

A System and Method for Simulator Agnostic Performance Evaluation and Remote Navigation Training

Priority Claim

[0001] The present application claims priority to Singapore Patent Application No. 10202302225V, the complete disclosure of which is hereby incorporated by reference.

Technical Field

[0002] The present invention relates broadly, but not exclusively, to a system and method for simulator agnostic performance evaluation and remote navigation training.

Background Art

[0003] Maritime navigation, in the open sea or near busy ports worldwide, presents many challenges for mariners. Full mission ship-handling simulators (FMSS) are critical for enhancing navigation and ship-handling skills in maritime setting. Traditionally, mariners need to travel to specific locations to access simulators due to a lack of local resource, leading to time and monetary loss. Some simulator facilities are under-utilised due to the inconvenience of traveling required. Furthermore, current performance assessment methods are reliant on human assessors, introducing subjectivity and inconsistency in the evaluation process.

[0004] Various tools and techniques exist for assessing performance and competence in maritime simulators. Some tools focus on evaluating ship handling exercises but may not assess other aspects of maritime operations. Others focus on assessing non-technical skills such as decision-making and communication. However, most tools do not assess the wide range of exercises and non-technical skills required and do not fully address the need for a comprehensive and objective assessment tool. Many assessments do not cover the diverse and complex maritime scenarios. These assessments are also not accepted across global standards.

[0005] Some known platforms combine remote training and auto-assessment capabilities. The Kongsberg Maritime's Remote Training and Assessment Solutions incorporates live virtual classrooms, online training tools, and the KONGSBERG Competence Assessment Tool (K-CAT). The Wärtsilä Voyage and Ocean Technologies Group's Cloud-Based Training and Assessment provides a robust cloud-based training platform that includes both training and assessment functionalities. However, both systems may be less adaptable to specific operational or training standards as they are limited in customisation and flexibility. Proprietary software typically lacks interoperability for broader adaptation. Additionally, these platforms are dependent on strong internet connectivity and advanced hardware, restricting their deployment in less technologically developed regions. When systems rely on third-party services, such as video conferencing tools and virtual machine hosting, this introduces vulnerabilities, potential outages, performance issues, and security risks that are beyond the control of the training provider. Systems relying on video

conferencing tools typically have server bottlenecks during peak usage. Such systems also incur additional costs from hosting and managing virtual resources and session-related data are potentially lost once the virtual machines are stopped.

[0006] Network stability can vary significantly depending on location and the technological capabilities of different vessels, potentially impacting the delivery of training content. Similarly, video conferencing tools like Zoom and Microsoft Teams, while enabling remote maritime training, have inadequate interactive capabilities that restrict hands-on experience. Video conferencing tools rely on high bandwidth which may not be consistently available, especially on ships or at remote areas. There may also be security issues that can jeopardise the privacy and integrity of training sessions. Many simulator training exercises require multiple screens to represent various aspects of a ship's bridge and surrounding environment. The current remote training tools generally support only one or two screens. Together, these factors can severely impact the overall effectiveness and applicability of remote training platforms in real-world maritime operations.

[0007] Thus, there is a need for a system and a method for simulator agnostic performance evaluation and remote navigation training which seek to address or at least ameliorate one or more of the above problems, or at least provide the public with a useful choice.

Summary of Invention

[0008] In an embodiment, there is provided a simulator agnostic performance evaluation method for evaluating user performance of maritime simulator training, the method comprising: extracting GPS position data for a user vessel and for a plurality of objects approached by the user vessel during the maritime simulator training, wherein the plurality of objects comprise at least one of a target vessel, a target navigational aid, and pilot boarding grounds; assessing penalty points based on the extracted GPS position data and trainer selectable assessment criteria; and generating a competence assessment report based on the penalty points.

