaluation metrics corresponding to a hazardous situation (event) based on navigation record data of a ship, and to calculate a navigation safety score based on the event safety score.

[0005] An object of the present disclosure is to provide a user interface (UI) which visually provides safety scores of a fleet and ships so as to help a fleet manager efficiently manage the safe operations of a plurality of ships included in the fleet.

[0006] The problems to be solved by the present disclosure are not limited to those described above, and other problems and advantages of the present disclosure that are not described herein will be understood from the following description and will be more clearly understood from embodiments of the present disclosure. Furthermore, it will be appreciated that the problems to be solved by the present disclosure and the advantages of the present disclosure may be realized by the means indicated in the claims and combinations thereof.

Solution to Problem

[0007] According to an embodiment of the present disclosure, a navigation safety score calculation method may include: obtaining navigation record data of an own ship; extracting an event based on the navigation record data; determining two or more evaluation metrics corresponding to the event; obtaining an evaluation score for each of the evaluation metrics, based on a ship's maneuver for the event; calculating an event safety score corresponding to the event, based on the evaluation metric score; and calculating a navigation safety score for navigation of the ship, based on event safety scores of one or more events belonging to the navigation record data.

[0008] According to an embodiment of the present disclosure, a navigation safety score calculation system may include a processor and a memory, wherein the processor is configured to obtain an evaluation score for each of evaluation metrics, based on a ship's maneuver for one or more events occurring during navigation of the ship, calculate an event safety score corresponding to the event, based on the evaluation score for each of the evaluation metrics, and calculate a navigation safety score for the navigation of the ship, based on event safety scores of the one or more events.

[0009] A computer-readable recording medium having recorded thereon a program for causing a computer to perform the method of the present disclosure may be provided.

Advantageous Effects of Invention

[0010] According to the problem solving means of the present disclosure described above, the navigation safety of a ship may be more accurately evaluated by systematically evaluating various hazardous situations occurring during navigation of the ship.

[0011] Furthermore, a fleet manager may easily monitor the safety scores of ships and a fleet and identify ships requiring retraining to maintain fleet safety.

Brief Description of Drawings

[0012]

FIG. 1 is a system diagram illustrating a system for calculating a navigation safety score and providing a fleet management interface, according to an embodiment.

FIG. 2 is a flowchart illustrating, in time series, a navigation safety score calculation method according to an embodiment of the present disclosure.

FIG. 3 illustrates an example in which a processor sets a safety buffer, according to an embodiment.

FIG. 4 is a diagram for describing an International Regulations for Preventing Collisions at Sea (COLREG) rule according to an embodiment of the present disclosure.

FIG. 5 is a diagram illustrating, in time series, a method of deriving weights for each of evaluation metrics, according to an embodiment of the present disclosure.

FIG. 6 illustrates a pair-wise comparison matrix between event-specific evaluation metrics, according to an embodiment of the present disclosure.

FIG. 7 illustrates a normalized matrix obtained by normalizing a pair-wise comparison matrix, according to an embodiment of the present disclosure.

FIG. 8 is a result table obtained by deriving weights using a normalized pair-wise comparison matrix, according to an embodiment of the present disclosure.

FIG. 9 illustrates a table for verifying consistency, according to an embodiment of the present disclosure.

FIG. 10 illustrates, in time series, a navigation safety score calculation method according to an embodiment of the present disclosure.

FIG. 11 illustrates, in time series, a method of providing a fleet management interface, according to an embodiment of the present disclosure.

FIG. 12 illustrates an example of a first screen of a fleet management system, according to an embodiment of the present disclosure.

FIG. 13 illustrates an example of a second screen displaying rankings and graphs of fleet safety scores, according to an embodiment of the present disclosure.

FIG. 14 illustrates a third screen, which is a management interface for individual ships, according to an embodiment of the present disclosure.

FIG. 15 is a block diagram of a server according to an embodiment.

Best Mode for Carrying out the Invention

[0013] According to an embodiment of the present disclosure, a navigation safety score calculation method may include: obtaining navigation record data of an own ship; extracting an event based on the navigation record data; determining two or more evaluation metrics corresponding to the event; obtaining an evaluation score for each of the evaluation metrics, based on a ship's maneuver for the event; calculating an event safety score corresponding to the event, based on the evaluation metric score; and calculating a navigation safety score for navigation of the ship, based on event safety scores of one or more events belonging to the navigation record data.

[0014] In the present disclosure, the calculating of the event safety score may include: deriving weights for each of the evaluation metrics; and calculating the event safety score corresponding to the event by applying the weights to the evaluation score for each of the evaluation metrics.

[0015] In the present disclosure, the deriving of the weights may include: generating a pair-wise comparison matrix by obtaining relative importance between the evaluation metrics; normalizing the pair-wise comparison matrix; and deriving the weights for each of the evaluation metrics by using the normalized pair-wise comparison matrix.

[0016] In the present disclosure, the navigation safety score calculation method may further include: performing consistency verification on the derived weights; and regenerating the pair-wise comparison matrix in case that it is determined that the derived weights are not consistent.

[0017] In the present disclosure, the evaluation metrics may be two or more of overlapped area, compliance with regulations, overlapped time, efficiency of navigational actions, reduction in contextual collision risk (CCR), and near-miss.

[0018] In the present disclosure, the evaluation metrics may include an overlapped area, and the overlapped area may be a maximum area of an area where a first safety buffer and a second safety buffer calculated based on the navigation record data overlap each other.

[0019] In the present disclosure, the evaluation metrics may include compliance with regulations, and the compliance with regulations may be a binary metric which determines whether evasive maneuver corresponding to the event complies with maritime regulations.

[0020] In the present disclosure, the calculating of the navigation safety score for the navigation of the ship may include calculating the navigation safety score by reflecting, to the event safety score, an environmental weight based on environmental conditions under which the event occurred.

[0021] In the present disclosure, the environmental weight may be set to be low for an event occurring in at least one of a port, a strait, and a congested area.

[0022] According to an embodiment of the present disclosure, a navigation safety score calculation system includes a processor and a memory, wherein the processor is configured to obtain an evaluation score for each of evaluation metrics, based on a ship's maneuver for one or more events occurring during navigation of the ship, calculate an event safety score corresponding to the event, based on the evaluation score for each of the evaluation metrics, and calculate a navigation safety score for the navigation of the ship, based on event safety scores of the one or more events.

[0023] In the present disclosure, the one or more events occurring during the navigation may be extracted based on navigation record data of an own ship.

[0024] In the present disclosure, the event safety score may be calculated by applying weights for each of the evaluation metrics to the evaluation score for each of the evaluation metrics.

[0025] In the present disclosure, a pair-wise comparison matrix may be generated by obtaining relative importance between the evaluation metrics, the pair-wise comparison matrix may be normalized, and the weights may be derived by using the normalized comparison matrix.

[0026] In the present disclosure, the evaluation metrics may be two or more of overlapped area, compliance with regulations, overlapped time, efficiency of navigational actions, reduction in contextual collision risk (CCR), and near-miss.

[0027] A computer-readable recording medium having recorded thereon a program for causing a computer to perform the method of the present disclosure may be provided.

Mode for the Invention

[0028] The advantages and features of the present disclosure, and methods of achieving them will be clarified with reference to embodiments described below in detail with reference to the accompanying drawings. However, the present disclosure is not limited to the embodiments presented below and may be implemented in various different forms. Rather, it will be understood that the present disclosure includes all modifications, equivalents, and substitutes falling within the concept and technical scope of the present disclosure.

[0029] The terms as used herein are only used to describe particular embodiments and are not intended to limit the present disclosure. The singular forms as used herein are intended to include the plural forms as well unless the context clearly indicates otherwise. The terms "comprise," "include," or "have" as used in the present application are inclusive and therefore specify the presence of one or more stated features, integers, steps, operations, elements, components, or any combination thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, or any combination thereof.

[0030] Some embodiments of the present disclosure may be represented by functional block configurations and various processing steps. Some or all of such functional blocks may be implemented in any number of hardware and/or software configurations that perform specific functions. For example, the functional blocks of the present disclosure may be implemented by one or more microprocessors 1120 or may be implemented by circuit configurations for certain functions. In addition, for example, the functional blocks of the present disclosure may be implemented in various programming or scripting languages. The functional blocks may be implemented as algorithms to be executed by one or more processors 1120. In addition, the present disclosure may employ conventional technologies for electronic environment setting, signal processing, and/or data processing. The terms such as "mechanism," "element," "means," and "configuration" may be used broadly and are not limited to mechanical and physical configurations.

[0031] In addition, connecting lines or connecting members illustrated in the drawings are intended to represent functional connections and/or physical or circuit connections. In an actual device, connecting lines or connecting members illustrated in the drawings may represent connections between components by means of a variety of functional, physical, or circuit connections that may be substituted or added.

[0032] Hereinafter, actions performed by a user may refer to actions performed by the user through a user terminal. As an example, commands corresponding to actions performed by the user may be input to the user terminal through an input device (e.g., a keyboard, a mouse, etc.) embedded in or additionally connected to the user terminal. As another example, commands corresponding to actions performed by the user may be input to the user terminal through a touch screen of the user terminal. At this time, the actions performed by the user may include a certain gesture. For example, the gesture may include tap, touch and hold, double tap, drag, pan, flick, drag and drop, etc.

[0033] Hereinafter, the present disclosure will be described in detail with reference to the attached drawings.

[0034] FIG. 1 is a system diagram illustrating a system for calculating a navigation safety score and providing a fleet management interface, according to an embodiment.

[0035] According to an embodiment of the present disclosure, a server 110 may be a system which calculates navigation safety scores of ships, calculates a fleet safety score of an entire fleet 120, based on the calculated navigation safety scores, and provides a fleet management interface, based on the calculated fleet safety score. The server 110 includes a processor 1120 illustrated in FIG. 15 to be described below.

[0036] On the other hand, although FIG. 1 illustrates that the server 110 is a single physical component, the server 110 may be a plurality of servers in which a plurality of physical computing devices are connected and operated organically, and furthermore, the scope of the server may include even a cloud server capable of communicating with the server.

[0037] In addition, the fleet 120 refers to a plurality of individual ships 121, 122, and 123 which come together to form a single unit. The server 110 may collect navigation record data of the individual ships 121, 122, and 123 and calculate the navigation safety scores of the individual ships, or calculate the fleet safety score of the fleet.

[0038] In addition, a manager terminal 130 is a terminal of a manager who controls the server 110, and in this case, the manager may be a manager of the fleet 120. That is, the server 110 may calculate the navigation safety scores of the individual ships or calculate the fleet safety score of the fleet by a command from the manager terminal 130, and furthermore, may provide a fleet management interface to the manager terminal 130.

[0039] The operation of the server 110 according to an embodiment of the present disclosure is described in more detail with reference to FIG. 2 in the specification.

[0040] FIG. 2 is a flowchart illustrating, in time series, a navigation safety score calculation method according to an embodiment of the present disclosure.

[0041] The navigation safety score calculation method of FIG. 2 may be performed by the processor 1120. First, the processor 1120 obtains navigation record data of an own ship (201).

[0042] Next, an event is extracted based on the navigation record data (202).

[0043] Next, two or more evaluation metrics corresponding to the event are determined (203).

[0044] Next, evaluation scores for each of the evaluation metrics are obtained based on the ship's maneuver for the event (204).

[0045] Next, weights for each of the evaluation metrics are derived (205).

[0046] Next, event safety scores corresponding to the event are calculated based on the evaluation scores and the weights for each of the evaluation metrics (206).

[0047] Next, a navigation safety score for the navigation of the ship is calculated based on the event safety scores of one or more events belonging to the navigation record data (207).

[0048] On the other hand, the ship may encounter various hazardous situations during navigation. The hazardous situations during navigation may refer to a hazardous situation caused by maritime traffic conditions, such as crowded sea areas, narrow waterways, and encounters with other ships, or physical obstacles, such as reefs, icebergs, and marine structures. The navigation safety may depend on how the ship responds to hazardous situations during navigation. For example, in case that a maneuver (in an embodiment, an evasive maneuver) is successfully performed in a situation where the ship encounters another ship, the ship may be evaluated as having navigated safely. However, even though the situation ends without an accident, in case that the evasive maneuver was not appropriate or there was a moment when the distance from another ship became too close, the ship may not be evaluated as having navigated safely.

[0049] In addition, the fleet refers to a plurality of ships which come together to form a single unit, and may be a general term for a plurality of ships owned by one individual or one company. The ships of the fleet may be managed systematically as a single-owner enterprise. For example, a global shipping company or fishing company may be a single fleet.

[0050] Because the fleet manages a plurality of ships, it is important to evaluate the navigational safety of the ships so as to maximize the safety, profitability, and efficiency of fleet management. The navigation safety according to an embodiment of the present disclosure may vary depending on how the ship responded to hazardous situations during navigation as described above, or depending on whether there was a rapid acceleration/deceleration or high-rate-of-turn situation. More specifically, whether there was a rapid acceleration/deceleration or high-rate-of-turn situation may be determined based on at least one of information about the type of ship, i.e., ship type, information about a shipment volume, a rudder angle, how fast the ship is attempting to change course at a corresponding angle, the operating speed of the ship, or an amount of change in engine revolutions per minute (RPM).