[0009] In another embodiment, there is provided a remote navigation training method, comprising: establishing a network connection between a navigation simulator and a remote site; transmitting audio input and video images via the network connection between the navigation simulator and the remote site; receiving user control inputs from the remote site and sending the user control inputs to the navigation simulator; and evaluating a user performance of maritime simulator training via the simulator agnostic performance evaluation method as disclosed herein.

[0010] In another embodiment, there is provided a performance evaluation system for evaluating user performance of maritime simulator training comprising: at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the system at least to: receive maritime simulator training data; extract GPS position data for a user vessel and for a plurality of objects approached by a user during the maritime simulator training, wherein the plurality of objects comprise at least one of a target vessel, a target navigational aid, and pilot boarding grounds; assess penalty points based on the extracted GPS position data and trainer selectable assessment criteria; and generate a competence assessment report based on the penalty points.

[0011] In another embodiment, there is provided a remote navigation training system, comprising: at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the system to: establish a network connection between a navigation simulator and a remote site; transmit audio input and video images via the network connection between the navigation simulator site and the remote site; receive user control inputs from the remote site and send the user control inputs to the navigation simulator; and evaluate a user performance of maritime simulator training via the performance evaluation system as disclosed herein.

[0012] In another embodiment, there is provided a computer readable medium comprising instructions which when executed by a processor cause the processor to perform the simulator agnostic performance evaluation method as disclosed herein.

Brief Description of Figures

[0013] Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

[0014] FIG. 1A shows a flow diagram of a simulator agnostic performance evaluation method according to an embodiment of the invention.

[0015] FIG. 1B shows a simplified block diagram of a device that is suitable for implementing example embodiments of the present disclosure.

[0016] FIG. 2 shows a diagram of a ship and the under keel clearance (UKC).

[0017] FIG. 3 shows a flow diagram of a simulator agnostic performance evaluation method to assess UKC.

[0018] FIG. 4 shows an example interface for customising the UKC assessment criteria.

[0019] FIG. 5 shows a flow diagram of a simulator agnostic performance evaluation method to assess closest point of approach (CPA).

[0020] FIG. 6 shows a table of the possible CPA vessel encounters and the penalties incurred.

[0021] FIG. 7 shows an example interface for customising the CPA assessment criteria.

[0022] FIG. 8 shows a flow diagram of a simulator agnostic performance evaluation method to assess safe distance with navigational aids.

[0023] FIG. 9 shows a table of the possible object (buoy) encounter and the penalties incurred.

[0024] FIG. 10 shows a flow diagram of a simulator agnostic performance evaluation method to assess safe distance during anchorage at pilot boarding grounds.

[0025] FIG. 11 shows an example interface for customising the safe distance assessment criteria.

[0026] FIG. 12 shows a flow diagram of a simulator agnostic performance evaluation method to assess compliance with navigational signalling requirements.

[0027] FIG. 13 shows a flow diagram of a simulator agnostic performance evaluation method to assess compliance with the marine very high frequency (VHF) communication guide.

[0028] FIG. 14 shows a table of the VHF communication checklist.

[0029] FIG. 15 shows a flow diagram of a simulator agnostic performance evaluation method to assess speed in varying traffic densities.

[0030] FIG. 16 shows a flow diagram of a simulator agnostic performance evaluation method to assess speed in varying visibility conditions.

[0031] FIG. 17 shows an example interface showing an assessment report.

[0032] FIG. 18A shows a flow diagram of a remote navigation training method according to an embodiment of the invention.

[0033] FIG. 18B shows a simplified block diagram of a device that is suitable for implementing example embodiments of the present disclosure.

[0034] FIG. 18C shows a diagram of a remote navigation training system embedded with a simulator agnostic performance evaluation system.

[0035] FIG. 19 shows an example set-up of the remote navigation training system at a remote site.

[0036] FIG. 20 shows an example of the peer-to-peer (P2P) network connection of the remote navigation training system.

[0037] FIG. 21 shows a flow diagram of transmitting audio in a remote navigation training method.