[0051] According to an embodiment of the present disclosure, the hazardous situation or the rapid acceleration/deceleration situation encountered by the ship during navigation is defined as an event, and the processor 1120 may calculate an event safety score based on the ship's maneuver associated with a specific event. In addition, the processor 1120 may calculate a navigation safety score for a specific navigation by aggregating event safety scores of one or more events corresponding to a specific navigation. The calculated navigation safety score may be an objective metric for evaluating navigation safety, and the fleet management score of the entire fleet may be derived based on the navigation safety score.

[0052] Hereinafter, a navigation safety evaluation method of the present disclosure is described with reference to the drawings.

[0053] First, the processor 1120 obtains navigation record data of the own ship (201). The navigation record data of the own ship is all pieces of data related to navigation and may include information about various situations occurring during the operation of the ship and the maneuvers taken to deal with them, and there are no restrictions on the format, including text, images, videos, sounds, and laser signals. According to an embodiment, the navigation record data may include a navigation log, and the navigation log may include location information that records the location (latitude, longitude), route, or speed of the ship sailing with respect to each time zone, speed information that records changes in the speed of the ship with respect to each time zone, and route information about a set route or a route change. Additionally, according to an embodiment, the navigation record data may include cognitive systems such as sensor data or map data, and collision avoidance system data may include radar and automatic identification system (AIS) data that record location information about other ships, obstacles, or marine structures around the ship.

[0054] Next, the processor 1120 extracts the event based on the obtained navigation record data. The event may be an accident involving the hazardous situation of the ship, or there may be an encounter situation between the own ship and another ship. The processor 1120 may determine an accident as the event in case that the conditions for establishing the encounter situation are satisfied by taking into account the location, speed, and route of the own ship and the other ship, based on the navigation record data.

[0055] According to an embodiment of the present disclosure, the processor 1120 may first set a safety buffer so as to extract the event. The safety buffer is an area determined based on a safety distance and a safety time. The safety distance may be a distance taken into account so as to avoid collisions between ships, and the safety time may be a time taken into account so as to avoid collisions between ships. That is, the safety buffer may be an area which is a basis for determining an event which has the possibility of collisions between the own ship and the other ship. The processor 1120 may set the safety buffers of the own ship and the other ship by using a fixed distance model, a proportional distance model, a dynamic model, a geometric model, a KIJIMA model (a KIJIMA ship domain model), or the like.

[0056] FIG. 3 illustrates an example in which the processor sets the safety buffer, according to an embodiment.

[0057] Referring to FIG. 3, an own ship 310 and another ship 320, a first safety buffer 311 which is a safety buffer of the own ship 310, and a second safety buffer 321 which is a safety buffer of the other ship are illustrated. In the embodiment of FIG. 3, the safety buffer of the ship is defined as an elliptical shape in accordance with a KIJIMA model, but according to another embodiment of the present disclosure, the safety buffer of the ship may be defined in various methods.

[0058] Referring to FIG. 3, the center of the own ship may be located at the focus of the ellipse so that the major axis of the ellipse, which is the safety buffer 311, is located in a direction of the own ship's bow. In addition, the speed of the other ship 320 may be represented by a relative speed. According to the embodiment of FIG. 3, the major axis of the safety buffer 311 may be set in proportion to the length and traveling direction speed of the ship, and the minor axis of the safety buffer 311 may be set according to the width and maneuverability of the ship.

[0059] After setting the safety buffers as illustrated in FIG. 3, the processor 1120 may consider, as a hazardous situation, a case where the first safety buffer 311, which is the safety buffer of the own ship, overlaps the second safety buffer 321, which is the safety buffer of the other ship, and may extract, as an event, a situation from a time point t1 when the first and second safety buffers begin to overlap each other to a time point t2 when the overlap ends. That is, the processor 1120 may determine that the navigation record data between t1 and t2 is data corresponding to the event. Hereinafter, location data (latitude, longitude), time, speed, direction, AIS data (position, speed, direction) of a surrounding ship, etc. between t1 and t2, which are an event period, may be referred to as event data.

[0060] On the other hand, various methods of determining the safety buffers 311 and 321 may be applied. For example, the safety buffers 311 and 321 may be determined as an elliptical shape as in the example of FIG. 3, based on the major axis and the minor axis of the ship, or may be determined by using a Kijima model, a Coldwell model, a Fujii model, a Smierzchalski model, a Davis model, etc. In case that the Kijima model is applied, the ellipse becomes longer in the longitudinal direction, which has an advantage of reflecting the inertia of the ship well. However, it should be understood that the method of determining the safety buffer of the ship is not necessarily limited to the examples described in the present specification.

[0061] Next, the processor 1120 determines two or more evaluation metrics corresponding to the event (203). The event evaluation metrics may be a metric used to objectively evaluate how hazardous an event is. According to an embodiment of the present disclosure, the event evaluation metrics may be one or more of overlapped area (or Severity of hazardous situation), compliance with regulations, overlapped time, efficiency (efficiency of navigational actions), reduction in contextual collision risk (CCR), and Near-miss.

[0062] According to an embodiment of the present disclosure, the overlapped area as the event evaluation metrics may be a metric indicating how much the safety buffers between the own ship and the other ship, i.e., the first safety buffer and the second safety buffer, overlap each other. The safety buffer described in FIG 3 only shows the safety buffer of the own ship, but the safety buffer of the other ship may also be assumed. Because there is a high possibility that a hazardous situation will occur in case that the safety buffer of the own ship overlaps the safety buffer of the other ship, the safety score needs to be set to be low. In addition, as the overlapped area between the safety buffers of the own ship and the other ship is wider, it may be determined as a more hazardous situation. Accordingly, as the overlapped area is wider, the lower the overlapped area score may be set to be lower.

[0063] More specifically, according to an embodiment of the present disclosure, the overlapped area may be defined as a maximum area where the first safety buffer overlaps the second safety buffer. That is, the processor 1120 may calculate, as the overlapped area, the maximum area where the first safety buffer and the second safety buffer overlap each other during one navigation unit, and may calculate the overlapped area safety score of the corresponding ship, based on the calculated overlapped area.

[0064] Next, according to an embodiment of the present disclosure, the compliance with regulations as the event evaluation metrics may be a metric indicating the extent to which a regulation, such as a COLREG rule, has been complied with. The COLREG rule is the International Regulations for Preventing Collisions at Sea, which are internationally accepted rules for preventing collisions between ships. All ships at sea have to comply with the COLREG rule, which clearly state how ships should behave when encountering one another at sea. That is, because the main principle of the COLREG rule is to clarify responsibilities between ships and help ships navigate safely, the compliance score may be set to increase when the COLREG rule is complied with. In a specific embodiment of the present disclosure, the compliance score may be a binary score in which the evaluation metric score is 0 in case that the COLREG rule is complied with and is 1 in case that the COLREG rule is not complied with.

[0065] FIG. 4 is a diagram for describing a COLREG rule according to an embodiment of the present disclosure.

[0066] Referring to FIG. 4, a large circle 402 drawn around a center point 401 and relative position zones R1 to R6 are zones for distinguishing the direction from which other ships are approaching based on a current position of an own ship. In addition, small circles 411 to 416 respectively corresponding to the relative position zones R1 to R6 include information about which ship should maintain its route and which ship should give way in case that another ship is present in the corresponding relative position zone. Hereinafter, the COLREG rule is described in more detail with reference to FIG. 4.

[0067] First, the abbreviations ABB and definitions shown at the bottom right of FIG 4 are described. The respective abbreviations define terms related to collision events between the own ship and the other ships. First, HO (Head on) is a head-on collision situation, which means that two ships are facing each other, and thus, there is a high possibility of collision. In addition, CR (Crossing) is a crossing situation, which is a situation occurring on a path where two ships intersect. In addition, OT (Overtaking) is an overtaking situation, which is a situation occurring in case that one ship overtakes another ship from behind. In addition, GW (Give-way) is a give-way ship, which has to change a route or adjust a speed so as to avoid collisions, and in this case, the give-way ship may be the own ship. In addition, SO (Stand-on) is a ship with priority, which has to maintain its own route, but may need to take action in case that the possibility of collision increases. In addition, ST(Stationary) refers to a stationary ship, which means a ship that is not moving. In addition, SF (Safe) means a safe situation, which means a state where there is no risk of collision.

[0068] In addition, each of the relative position zones R1 to R6 of the large circle 402 of FIG. 4 may represent a situation in which surrounding other ships approach at various angles, based on the head direction of the own ship. Each zone may be interpreted differently depending on the angle.

[0069] First, based on the direction (0°) of the bow of the own ship, a zone R1 is a case where the other ship is located within an angle range of $-\alpha°$ to $+\alpha°$. In addition, a zone R2 is a case where the other ship is located within an angle range of $\alpha°$ to 67.5° with respect to the direction (0°) of the bow of the own ship. In addition, a zone R3 is a case where the other ship is located within an angle range of 67.5° to 112.5°. In addition, a zone R4 is a case where the other ship is located within an angle range of 112.5° to 247.5°. In addition, a zone R5 is a case where the other ship is located within an angle range of 247.5° to 292.5°. In addition, a zone R6 is a case where the other ship is located within an angle range of 292.5° to $360-\alpha°$.

[0070] In addition, characters written in the small circles 411 to 416 corresponding to the respective zones represent the relationships and obligations between ships according to each encounter situation. The characters may clearly distinguish which ship has to maintain its own route and which ship has to avoid, in accordance with the COLREG rule. For example, the characters written in the small circles 411 to 416 corresponding to the respective zones may represent the relationship between the own ship and the other ships and the status of the own ship.

[0071] First, in accordance with the COLREG rule, OT in OT-GW (Overtaking - Give-Way) written in the small circle 411 means an overtaking situation, and thus, the ship approaching from behind is a ship that has to give way. That is, GW represents the give-way ship, and the overtaking ship has to change a route or adjust a speed. In addition, CR in CR-GW (Crossing - Give-Way)represents a crossing situation, which is a situation where ships are on paths that intersect each other. At this time, GW is the give-way ship which has to change a route so as to avoid collisions, and the ship approaching from right has priority. In addition, CR in CR-SO (Crossing - Stand-On) represents a crossing situation which indicates a situation where ships intersect. SO represents a stand-on ship which has to maintain a route. Because the ship located on the right side has priority, this ship has to maintain its route, but may take necessary actions in case that a risk occurs. In addition, HO (Head-On) represents a head-on collision situation, in which both ships have to turn to starboard so as to avoid collisions.

[0072] In addition, OT in OT-SO (Overtaking - Stand-On) written in the small circle 414 represents an overtaking situation, which is a situation where the ship approaches from behind and attempts to overtake the ship in front. At this time, SO represents a (stand-on) ship which has to maintain its route, and the ship in front may maintain its own route and the ship behind has to give way.

[0073] In addition, ST (Stationary) written in the small circles 411 to 416 means a stationary ship. This ship is not moving and the moving ship has to avoid collisions.

[0074] In addition, SF (Safe) written in the small circles 412 to 416 means a safe state. In this zone, there is no risk of collision and sufficient distance is secured between ships.

[0075] According to an embodiment of the present disclosure, compliance with regulations may be determined as 0 or 1 depending on compliance with the COLREG rule is complied with. For example, in the OT-GW situation, in case that the own ship approaching from behind does not change a route or adjust a speed, the COLREG score may be calculated as 0.

[0076] Continuously, according to an embodiment of the present disclosure, the overlapped time may be evaluation metrics indicating the time adjusted by the own ship at a short distance from another ship or an obstacle. In other words, the overlapped time index is metrics which show how long a ship has sailed in close proximity to another ship or an obstacle at a short distance. As the time adjusted in a short distance increases, it is determined that the risk increases, and the overlapped time score decreases.

[0077] In a specific embodiment, the overlapped time score may be calculated based on the time when the safety buffers between the own ship and the other ship overlap each other. As described above, because there is a high possibility that a hazardous situation will occur in case that the safety buffer of the own ship overlaps the safety buffer of the other ship, the safety score needs to be set to be low. Therefore, after the overlapped area is set as the evaluation metrics, as the overlapped time between the own ship and the other ship increases, the overlapped time score may be set to be lower.

[0078] In another embodiment, the overlapped time score may be calculated based on the time when the other ship enters the safety buffer of the own ship, rather than the time when the safety buffers between the own ship and the other ship overlap each other. In case that it is difficult to assume the safety buffer of the other ship for various reasons, the time when the other ship invades the safety buffer of the own ship may be set as the reference for the overlapped time.

[0079] Next, according to an embodiment of the present disclosure, efficiency (efficiency of navigational actions) may be evaluation metrics associated with the deviation of the navigation distance from the calculated path. The efficiency metric is to evaluate how efficient a ship's navigational actions are and may be calculated based on the extent to which the current location of the ship deviates from the calculated path. According to an embodiment of the present disclosure, as the deviation from the calculated path increases, the efficiency score may be lowered.

[0080] More specifically, the processor 1120 may calculate the scores of the efficiency evaluation metrics based on an error between an ideal solution for a hazardous situation and a navigator's response. The processor 1120 may take into account temporal errors, maneuver errors, and appropriateness evaluations so as to calculate the efficiency evaluation score. The temporal errors may be determined based on the difference between the time taken for the navigator to recognize and respond to a risk and the ideal response time. The maneuver errors may be determined based on how much an actual route correction angle or speed change taken by the navigator differs from an ideal value. The appropriateness evaluation is to evaluate whether the navigator's actions were appropriate, and may be determined based on cases where, in an ideal situation, the ship should have slowed down, but the navigator maintained or accelerated a speed.