[0038] FIG. 22 shows a flow diagram of transmitting video in a remote navigation training method.

Detailed Description

[0039] The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description.

[0040] Certain terminology may be used in the following description for the purpose of reference only, and thus are not intended to be limiting. For example, the term 'student' may also be referred to as the 'user', the terms 'vessel' and 'ship' may be used interchangeably, the 'instructor' may also be a 'training provider'.

[0041] A simulator agnostic performance evaluation method and a performance evaluation system are now described with reference to the accompanying Figures. Referring to FIG.

1A, there is provided a simulator agnostic performance evaluation method (10) for evaluating user performance of maritime simulator training. In step 11, the method extracts GPS position data for a user vessel and for a plurality of objects approached by the user vessel during the maritime simulator training. The GPS position data may be the position data of the user vessel and/or the position data of the plurality of objects within the virtual environment of the simulator. In other context, the GPS position data may be the real-life GPS position of the user vessel. The GPS position may be important for assessing real-time geographic positioning of vessels. The plurality of objects may comprise at least one of a target vessel, a target navigational aid, and pilot boarding grounds. The target vessel may be another vessel or vessels that is near the user vessel in the virtual environment. The target navigational aid may be at least one of buoys, beacons, lighthouses, and navigational marks. In step 12, the method assesses penalty points based on the extracted GPS position data and trainer selectable assessment criteria. In step 13 the method generates a competence assessment report based on the penalty points.

[0042] In another embodiment, there is provided a performance evaluation system for evaluating user performance of maritime simulator training. Referring to FIG. 1B the performance evaluation system (System 1) comprises: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (10) as described herein with reference to FIG. 1A. All operations and features as described herein with reference to FIG. 1A are likewise applicable to System 1 and have similar effects.

[0043] In an embodiment, extracting GPS position data for the user vessel may comprise extracting GPS positions for the user vessel at times during the maritime simulator training separated by a predetermined time interval. For example, the predetermined time interval may be about 0.25 seconds. The predetermined time interval may be less than 0.25 seconds, such that the GPS position data is updated more regularly for accuracy. The predetermined time interval may be more than 0.25 seconds, to reduce using computing resources.

[0044] Assessment of under keel clearance (UKC)

[0045] Referring to FIG. 2, the UKC is the distance between a vessel's squat and the seabed. UKC may be assessed to ensure safe maritime navigation, particularly in shallow or restricted waters.

[0046] FIG. 3 shows the simulator agnostic performance evaluation method, wherein assessing penalty points comprises assessing penalty points based further on UKC (30). Step 31 comprises extracting GPS position data and accompanying depth information for the student vessel. Trainer selectable UKC assessment criteria comprises one or more minimum UKC which may depend on the depth of water and/or adjustments made by the instructor. If the depth of water beneath the student vessel is less than the trainer selectable UKC assessment criteria then a penalty event is added in step 33. Otherwise, the method continues to extract GPS position data and depth information in step 31. In an embodiment, step 32 comprises determining if penalty points have been assessed for the depth of water beneath the student vessel being less than the trainer selectable UKC assessment criteria, and assessing penalty points if penalty points have not been assessed for any of the depth of

water beneath the student vessel being less than the trainer selectable minimum UKC assessment criteria.

[0047] In an embodiment, the trainer selectable UKC assessment criteria comprises one or more of minimum UKC when making way in depth of water of more than two times draft of the user vessel, minimum UKC when making way in depth of water of less than two times draft of the user vessel, and minimum UKC when the user vessel is at anchor. When assessing penalty points, the method is caused to assess penalty points based further on UKC determined from the extracted GPS position data and trainer selectable UKC assessment criteria.

[0048] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (30) as described herein with reference to FIG. 3. All operations and features as described herein with reference to FIG. 3 are likewise applicable to System 1 and have similar effects.