[0081] Next, according to an embodiment of the present disclosure, the near-miss may be evaluation metrics associated with whether a near-miss accident has been observed. The near-miss metric is to evaluate how often a ship experiences a near-collision situation. As more near-collision accidents occur, the near-miss score may be lowered. According to an embodiment of the present disclosure, the determination of the near-miss accident may be made based on whether another ship invades the safety buffer of the own ship described above. That is, the overlapped area metric is a metric associated with the overlap between the safety buffers of the own ship and the other ship, but the near-miss metric may be determined based on whether the other ship or obstacle invades the safety buffer of the own ship. In an embodiment, as the other ship or obstacle invades the safety buffer of the own ship more frequently, the near-miss score may be calculated to be lower.

[0082] Next, according to an embodiment of the present disclosure, the presence or absence of the reduction in CCR is a metric for evaluating whether the CCR has been reduced during the navigation of the ship. The CCR is a method of more precisely analyzing the risk of collisions between ships by aggregating various situational factors in the maritime environment. In case that the CCR decreases, the CCR score may be calculated as 1 point, and in case that the CCR increases, the CCR score may be calculated as 0 points. That is, the CCR score may be a binary score.

[0083] Next, referring again to FIG. 2, the processor 1120 obtains an evaluation score for each of the evaluation metrics, based on the ship's maneuver for the event (204).

[0084] At this time, the evaluation score for each of the evaluation metrics may be determined based on the ship's maneuver for the event. As described above, the evaluation metrics may include overlapped area, compliance with regulations, overlapped time, efficiency, reduction in CCR, and near-miss, and the evaluation score may be calculated by the evaluation score calculation criteria for each of the evaluation metrics described above.

[0085] According to a specific embodiment of the present disclosure, the evaluation score based on the ship's maneuver for the event may be automatically calculated by analyzing the navigation record data of the ship. For example, the processor 1120 may analyze the navigation record data of the ship to be evaluated and may determine that the overlapped area score is less than or equal to a reference score in case that the area of the maximum overlapped area exceeds a preset value. That is, in case that the ship's maneuver is performed so that the maximum overlapped area exceeds the preset value, the processor 1120 may calculate the overlapped area score lower than or equal to the reference score.

[0086] Alternatively, in another embodiment of the present disclosure, the evaluation score may be a value input by a manager. That is, the manager may analyze the navigation record data of the ship to be evaluated and may input the evaluation score according to each of the evaluation metrics, and the processor 1120 may obtain the evaluation score by using the input value.

[0087] More specifically, in case that the evaluation score is input by the manager, it may be assumed that the manager inputting the evaluation score is an operational control department in which the fleet is operating or a person with sufficient operational knowledge. That is, because the fleet company and the fleet company's employees (managers) utilizing the navigation safety score calculation method may be determined to have sufficient knowledge of risk factors regarding the operating situation, and thus, they may be granted control over parameter values required to measure the evaluation score. Accordingly, the navigation safety score calculation system of the present disclosure may provide an environment in which the manager may directly adjust detailed factor values such as evaluation scores and weights, which will be described below. On the other hand, a plurality of managers who are able to input evaluation scores and weights may have different opinions, and may evaluate the same situation differently depending on each individual's safety operating criteria.

[0088] Next, the processor 1120 obtains weights for each of the evaluation metrics (205). The weights for each of the evaluation metrics may be a numerical value indicating which metric is more important among the evaluation metrics adopted in the safety score evaluation method according to an embodiment of the present disclosure. As described above, the evaluation metrics may include overlapped area, compliance with regulations, overlapped time, efficiency, reduction in CCR, and near-miss, and two or more of these evaluation metrics may be adopted in the safety score evaluation method. In addition, the processor 1120 may calculate the weights of the evaluation metrics. At this time, the weights may be obtained from the relative importance between the evaluation metrics.

[0089] More specifically, according to an embodiment of the present disclosure, the processor 1120 may obtain the relative importance between evaluation metrics input by the manager. At this time, the relative importance may be a numerical value obtained by comparing two metrics among the adopted evaluation metrics and determining how much importance they have with each other. In addition, the processor 1120 may derive the weights for each adopted evaluation metric, based on the relative importance. A specific method of deriving weights for each of evaluation metrics, according to an embodiment of the present disclosure, is described with reference to FIGS. 5 to 9.

[0090] FIG. 5 is a diagram illustrating, in time series, a method of deriving weights for each of evaluation metrics, according to an embodiment of the present disclosure.

[0091] Referring to FIG. 5, the processor 1120 generates a pair-wise comparison matrix by obtaining relative importance between evaluation metrics (501). Next, the processor 1120 normalizes the pair-wise comparison matrix (502). Next, the processor 1120 derives weights by using the normalized pair-wise comparison matrix (503). Next, the processor 1120 determines whether the derived weights are consistent (504), and when there is consistency, determines the derived weights as reliable weights (505). Alternatively, when there is no consistency, the processor 1120 returns to operation 501 described above and repeats the process.

[0092] More specifically, first, the processor 1120 generates the pair-wise comparison matrix by obtaining the relative importance between the evaluation metrics (501). The pair-wise comparison matrix is a method of, when comparing a plurality of evaluation metrics, evaluating the relative importance of each of evaluation metrics by comparing the plurality of evaluation metrics in a 1:1 manner. According to an embodiment of the present disclosure, the values of the pair-wise comparison matrix may use relative 1 (equal), 3 (important), 5 (strong), 7 (very strong), 9 (extremely strong) and values therebetween (2, 4, 6, 8), and the opposite comparison values may use 1/3, 1/5, 1/7, 1/9, etc.

[0093] FIG. 6 illustrates a pair-wise comparison matrix between event-specific evaluation metrics, according to an embodiment of the present disclosure.

[0094] Referring to FIG. 6, a pair-wise comparison matrix between event-specific evaluation metrics, that is, overlapped area, COLREGS, overlapped time, and efficiency, is shown in a table. At this time, the pair-wise matrix values may be obtained from the manager. More specifically, according to a specific embodiment, the manager may input that the overlapped area is twice as important as COLREGS and nine times as important as efficiency, as illustrated in FIG. 6. The processor 1120 may calculate the sum of comparison values of the respective evaluation metrics by using the obtained pair-wise comparison matrix values. In the example of FIG. 6, the sum of the overlapped areas may be 1.811 and the sum of the COLREGS may be 3.4.

[0095] Next, referring again to FIG. 5, the processor 1120 may normalize the pair-wise comparison matrix (502). The normalization of the pair-wise comparison matrix refers to dividing the sum of the values of the respective rows of the previously obtained pair-wise matrix by the sum of columns thereof.

[0096] FIG. 7 illustrates a normalized matrix obtained by normalizing a pair-wise comparison matrix, according to an embodiment of the present disclosure.

[0097] Referring to FIG. 7, a matrix obtained by normalizing the pair-wise comparison matrix of FIG. 6 is shown in a table. Referring to FIG. 7, it may be confirmed that, to normalize the pair-wise comparison matrix, the values obtained by dividing the values of respective cells by the sum of the respective columns are written as the values of the cells of the normalized matrix.

[0098] Next, referring again to FIG. 5, the processor 1120 derives weights by using the normalized pair-wise comparison matrix (503). More specifically, the processor 1120 calculates an average by summing the values of the respective rows of the normalized pair-wise comparison matrix, and derives the weights of the respective metrics therethrough. According to an embodiment of the present disclosure, the processor 1120 may derive the weights of the respective evaluation metrics by calculating the average of the respective rows in the normalized matrix described above so as to derive the weights. That is, the processor 1120 may calculate the weights of the respective criteria by summing the values for each evaluation criterion (overlapped area, COLREGS, overlapped time, efficiency) in units of rows and then calculating the average thereof.

[0099] FIG. 8 is a result table obtained by deriving weights using a normalized pair-wise comparison matrix, according to an embodiment of the present disclosure.

[0100] Referring to FIG. 8, the weights (criteria weights) of the overlapped area evaluation metric in the examples of FIGS. 6 and 7 described above may be determined as 1/4 (1/1.811+2/3.4+5/11.2+9/20) =0.5090. Weights of other evaluation metrics may also be calculated in the same method. Weights may be calculated such that COLREGS is 0.3165, overlapped time is 0.1270, and efficiency is 0.0470.

[0101] Next, referring again to FIG. 5, the processor 1120 determines whether the derived weights are consistent (504). That is, the processor 1120 verifies whether the derived weights are consistent (verify the weights by checking consistency ratio). This is to check how consistently the values of the pair-wise comparison matrix are evaluated, and may be determined by a consistency ratio (CR) based on a consistency index (CI). The processor 1120 may determine that there is consistency when the consistency ratio is 0.1 or less. When the processor 1120 determines that the derived weights are consistent, the processor 1120 determines that the derived weights are reliable weights (505), and when the processor 1120 determines that the derived weights are not consistent, the processor 1120 returns to operation 501 and repeats the process.

[0102] More specifically, the processor calculates the CI by using a maximum eigenvalue (λmax) and a dimension n of the matrix (4 in the embodiments of FIGS. 6 to 9). The formula for calculating the CI is represented by Equation 1 below.

[Equation 1]

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

[0103] In Equation 1 above, λ_{max} (maximum eigenvalue) is a maximum eigenvalue calculated from the pair-wise comparison matrix, and is an average of λ (eigenvalue) of the respective evaluation metrics. Ideally, λ_{max} should be n, but in reality, a slight difference may occur. Specifically, the method of obtaining the CI and CR values is described in detail with reference to FIG. 9 below.

[0104] FIG. 9 illustrates a table for verifying consistency, according to an embodiment of the present disclosure.

[0105] Referring to FIG. 9, based on FIG. 6, a value obtained by multiplying the weights of the evaluation metrics corresponding to the columns of the matrix may be calculated. For example, because the value of (1,2) in FIG. 6 is 2 and the weight of COLREGS is 0.3165, the value to be input to (1,2) in FIG. 9 may be 2*0.3165. At this time, λ (eigenvalue) uses the value obtained by multiplying the weight and the comparison matrix value with respect to each of evaluation metrics. Therefore, $\lambda_{\text{Overlapped Area}}$ may be calculated as 2.2/0.5090=4.322. The processor may calculate λ (eigenvalue) for other evaluation metrics in the same method. λ_{max} (maximum eigenvalue), which is calculated by averaging the λ (eigenvalue) of the respective evaluation metrics, may be 4.2274.

[0106] In the embodiment of FIG. 9, when the processor calculates the CI of Equation 1 described above by substituting λ_{max} (maximum eigenvalue) and n, a value of 0.0925 may be calculated. That is, in the embodiments of FIGS. 6 to 9, the CI is 0.0925.

[0107] In addition, the processor may calculate the CR. The CR is calculated by dividing the CI by a random index (RI), which is a CI of a randomly generated pair-wise comparison matrix. This value depends on the dimension of the matrix, and when n = 4, the RI is set to 0.90. The RI value may be referenced through a predefined table. Therefore, the processor may calculate CR = CI / CR = 0.0925 / 0.9 = 0.1028.

[0108] According to an embodiment of the present disclosure, the processor may determine that the manager's evaluation is consistent when the CR is less than or equal to 0.10, and may determine that the evaluation is not consistent when the CR is greater than 0.10. In this case, an appropriate error range may be referenced. In the embodiments of FIGS. 6 and 9, because CR = 0.1028, the CR exceeds a reference value of 0.10, but when it is determined that the CR is within the error range, the processor may determine that the consistency of the evaluation is appropriate (may determine that the derived weights are consistent). That is, the processor may determine the weights (criteria weights) derived in the embodiments of FIGS. 6 and 9 as reliable weights, and may calculate the safety score for the individual event by using the weights.

[0109] As described above, a analytic hierarchy process (AHP) technique was used to determine the weights for each of evaluation metrics, but the present disclosure is not necessarily limited thereto. An entropy weight method, a technique for order preference by similarity to ideal solution (TOPSIS), a fuzzy logic, an analytic network process (ANP), etc. may be used without limitation as the method of determining the weights for each of the evaluation metrics.

[0110] Referring again to FIG. 2, the processor calculates the event safety score corresponding to the event, based on the evaluation score and the reliable weights for each of the evaluation metrics (206). More specifically, first, the processor normalizes each evaluation metric score because the dimensions of the evaluation score metrics for each of the evaluation metrics may be different from each other.

[0111] For example, when the overlapped time evaluation metric has a score range of 0 to 10 and the efficiency evaluation metric has a score range of 0 to 5, the respective evaluation metrics may be normalized to all have a score range of 0 to 10. Furthermore, binary metrics such as COLREGS may be normalized so that 0 is a minimum value and 1 is a maximum value. In addition, the processor may calculate an event-specific safety score based on the normalized evaluation metrics and the reliable weights derived in operation 205 described above.

[0112] Next, the processor calculates a navigation safety score for the navigation of the ship, based on the event safety scores of one or more events belonging to the navigation record data (207). At this time, the processor may calculate the navigational safety score for the navigation of the ship by applying an environmental weight to the event-specific safety score. According to an embodiment of the present disclosure, the environmental weight is a weight that reflects environmental conditions such as port, and may be determined according to conditions such as port, strait, congested (congested area), and open sea. For example, in the case of events that occur in the port, strait, or congested area, a low environmental weight may be set. Alternatively, in another embodiment of the present disclosure, the manager may directly input the environmental weights. In this case, the environmental weights may vary depending on the determination of the authorized manager. That is, environmental weights may be set differently for each specific region. Hereinafter, a method of calculating a navigation safety score for navigation of a ship by applying environmental weights is described.

[0113] FIG. 10 illustrates, in time series, a navigation safety score calculation method according to an embodiment of the present disclosure.

[0114] Referring to FIG. 10, first, the processor defines a variable (x_{ij}) for each of detailed metrics so as to calculate a safety score for navigation (1001). The variable (x_{ij}) for each of the detailed metrics refers to a variable in region i for ship j, and the environmental weight described above may correspond to the variable (x_{ij}).

[0115] Next, the processor calculates the extent to which the variable for each of the detailed metrics deviates from an average (1002). That is, the processor calculates a z-score (z_{ij}). The z-score (z_{ij}) is a statistical metric of how far data deviates from the average of the group, and the relative location of the data may be evaluated through the score. According to an embodiment, the z-score (z_{ij}) may be calculated as in Equation 2.

[Equation 2]

$$z_{ij} = \frac{x_{ij} - \overline{x_\iota}}{i}$$

[0116] That is, referring to Equation 2, for a jth ship, it may be evaluated how far the average safety score of events occurring in each region i and the safety score of each event deviate from each other.

[0117] Next, the processor performs percentile normalization on each z-score (z_{ij}) value by using the minimum value and the maximum value (1003). More specifically, the processor normalizes each z-score (z_{ij}) to be between 0 and 1, so as to be compared with each other. The percentile-normalized value may be calculated as in Equation 3 below.

[Equation 3]

$$a_{ij} = \frac{z_{ij} - \min(z_i)}{\max(z_i) - \min(z_i)}$$

[0118] Next, the processor calculates a safety score (y_{ij}) for each of the detailed metrics, which is a score obtained by a specific ship j in region i, based on a normalized value (a_{ij}) (1005). According to an embodiment of the present disclosure, the safety score (y_{ij}) for each of the detailed metrics may be a value obtained by summing the a_{ij} values for all i.

[0119] Next, the processor calculates a safety score for each navigation area (1005). More specifically, the processor may calculate A_{ij}, which is the safety score in the region i of the ship j. At this time, A_{ij} may be calculated as in Equation 4. Here, n is the number of regions.

[Equation 4]

$$A_{ij} = \sum_i \frac{y_{ij}}{n}$$

[0120] Next, the processor calculates a final safety score for the navigation of the ship (1006). That is, the processor may calculate a final safety score A_j for the navigation of the ship j as in Equation 5. At this time, α_i may be the weight of the region i. That is, according to the embodiment described above with reference to FIG. 10, the influence of the score of each region on the navigation safety score of the ship may be set differently by reflecting the importance or risk for each environment.

[Equation 5]

$$A_j = \frac{\sum_i \alpha_i A_{ij}}{\sum_i \alpha_i}$$

[0121] In addition, according to an embodiment of the present disclosure, the processor may calculate the safety score of the entire fleet, based on the navigation safety score. The processor may calculate the fleet safety score by averaging the navigation safety scores of the respective ships. The processor may calculate the fleet safety score by reflecting the operating characteristics of each ship type through fleet classification by the ship type or size of the fleet to which the ship belongs. In addition, the processor may calculate the fleet safety score that reflects the navigation characteristics of the navigator (career, main navigation areas, etc.). However, it will be understood that the method of calculating the fleet safety score based on the navigation safety score is not necessarily limited to those described in the present specification.

[0122] FIG. 11 illustrates, in time series, a method of providing a fleet management interface, according to an embodiment of the present disclosure.

[0123] The method of providing the fleet management interface in FIG. 11 may be performed by the processor 1120 of the fleet management system of the present disclosure. Referring to FIG. 11, first, the processor 1120 obtains one or more of: one or more event safety scores associated with one or more ships, ship-specific navigation safety scores corresponding to one or more ships, and the fleet safety score of the fleet including one or more ships (1101).

[0124] Next, the processor 1120 displays the fleet safety score in a first area of a first screen (1102).

[0125] Next, the processor 1120 displays information about ships, ship-specific navigation safety scores of which are lower than or equal to a preset score, in a second area of the first screen (1103). In the following specification, the ship, the ship-specific navigation score of which is less than or equal to the preset score, may be referred to as a 'ship to be retrained.'

[0126] Next, the processor 1120 displays an event video corresponding to the event safety score in a third area of the first screen (1104).

[0127] Hereinafter, the fleet management system of the present disclosure is described in more detail.

[0128] According to an embodiment of the present disclosure, the processor 1120 obtains one or more of: one or more event safety scores associated with one or more ships, ship-specific navigation safety scores corresponding to one or more ships, and the fleet safety score of the fleet including one or more ships (1101). As described above, the event safety score associated with the ship may be calculated by operation 206 of FIG. 2. In addition, the ship-specific navigation safety score corresponding to the ship may be calculated by operation 207 of FIG. 2. In addition, the fleet safety score may be calculated by the mechanism described in the specification.

[0129] According to an embodiment of the present disclosure, the fleet include a plurality of ships owned by one individual or one company, and the ships included in the fleet are operated under the command of the fleet owner or fleet manager and are systematically managed as a single business entity. The fleet referred to in the specification of the present disclosure may be organized and operated to perform various commercial activities such as cargo transportation, passenger transportation, fishing, and oil transportation, but the purpose and form of the fleet are not limited.

[0130] For the fleet manager, it is an important issue to manage the safety scores of the ships constituting the fleet and increase the efficiency and safety of fleet management. **In** particular, that the navigation safety scores of the ships are less than or equal to a reference value supports that the captains of the ships did not navigate safely, and thus, it is necessary to determine the corresponding ships as ships to be retrained and provide caution and education on safe navigation. Therefore, there is a need for the fleet management system capable of identifying the safety score of the ship and also grasping the safety score of the entire fleet.

[0131] To this end, according to an embodiment of the present disclosure, the processor 1120 may provide a fleet management system, and an interface of the fleet management system may include the first to third screens. In addition, the processor 1120 may display, on the first screen, event images corresponding to the fleet safety score, the ship to be retrained, and the event safety score.

[0132] FIG. 12 illustrates an example of the first screen of the fleet management system, according to an embodiment of the present disclosure.

[0133] The first screen is a fleet management screen. A first area 1210 displays the fleet safety score and the trend thereof, a second area 1220 displays the ship to be retrained, a third area 1230 displays the images of ships corresponding to the event and the event type, and a fourth area 1240 displays the number of occurrences for each event type. Each of the areas is designed to quickly identify the fleet safety score and the information about the events during the navigation of the ship, and a detailed configuration thereof is as follows.

[0134] First, the first area 1210 is an area which represents a total fleet safety score. The processor 1120 may display the fleet safety score 1211 in a numerical value on the first area 1210, as illustrated in FIG. 12. In the embodiment of FIG. 12, the fleet safety score 1211 is 88 points, and the phrase indicating that the score belongs to a "good" grade may be additionally displayed (Your score is Good). Additionally, the date when the fleet safety score 1211 was updated may be written.

[0135] In a specific embodiment, the processor 1120 may classify the grade into four grades: excellent / good / fair / poor, according to the fleet safety score. However, the grade according to the fleet safety score may be variously set, and the classification into excellent, good, fair, and poor expressed in the example of FIG. 12 may be replaced with similar words (highly secure / secure / moderate / risky range, etc.) which indicate upper and lower grades of safety. Accordingly, the phrase indicating each grade may be variously modified into, for example, "Your safety score is in the highly secure / secure / moderate / risky range."

[0136] In addition, the visual display method of the interface is set differently according to each grade, allowing the manager to quickly identify the current state of the fleet. First, in case that the fleet safety score is 90 or higher, the grade may be displayed in green and the phrase "Your score is Excellent" is provided together. In addition, in case that the fleet safety score is 80 or more and 89 or less, the score is displayed in yellow and the phrase "Your score is Good" is provided together. In addition, in case that the fleet safety score is 60 or more and 79 or less, the score may be displayed in brown and the phrase "Your score is Fair" may be displayed. In addition, in case that the fleet safety score is 59 or less, the score may be displayed in red and the phrase "Your score is Poor" may be displayed. That is, by displaying the phrase indicating the grade in red, it is possible to visually convey to the fleet manager that the fleet is currently being operated unsafely.

[0137] Additionally, referring to FIG. 12, the first area 1210 may display a fleet safety score graph 1212 based on the fleet safety score 1211. At this time, the fleet safety score graph 1212 may be represented by a circular gauge so that the overall safety state may be identified at a glance. The fleet safety score graph 1212 may be segmented and displayed according to the grade described above, and each segmented area may be displayed in a color matching the corresponding grade. In addition, an icon may be additionally displayed on the circular gauge of the fleet safety score graph 1212 at a location corresponding to the fleet safety score 1211.

[0138] Additionally, referring to FIG. 12, the first area 1210 may additionally show a time-series fleet safety score graph 1213. The time-series fleet safety score graph 1213 may be a graph which visualizes changes in the fleet safety score in units of 7 days, 1 month, 3 months, 6 months, and 1 year, thereby allowing the user to check past safety score trends. In particular, the time-series fleet safety score graph 1213 displays a point where a risk event occurred in the form of a separate dot, so that it is possible to analyze the influence the event had on the safety score.

[0139] Next, the second area 1220 provides information about the ship to be retrained among the individual ships included in the fleet. At this time, the ship to be retained may be a ship whose navigation safety score described above is less than or equal to a preset reference. The processor 1120 may display ship information 1221 in the second area 1220, and the ship information 1220 may include a representative ship photograph icon and a ship name. At this time, when the manager selects the representative ship photograph icon of the ship information 1220, the first screen of FIG. 12 may be transferred to an individual ship management screen illustrated in FIG. 13 to be described below. That is, the processor 1120 displays the ship to be retrained among the ships of the fleet in the second area 1220, thereby enabling customized management for each ship.

[0140] Next, the third area 1230 may provide event information about events occurring during the navigation of the ships included in the fleet. The processor 1120 display an event video 1231 and an event type 1232 in the third area 1230. The event video 1231 may be a video or image of an event occurring during the navigation of the ship, and the event type 1232 may be the type of the event, more specifically, the event type according to the COLREG rule. More specifically, the event video 1231 may be a frame video of a time when the other ship is in a most near-miss state with respect to the own ship among videos of an event recording period. At this time, the processor 1120 may display a ship name and an event occurrence time together with the event type 1232. That is, the processor 1120 displays the video or image of the event of the ship and provides information about the event, thereby allowing the manager to easily identified the event of the ships belonging to the fleet. In addition, in case that the manager selects the event video 1231, a pop-up window which reproduces the event video of the recording period associated with the event safety score may be overlaid on the first screen.

[0141] Next, the fourth area 1240 may be an area which displays information about the number of events of the fleet and the number of occurrences for each type. According to the example of FIG. 12, the processor 1120 may display the total number of events (129 times) of the fleet for 7 days and display an event type distribution chart 1241 representing the total number of events of the fleet as a bar graph. The event type distribution chart 1241 may display the respective events in different colors as Lookout, Safe Speed, Overtaking, Head-on, and Crossing. That is, the processor 1120 displays the number of occurrences of each event type as a bar graph, thereby allowing the manager to easily identify the types of events that frequently occur in the fleet. The names of the respective events, which are divided into five categories, may be defined in accordance with COLREGS, or may be variously changed in light of user experience. For example, the event Safe Speed which include rapid acceleration/deceleration information may be referred to as an abnormal speed.

[0142] FIG. 13 illustrates an example of the second screen displaying rankings and graphs of fleet safety scores, according to an embodiment of the present disclosure.

[0143] Referring to FIG. 13, a first area 1310 of the second screen may include a total fleet safety score 1311, a ranking based on the fleet safety score, and a ship safety score distribution graph 1312 showing a ship safety score distribution. The processor 1120 may calculate and display the fleet safety score 1311 by aggregating the safety scores of all ships included in the fleet in the method described above.

[0144] In addition, the ship safety score distribution graph 1312 may be a vertical bar graph that visually shows a section in which the ship safety score is distributed during a specific period. The graph, divided into the Risk section (0-50 points), Warning section (50-70 points), Average section (70-90 points), and Safe section (90-100 points), clearly shows which section the safety score of the ship belongs to, allowing you to clearly recognize the distribution of the ship safety scores that make up the entire fleet safety score, allowing you to quickly recognize the status of the fleet.

[0145] Next, a second area 1320 of the second screen displays ship attributes 1321 and includes a ship list 1322 listing ship information in descending order of ship safety scores of individual ships included in the fleet according to the ship attributes 1321.

[0146] First, the ship attributes 1321 may include rank, ship name, navigation safety score, rank shift, ship type, age, ship builder, etc. The ship list 1322 lists ship information in descending order of navigational safety scores and displays ship names based on the ship attributes 1321. In particular, representative ship photograph icons may be displayed next to the ship names. Through the second screen, the fleet manager may easily determine which ships have high navigational safety scores, and additionally, may easily check how much the ship navigation safety score has increased or decreased, compared to the previous cycle through rank changes.

[0147] FIG. 14 illustrates a third screen, which is a management interface for individual ships, according to an embodiment of the present disclosure.

[0148] According to an embodiment of the present disclosure, in case that the manager selects the representative ship image icon of the second area 1220 on the screen of FIG. 12 described above, or in case that the manager selects the representative ship image icon or the ship name of the second area 1320 in the screen of FIG. 13, the screen may transition to the third screen of FIG. 14.

[0149] Referring to FIG. 14, the third screen may include a first area 1410 which displays a search target ship 1401 and a trend graph of a ship navigation safety score, a second area 1420 which displays the ship navigation safety score and event classification, and a third area 1430 which displays an event video and type of the ship. That is, the third screen includes an interface which visually provides navigation safety scores of individual ships and aggregates and displays the corresponding events to only the individual ships.

[0150] More specifically, the search target ship 1401 provides information about the individual ship selected by the current manager. In the example of FIG. 14, information about the ship name, safety score, ship type, ship builder, and age is included.

[0151] In addition, the first area 1410 may display a safety score trend 1411 for the safety state of the ship. The safety score trend 1411 visually provides a change in the ship navigational safety score during a certain period. For example, it is provided in the form of a solid line graph so that the manager easily identify the trend of rising or falling scores during a certain period. The range of the graph may be selected for various periods, such as 1 month, 3 months, 6 months, or 1 year.

[0152] Next, the second area 1420 may display a navigation safety score 1421, a total number of events 1422, a hexagonal graph 1423, and a number of event types 1424. The navigation safety score 1421 may display the navigation safety score of the ship by using various numerical systems. For example, the navigation safety score 1421 displays the navigation safety score of the ship on a full 100-point scale, and may display a grade notice phrase based on a grade for each score (Your score is Poor). However, the present disclosure is not limited thereto, and the navigation safety score 1421 may display the navigation safety score of the ship as a full 10-point scale or as a decimal point. For example, the navigation safety score 1421 may display the navigation safety score of the ship as a full 10-point basis to one decimal place.

[0153] More specifically, the processor 1120 may classify the grade into four grades: excellent, good, fair, and poor, according to the navigation safety score. In addition, the visual display method of the interface is set differently according to each grade, allowing the manager to quickly identify the current state of the fleet. First, in case that the navigation safety score is 90 or more, the grade may be displayed in green and the phrase "Your score is Excellent" is provided together. In addition, in case that the navigation safety score is 80 or more and 89 or less, the score is displayed in yellow and the phrase "Your score is Good" is provided together. In addition, in case that the navigation safety score is 60 or more and 79 or less, the score may be displayed in brown and the phrase "Your score is Fair" may be displayed. In addition, in case that the navigation safety score is 59 or less, the score may be displayed in red and the phrase "Your score is Poor" may be displayed. That is, by displaying the phrase indicating the grade in red, it is possible to visually convey to the fleet manager that the ship is not operating safely.

[0154] In addition, the total number of events 1422 displays the total number of events occurring during the navigation of the ship. Furthermore, navigation information, such as a total navigation distance and an average speed (SOG), may be displayed together with the total number of events 1422.

[0155] In addition, the hexagonal graph 1423 in the second area 1420 is a graph which visualizes a navigation safety score of a specific ship according to various metrics. The respective axes of the hexagon represent the type of events occurring most frequently (e.g., Lookout, Safe Speed, Head-on, Crossing, Overtaking), and the values of the respective axes are displayed as scores based on how frequently the corresponding event type occurs. At this time, the hexagonal graph 1423 may show event types for not only specific ships but also the entire fleet. In addition, the number of event types 1424 shows how frequently each type occurred by analyzing the type of events occurring in the ship.

[0156] Next, the third area 1430 is an area which provides the type and details of the event of the ship, and an event video 1431 and an event type 1432 may be displayed. More specifically, the event video 1431 provides a video recorded when a hazardous situation occurred, allowing the manager to check a specific situation. For example, in case that an accident, such as collision avoidance, speed limit exceeding, or failure to pay attention, occurs and the event video 1431 is selected, the manager may search for a video recorded during a section where the event occurred. In addition, the event type 1432 displays what type of risk each event belongs to.

[0157] FIG. 15 is a block diagram of a server according to an embodiment.

[0158] The server 1100 of FIG. 15 may be the server 110 of FIG. 1. Referring to FIG. 15, the server 1100 may include a communication unit 1110, a processor 1120, and a database (DB) 1130. Only components related to the embodiment are illustrated in the server 1100 of FIG. 15. Accordingly, it will be understood by those of ordinary skill in the art that, in addition to the components illustrated in FIG. 10, other general-purpose components may be further included.

[0159] The communication unit 1110 may include one or more components which enable wired/wireless communication with other nodes. For example, the communication unit 1110 may include at least one of a short-range communication unit (not shown), a mobile communication unit (not shown), and a broadcasting reception unit (not shown).

[0160] The DB 1130 is hardware which stores various data processed within the server 1100, and may store a program for processing and control by the processor 1120. The DB 1130 may store payment information, user information, etc.

[0161] The DB 1130 may include random access memory (RAM), such as dynamic random access memory (DRAM) or static random access memory (SRAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), compact-disc read-only memory (CD-ROM), Blu-ray or other optical disk storage, hard disk drive (HDD), solid state drive (SSD), or flash memory.

[0162] The processor 1120 controls the overall operation of the server 1100. For example, the processor 1120 may execute programs stored in the DB 1130 to perform overall control on an input unit (not shown), a display (not shown), the communication unit 1110, the DB 1130, etc. The processor 1120 may execute the programs stored in the DB 1130 to control the operation of the server 1100. The processor 1120 may control at least some of the operations of the game server 2000 or the mediation server 3000 described above with reference to FIGS. 1 to 10.

[0163] The processor 1120 may be implemented by using at least one of application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), controllers, micro-controllers, microprocessors 1120, or other electrical units for performing functions.

[0164] Embodiments according to the present disclosure may be implemented in the form of a computer program that may be executed through various elements on a computer, and such a computer program may be recorded on a computer-readable medium. At this time, the medium may include a magnetic medium such as hard disk, floppy disk, and magnetic tape, an optical recording medium such as CD-ROM and DVD, a magneto-optical medium such as floptical disks, and hardware devices specially configured to store and execute program instructions, such as ROM, RAM, or flash memory.

[0165] The computer program may be specially designed and configured for the present disclosure or may be known and available to those of ordinary skill in the art of computer software. Examples of the computer program may include not only machine language code generated by a compiler but also high-level language code that is executable using an interpreter or the like by a computer.

[0166] According to an embodiment, the methods according to various embodiments of the present disclosure may be provided by being included in a computer program product. The computer program product may be traded between a seller and a buyer as commodities. The computer program product may be distributed in the form of a machine-readable storage medium (for example, CD-ROM), or may be distributed (for example, downloaded or uploaded) online, either via an application store (for example, Play Store™) or directly between two user devices. In the case of the online distribution, at least part of the computer program product may be stored at least temporarily on a machine-readable storage medium, such as a server of a manufacturer, a server of an application store, or a memory of a relay server, or may be temporarily generated.

Claims

1. A navigation safety score calculation method comprising:

   obtaining navigation record data of an own ship;
   extracting an event based on the navigation record data;
   determining two or more evaluation metrics corresponding to the event;
   obtaining an evaluation score for each of the evaluation metrics, based on a ship's maneuver for the event;
   calculating an event safety score corresponding to the event, based on the evaluation metric score; and
   calculating a navigation safety score for navigation of the ship, based on event safety scores of one or more events belonging to the navigation

record data.

2. The navigation safety score calculation method of claim 1, wherein the calculating of the event safety score comprises:

deriving weights for each of the evaluation metrics; and
calculating the event safety score corresponding to the event by applying the weights to the evaluation score for each of the evaluation metrics.

3. The navigation safety score calculation method of claim 2, wherein the deriving of the weights comprises:

generating a pair-wise comparison matrix by obtaining relative importance between the evaluation metrics;
normalizing the pair-wise comparison matrix; and
deriving the weights for each of the evaluation metrics by using the normalized pair-wise comparison matrix.

4. The navigation safety score calculation method of claim 3, further comprising:

performing consistency verification on the derived weights; and
regenerating the pair-wise comparison matrix in case that it is determined that the derived weights are not consistent.

5. The navigation safety score calculation method of claim 1, wherein the evaluation metrics are two or more of overlapped area, compliance with regulations, overlapped time, efficiency of navigational actions, reduction in contextual collision risk (CCR), and near-miss.

6. The navigation safety score calculation method of claim 1, wherein the evaluation metrics comprise an overlapped area, and the overlapped area is a maximum area of an area where a first safety buffer and a second safety buffer calculated based on the navigation record data overlap each other.

7. The navigation safety score calculation method of claim 1, wherein the evaluation metrics comprise compliance with regulations, and the compliance with regulations is a binary metric which determines whether evasive maneuver corresponding to the event complies with maritime regulations.

8. The navigation safety score calculation method of claim 1, wherein the calculating of the navigation safety score for the navigation of the ship comprises calculating the navigation safety score by reflecting, to the event safety score, an environmental weight based on environmental conditions under which the event occurred.

9. The navigation safety score calculation method of claim 8, wherein the environmental weight is set to be low for an event occurring in at least one of a port, a strait, and a congested area.

10. A navigation safety score calculation system comprising a processor and a memory, wherein the processor is configured to:

obtain an evaluation score for each of evaluation metrics, based on a ship's maneuver for one or more events occurring during navigation of the ship;
calculate an event safety score corresponding to the event, based on the evaluation score for each of the evaluation metrics; and
calculate a navigation safety score for the navigation of the ship, based on event safety scores of the one or more events.

11. The navigation safety score calculation system of claim 10, wherein the one or more events occurring during the navigation are extracted based on navigation record data of an own ship.

12. The navigation safety score calculation system of claim 10, wherein the event safety score is calculated by applying weights for each of the evaluation metrics to the evaluation score for each of the evaluation metrics.

13. The navigation safety score calculation system of claim 12, wherein a pair-wise comparison matrix is generated by obtaining relative importance between the evaluation metrics, the pair-wise comparison matrix is normalized, and the weights are derived by using the normalized comparison matrix.

14. The navigation safety score calculation system of claim 10, wherein the evaluation metrics are two or more of overlapped area, compliance with regulations, overlapped time, efficiency of navigational actions, reduction in contextual collision risk (CCR), and near-miss.

15. A computer-readable recording medium having recorded thereon a program for causing a computer to perform the method of claim 1.

FIG. 1

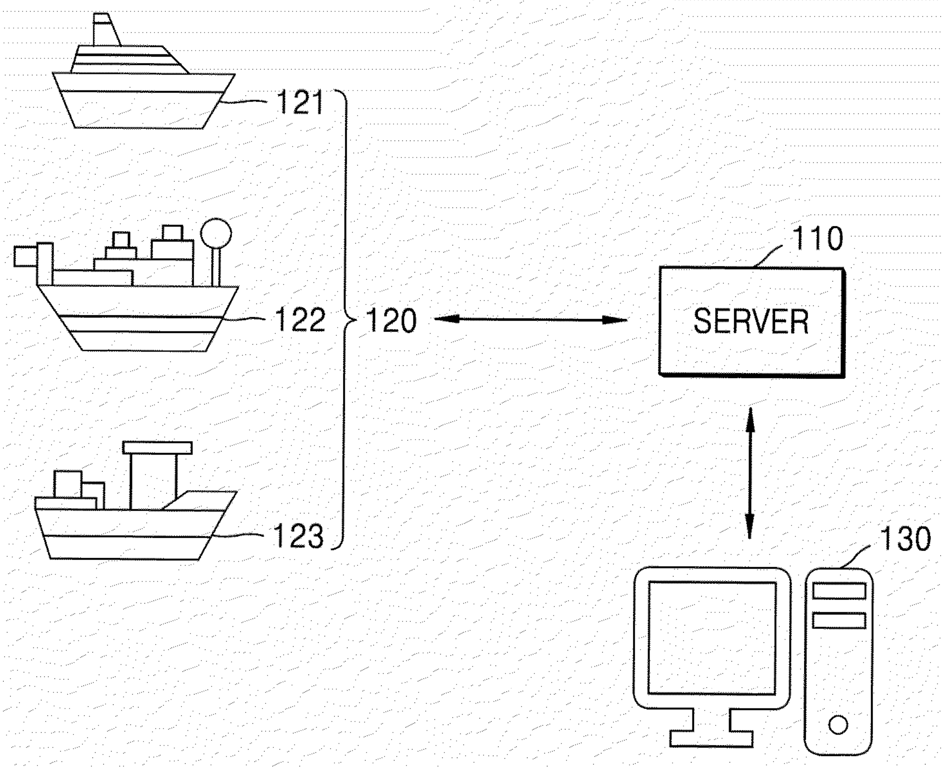


FIG. 2

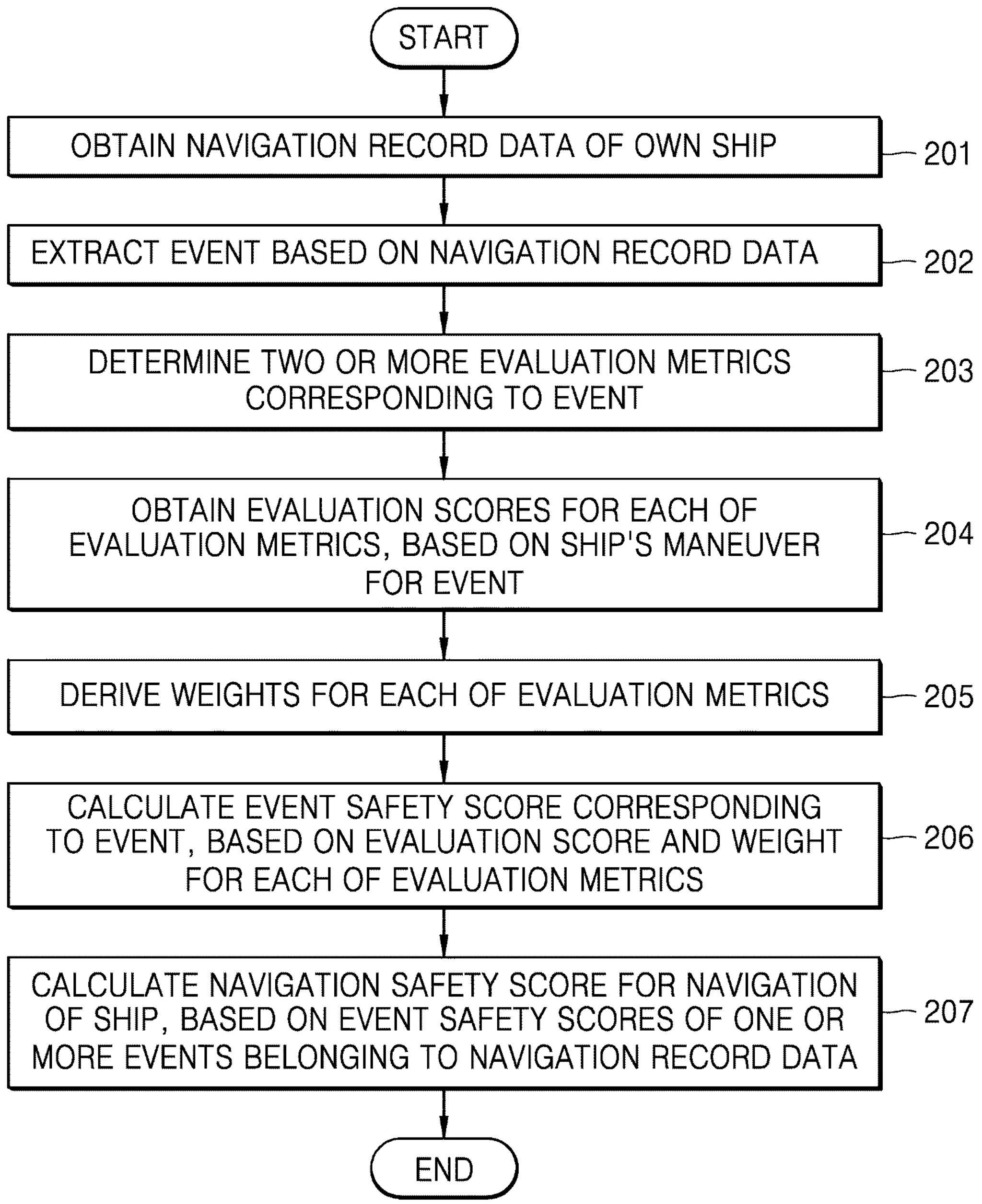

START
OBTAIN NAVIGATION RECORD DATA OF OWN SHIP
201
EXTRACT EVENT BASED ON NAVIGATION RECORD DATA
202
DETERMINE TWO OR MORE EVALUATION METRICS CORRESPONDING TO EVENT
203
OBTAIN EVALUATION SCORES FOR EACH OF EVALUATION METRICS, BASED ON SHIP'S MANEUVER FOR EVENT
204
DERIVE WEIGHTS FOR EACH OF EVALUATION METRICS
205
CALCULATE EVENT SAFETY SCORE CORRESPONDING TO EVENT, BASED ON EVALUATION SCORE AND WEIGHT FOR EACH OF EVALUATION METRICS
206
CALCULATE NAVIGATION SAFETY SCORE FOR NAVIGATION OF SHIP, BASED ON EVENT SAFETY SCORES OF ONE OR MORE EVENTS BELONGING TO NAVIGATION RECORD DATA
207
END

FIG. 3

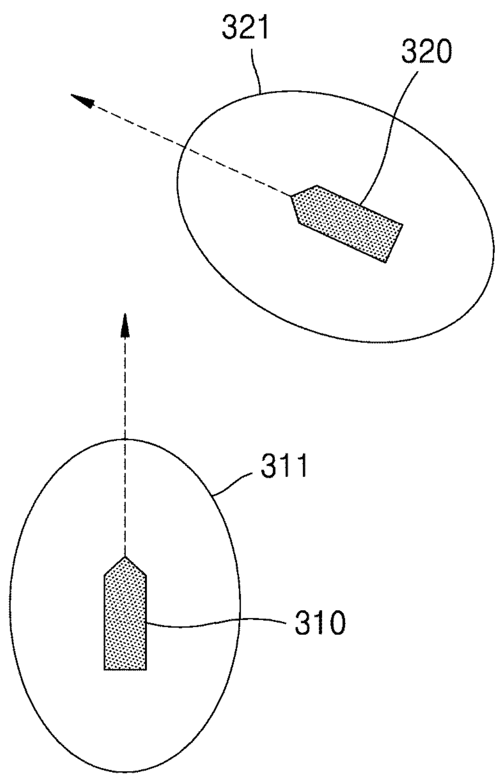


FIG. 4

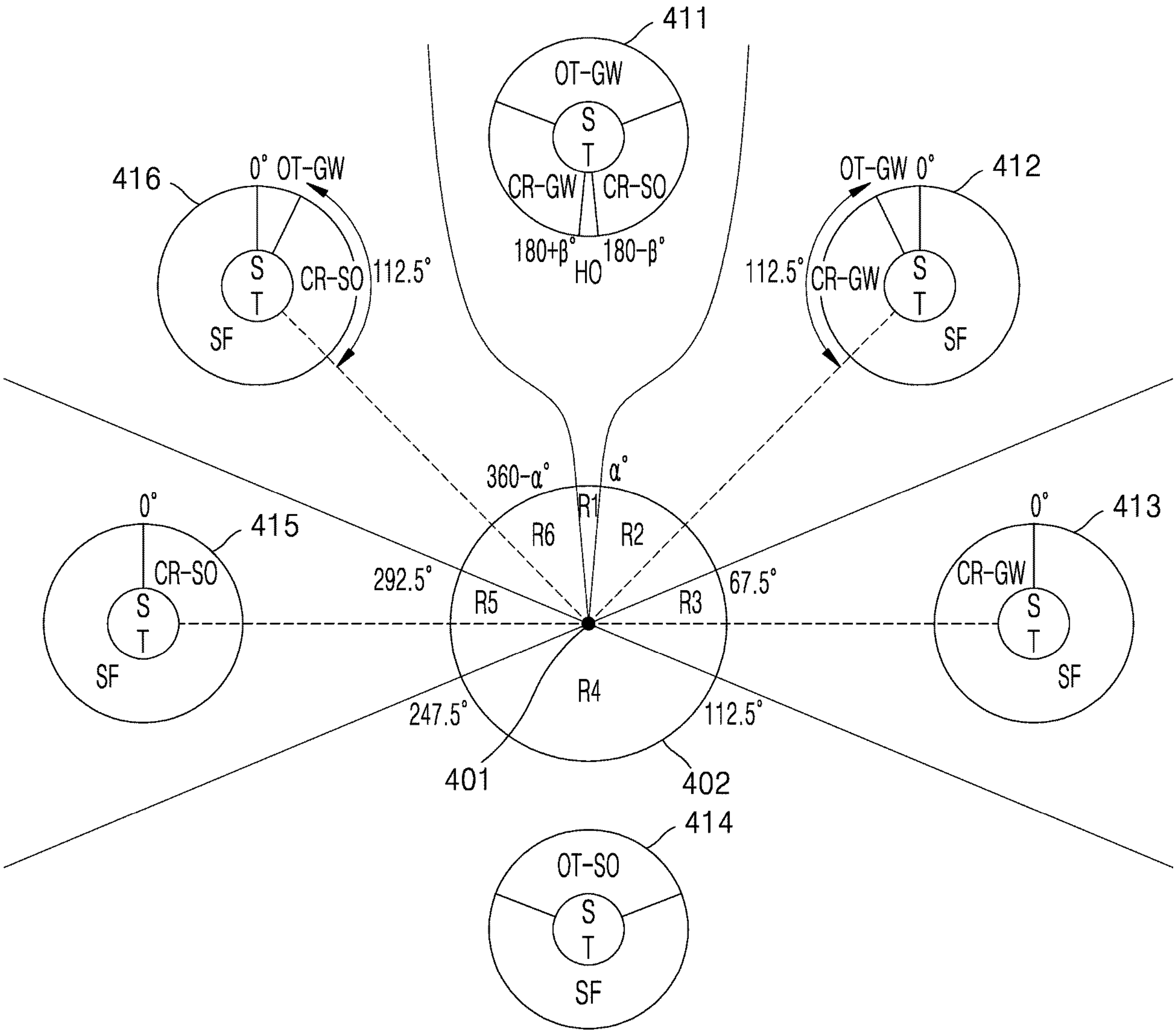


ABB	Definition
HO	Head on
CR	Crossing
OT	Overtaking
GW	Give-way
SO	Stand-on
ST	Stationary
SF	Safe

FIG. 5

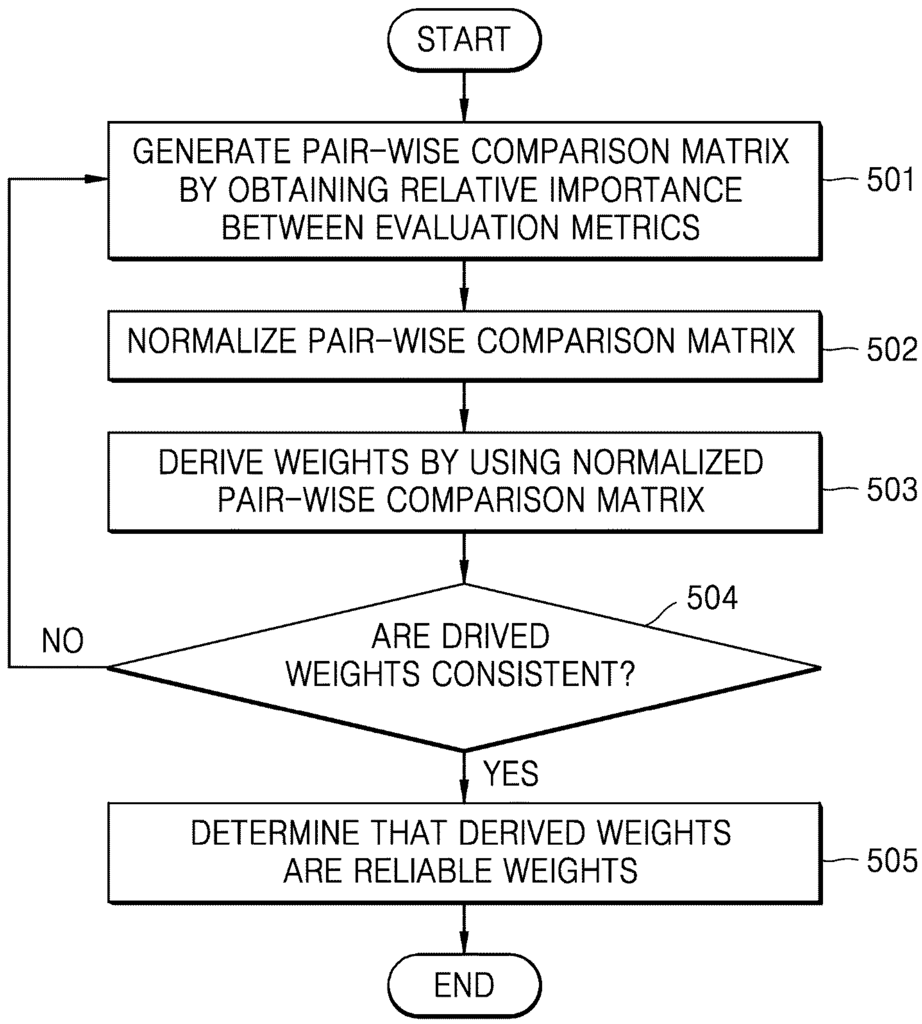

START
GENERATE PAIR-WISE COMPARISON MATRIX BY OBTAINING RELATIVE IMPORTANCE BETWEEN EVALUATION METRICS
501
NORMALIZE PAIR-WISE COMPARISON MATRIX
502
DERIVE WEIGHTS BY USING NORMALIZED PAIR-WISE COMPARISON MATRIX
503
504
NO
ARE DRIVED WEIGHTS CONSISTENT?
YES
DETERMINE THAT DERIVED WEIGHTS ARE RELIABLE WEIGHTS
505
END

FIG. 6

	Overlapped Area	COLREGS	Overlapped Time	Efficiency
Overlapped Area	1	2	5	9
COLREGS	1/2	1	5	5
Overlapped Time	1/5	1/5	1	5
Efficiency	1/9	1/5	1/5	1
SUM	1.811	3.4	11.2	20

FIG. 7

	Overlapped Area	COLREGS	Overlapped Time	Efficiency
Overlapped Area	1/1.811	2/3.4	5/11.2	9/20
COLREGS	0.5/1.811	1/3.4	5/11.2	5/20
Overlapped Time	0.2/1.811	0.2/3.4	1/11.2	5/20
Efficiency	0.111/1.811	0.2/3.4	0.2/11.2	1/20
SUM	1	1	1	1

FIG. 8

	Overlapped Area	COLREGS	Overlapped Time	Efficiency	Criteria Weights
Overlapped Area	0.552	0.588	0.446	0.45	0.5090
COLREGS	0.276	0.294	0.446	0.25	0.3165
Overlapped Time	0.11	0.059	0.089	0.25	0.1270
Efficiency	0.061	0.059	0.018	0.05	0.0470

FIG. 9

	Overlapped Area	COLREGS	Overlapped Time	Efficiency	Weighted Sum Value	λ (Sum/weight)
Overlapped Area	1×0.5090	2×0.31652	5×0.12705	9×0.04709	2.2	4.3222
COLREGS	1/2×0.5090	1×0.31651	5×0.12705	5×0.04705	1.441	4.5529
Overlapped Time	1/5×0.5090	1/5×0.3165	1×0.12701	5×0.04705	0.527	4.1496
Efficiency	1/9×0.5090	1/5×0.3165	1/5×0.1270	1×0.04701	0.192	4.0851

FIG. 10

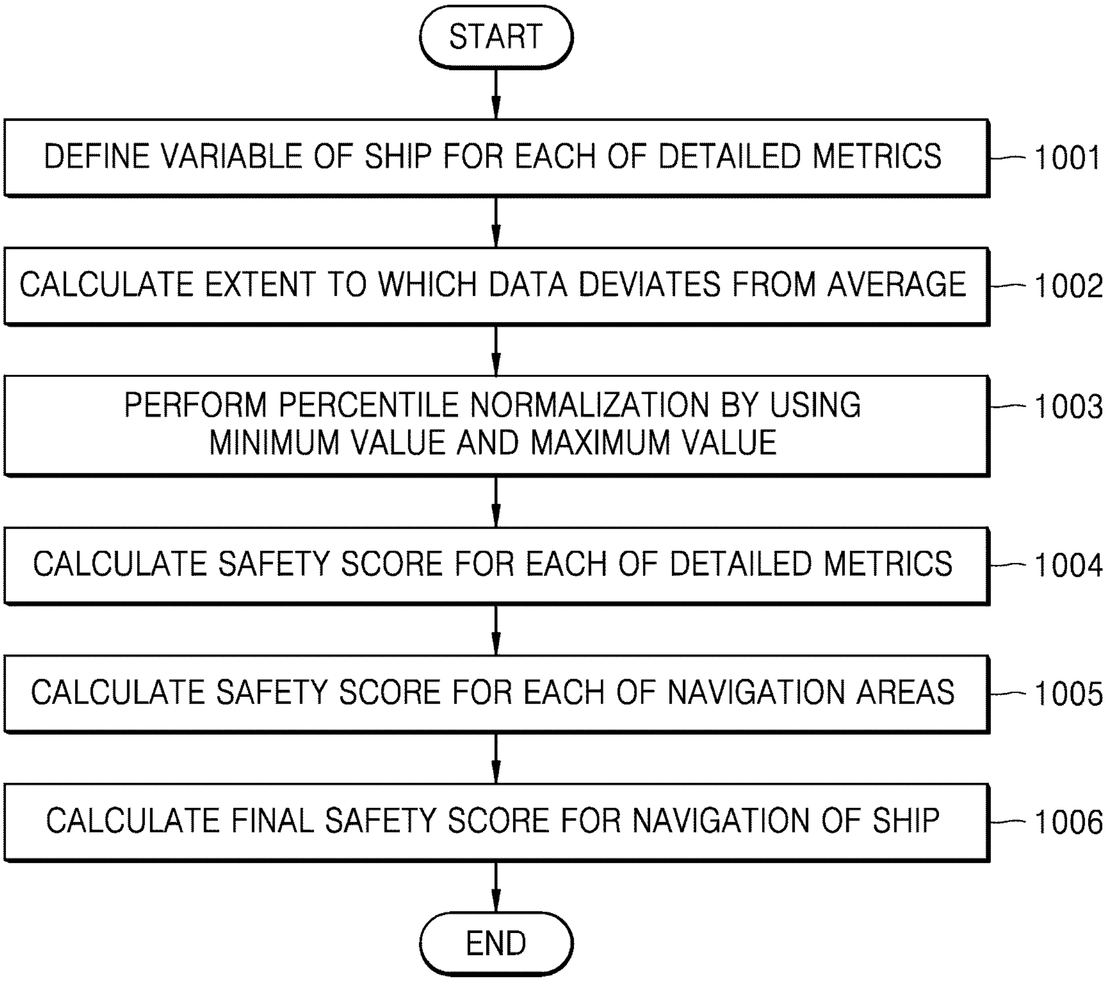

START
DEFINE VARIABLE OF SHIP FOR EACH OF DETAILED METRICS
1001
CALCULATE EXTENT TO WHICH DATA DEVIATES FROM AVERAGE
1002
PERFORM PERCENTILE NORMALIZATION BY USING MINIMUM VALUE AND MAXIMUM VALUE
1003
CALCULATE SAFETY SCORE FOR EACH OF DETAILED METRICS
1004
CALCULATE SAFETY SCORE FOR EACH OF NAVIGATION AREAS
1005
CALCULATE FINAL SAFETY SCORE FOR NAVIGATION OF SHIP
1006
END

FIG. 11

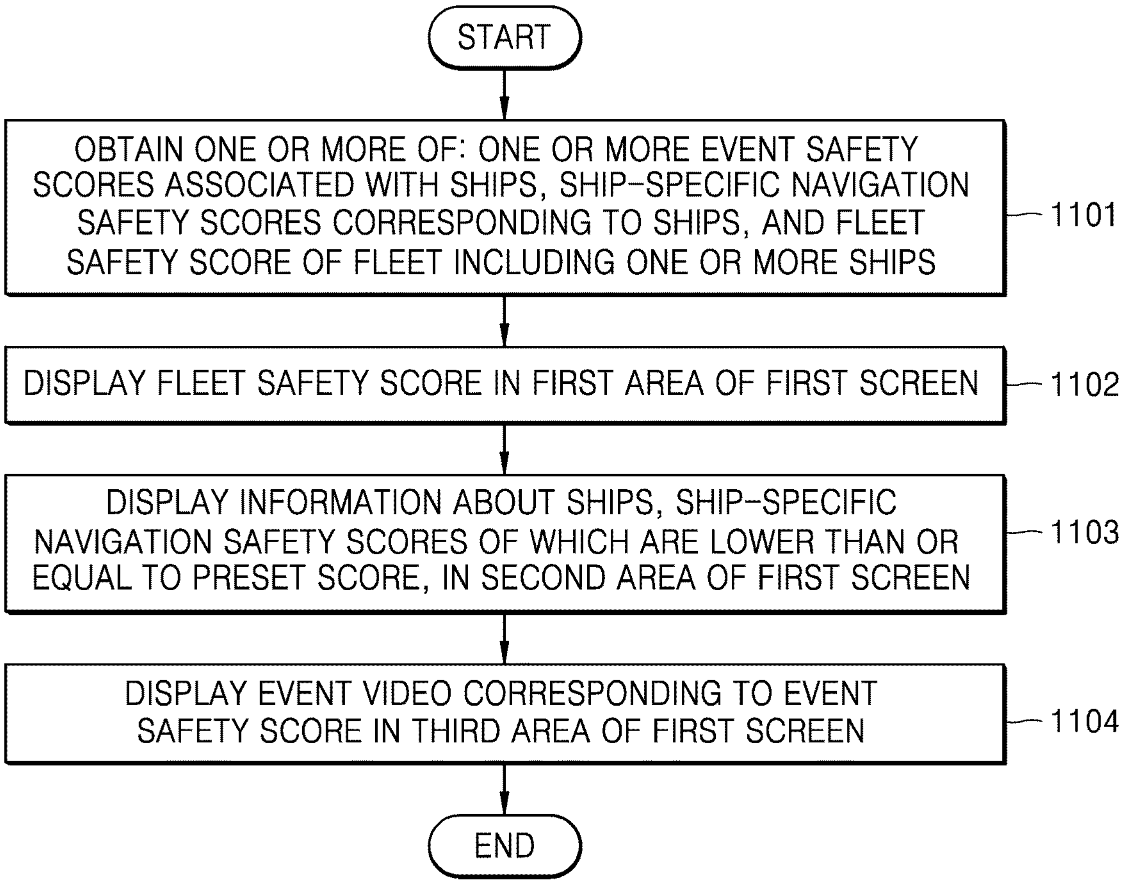

START
OBTAIN ONE OR MORE OF: ONE OR MORE EVENT SAFETY SCORES ASSOCIATED WITH SHIPS, SHIP-SPECIFIC NAVIGATION SAFETY SCORES CORRESPONDING TO SHIPS, AND FLEET SAFETY SCORE OF FLEET INCLUDING ONE OR MORE SHIPS
1101
DISPLAY FLEET SAFETY SCORE IN FIRST AREA OF FIRST SCREEN
1102
DISPLAY INFORMATION ABOUT SHIPS, SHIP-SPECIFIC NAVIGATION SAFETY SCORES OF WHICH ARE LOWER THAN OR EQUAL TO PRESET SCORE, IN SECOND AREA OF FIRST SCREEN
1103
DISPLAY EVENT VIDEO CORRESPONDING TO EVENT SAFETY SCORE IN THIRD AREA OF FIRST SCREEN
1104
END

FIG. 12

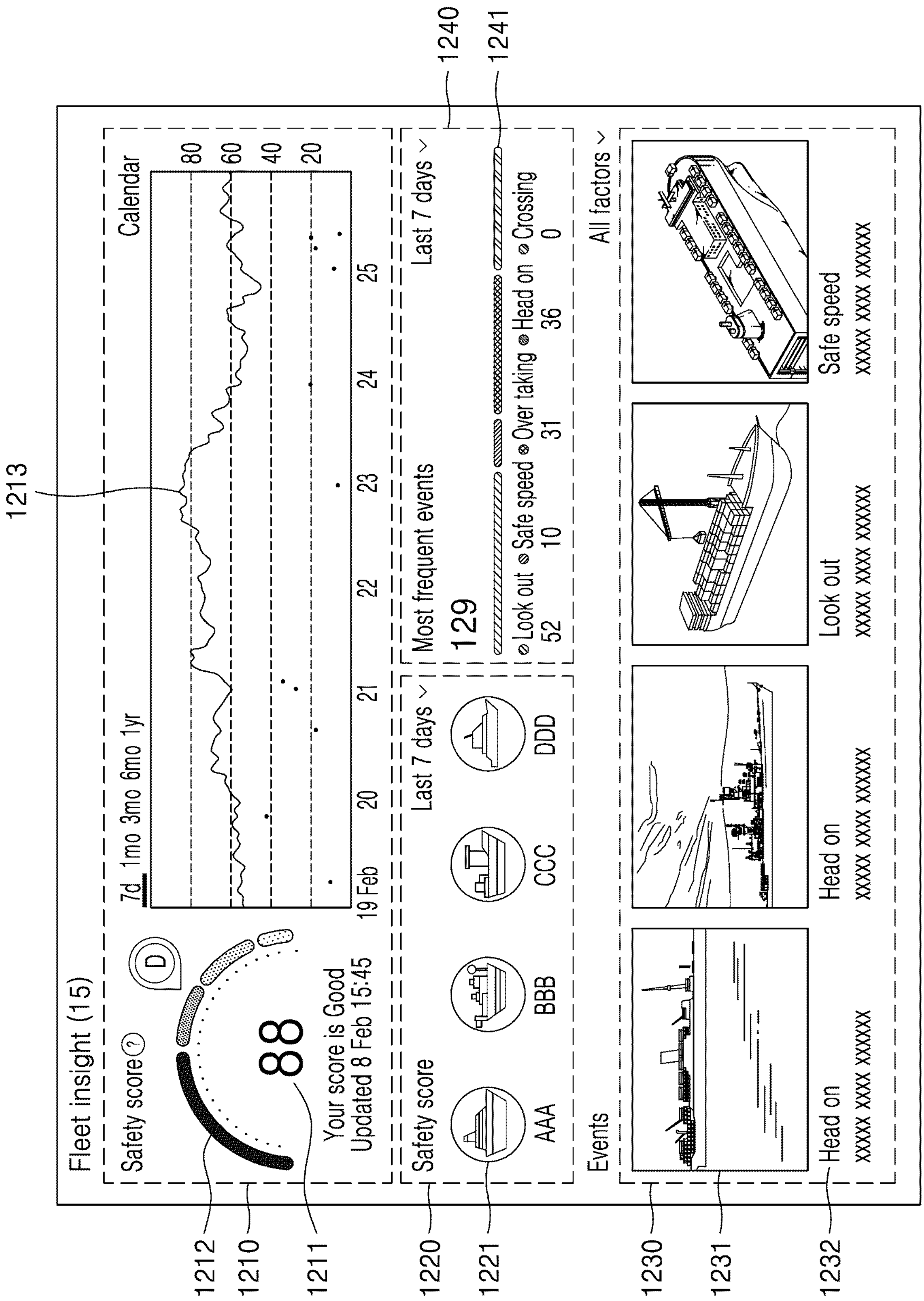

Fleet insight (15)
Safety score
D
88
Your score is Good
Updated 8 Feb 15:45
Calendar
7d 1mo 3mo 6mo 1yr
80
60
40
20
19 Feb 20 21 22 23 24 25
Safety score
Last 7 days
AAA
BBB
CCC
DDD
Most frequent events
Last 7 days
129
Look out 52
Safe speed 10
Over taking 31
Head on 36
Crossing 0
Events
All factors
Head on
XXXXX XXXX XXXXXX
Head on
XXXXX XXXX XXXXXX
Look out
XXXXX XXXX XXXXXX
Safe speed
XXXXX XXXX XXXXXX
1210
1211
1212
1213
1220
1221
1230
1231
1232
1240
1241

FIG. 13

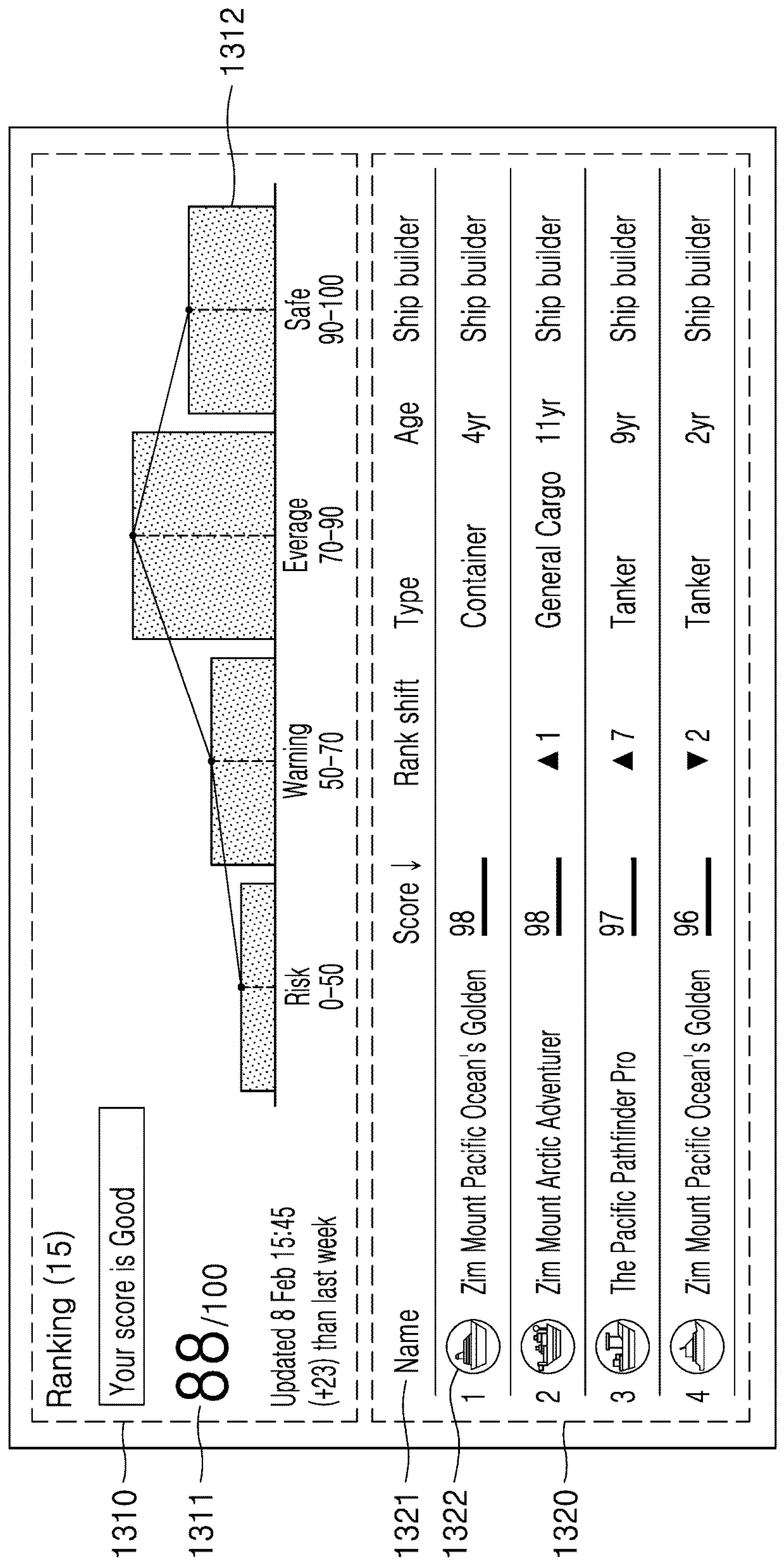

1312
1310
1311
1321
1322
1320
Ranking (15)
Your score is Good
88/100
Updated 8 Feb 15:45
(+23) than last week
Risk
0–50
Warning
50–70
Everage
70–90
Safe
90–100
Name
Score ↓
Rank shift
Type
Age
1
Zim Mount Pacific Ocean's Golden
98
Container
4yr
Ship builder
2
Zim Mount Arctic Adventurer
98
▲1
General Cargo
11yr
Ship builder
3
The Pacific Pathfinder Pro
97
▲7
Tanker
9yr
Ship builder
4
Zim Mount Pacific Ocean's Golden
96
▼2
Tanker
2yr
Ship builder

FIG. 14

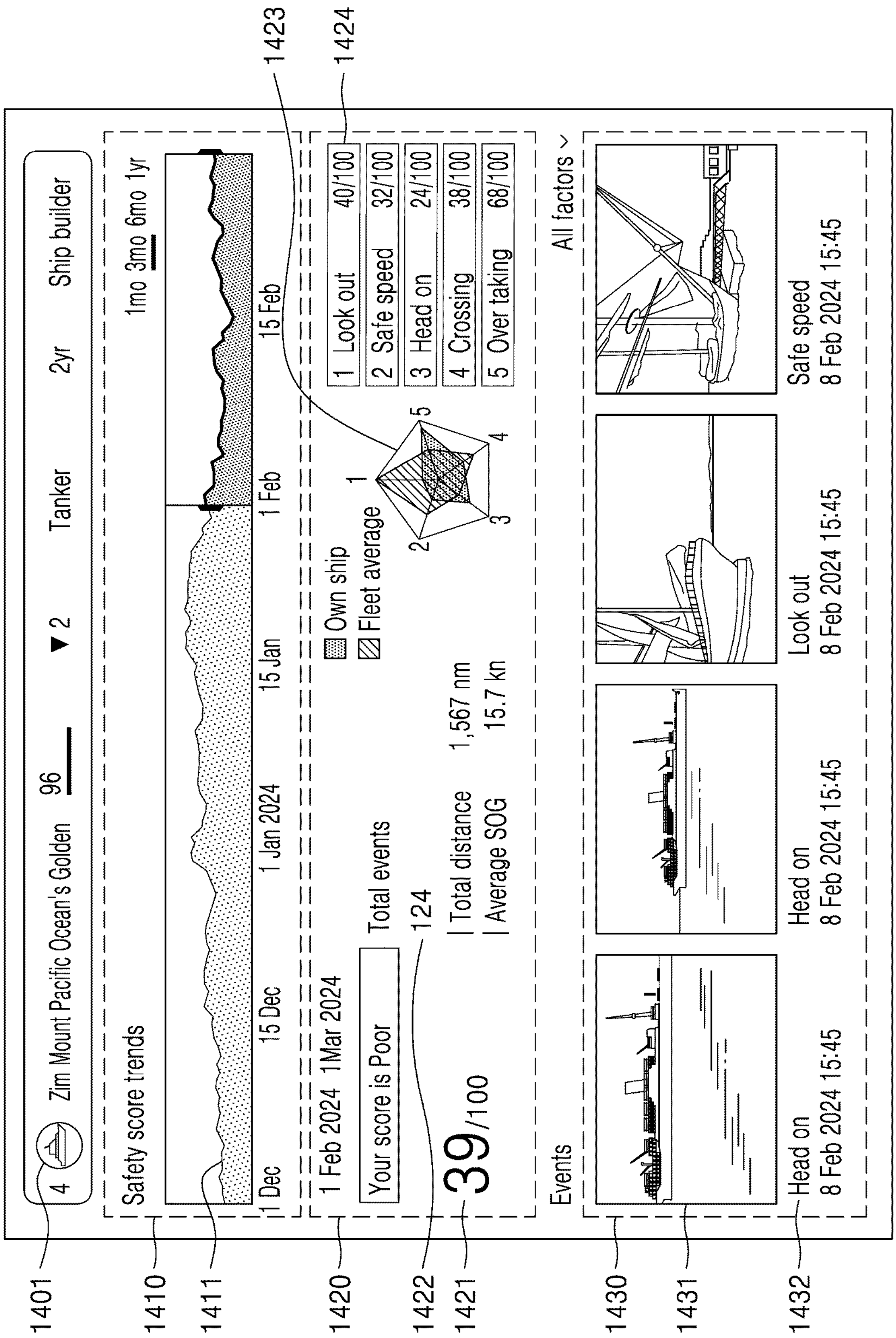
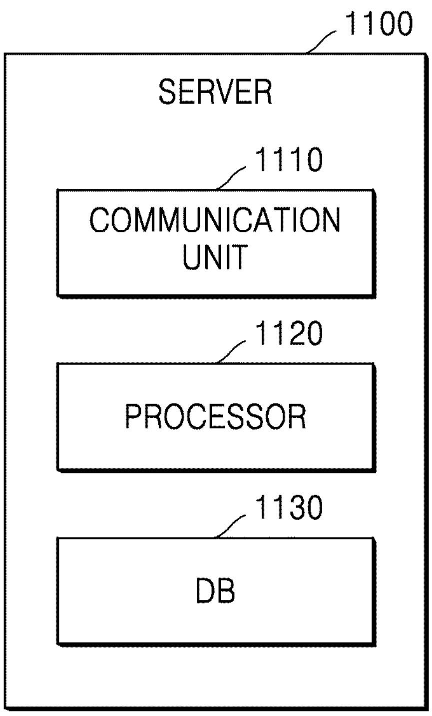

4
Zim Mount Pacific Ocean's Golden
96
▼2
Tanker
2yr
Ship builder
Safety score trends
1mo 3mo 6mo 1yr
1 Dec
15 Dec
1 Jan 2024
15 Jan
1 Feb
15 Feb
1 Feb 2024 1Mar 2024
Your score is Poor
39/100
Total events
124
Total distance 1,567 nm
Average SOG 15.7 kn
Own ship
Fleet average
1
2
3
4
5
1 Look out 40/100
2 Safe speed 32/100
3 Head on 24/100
4 Crossing 38/100
5 Over taking 68/100
Events
All factors
Head on
8 Feb 2024 15:45
Head on
8 Feb 2024 15:45
Look out
8 Feb 2024 15:45
Safe speed
8 Feb 2024 15:45
1401
1410
1411
1420
1422
1421
1430
1431
1432
1423
1424

FIG. 15


1100
SERVER
1110
COMMUNICATION UNIT
1120
PROCESSOR
1130
DB

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2025/006126

A. CLASSIFICATION OF SUBJECT MATTER

B63B 79/30(2020.01)i; **B63B 79/10**(2020.01)i; **B63B 49/00**(2006.01)i; **B63B 79/20**(2020.01)i; **B63H 21/21**(2006.01)i; **B63B 79/40**(2020.01)i; **B63B 43/18**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63B 79/30(2020.01); B60W 50/14(2012.01); B63B 79/15(2020.01); G06Q 50/30(2012.01); G07C 5/00(2006.01); G08G 1/00(2006.01); G08G 3/02(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & keywords: 점수(score), 이벤트(event), 안전(safety), 평가(evaluation), 선박(ship)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-072766 A (SHINANO KENSHI CO., LTD.) 02 April 2010 (2010-04-02) paragraphs [0024]-[0053] and figures 3, 6	1-15
A	KR 10-2019-0084733 A (SAMSUNG ELECTRONICS CO., LTD.) 17 July 2019 (2019-07-17) paragraphs [0048], [0050]	1-15
A	JP 2005-031726 A (INOUE, Kinzo et al.) 03 February 2005 (2005-02-03) claim 1 and figure 1	1-15
A	KR 10-2661624 B1 (MARINE INFORMATION TECHNOLOGY CORP.) 30 April 2024 (2024-04-30) paragraphs [0059]-[0063] and figure 3	1-15
A	KR 10-2013-0082644 A (SUNTECH INTERNATIONAL LTD.) 22 July 2013 (2013-07-22) paragraphs [0038]-[0041]	1-15

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 August 2025	**07 August 2025**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208	
Facsimile No. **+82-42-481-8578**	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2025/006126

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2010-072766 A	02 April 2010	None	
KR 10-2019-0084733 A	17 July 2019	KR 10-2466310 B1	15 November 2022
		US 11492002 B2	08 November 2022
		US 2021-0188300 A1	24 June 2021
		WO 2019-139311 A1	18 July 2019
JP 2005-031726 A	03 February 2005	JP 3769269 B2	19 April 2006
KR 10-2661624 B1	30 April 2024	KR 10-2025-0066394 A	13 May 2025
KR 10-2013-0082644 A	22 July 2013	BR 102012007325 A2	22 October 2013
		MX 2012003758 A	14 June 2013

Form PCT/ISA/210 (patent family annex) (July 2022)