[0049] FIG. 4 shows an example of the UKC settings interface (40). The UKC settings interface (40), allows instructors or training providers to customise the minimum UKC based on specific training needs or environmental conditions. The system (System 1 of FIG. 1B) may provide a recommended minimum UKC and the instructor may use the predefined settings based on known recommended minimum UKC. Examples of parameters that may be changed include vessel type and vessel length which may affect the minimum UKC.

[0050] Assessment of closest point of approach (CPA)

[0051] FIG. 5 shows the simulator agnostic performance evaluation method, wherein the plurality of objects comprise a target vessel and wherein the trainer selectable assessment criteria comprises a trainer selectable CPA assessment criteria (50). CPA may be assessed across different vessel encounter scenarios. CPA is a crucial parameter in assessing the risk of collision between the user vessel and the target vessel. It is measured perpendicular to the course of the user vessel from the closest point of the other vessel's trajectory. By monitoring the CPA, mariners can evaluate the risk of collision and take appropriate navigational actions to ensure the safety of their vessel and crew. If the CPA is determined to be uncomfortably close, actions such as altering course, changing speed, or establishing communication with the other vessel may be necessary to maintain a safe distance and avoid potential collisions. In step 51, the method extracts the GPS position data for the student vessel and all target vessels. In step 52, assessing penalty points comprises: calculating the CPA between the student vessel and the target vessel during a passing manoeuvre. In step 53, the CPA is typically calculated by considering the relative positions, courses, and speeds of the vessels involved. Multiple reference points are created on all 4 sides of the student vessel and target vessel using half of the vessel length as the offset distance. The multiple reference points for the student vessel are determined in response to at least one dimension of the student vessel. The multiple reference points for the target vessel are determined in response to at least one dimension of the target vessel. The reference points may be on the four sides of the student vessel and the target vessel, when

viewed from above. The reference points may be labelled by referencing the offset coordinates. The reference points may be labelled as 'ahead', 'astern', and 'aside'. Step 54 comprises calculating all distances between each of multiple reference points for the student vessel and each of multiple reference points for the target vessel during the passing manoeuvre. Step 55 comprises identifying a lowest one of the calculated distances as the CPA between the student vessel and the target vessel during the passing manoeuvre. The label of the reference point with the shortest distance during the passing manoeuvre is returned for assessment. In step 56, whether the CPA between the student vessel and the target vessel during the passing manoeuvre is less than the trainer selectable CPA assessment criteria is determined. If the CPA between the student vessel and the target vessel during the passing manoeuvre is less than the trainer selectable CPA assessment criteria, a penalty event is added in step 57.

[0052] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (50) as described herein with reference to FIG. 5. All operations and features as described herein with reference to FIG. 5 are likewise applicable to System 1 and have similar effects.

[0053] In an embodiment, the trainer selectable CPA assessment criteria may comprise one or more CPA assessment criteria based on traffic density and/or visibility. For example, the trainer selectable CPA assessment criteria may be higher if the visibility is low.

[0054] Traditional CPA calculations usually involve complex predictions during real-time navigation. In an embodiment, post-simulation analysis may be utilised. During the simulation exercise, all navigational routes may be recorded by the simulator. Upon completion of the simulation exercise, navigational routes may be analysed retrospectively for CPA calculations. The distances between the student vessel and all surrounding target ships may be measured at every quarter-second position, for example, along the navigational route. This high-frequency measurement approach provides a detailed, moment-to-moment analysis of the user vessel's navigation. The measurements are compared to the assessment criteria, to identify and penalise occurrences of CPA violations.

[0055] In one embodiment, the passing manoeuvre is one of passing manoeuvres comprising of passing ahead, passing astern, and passing side by side. FIG. 6 shows the possible CPA violations for the respective passing manoeuvres during vessel encounter. Passing ahead refers to a scenario where the target vessel intends to overtake and cross in front of the user vessel's path. Passing astern refers to a situation where the target vessel intends to overtake and cross behind the user vessel's path. Passing side by side involves determining the side (port or starboard) where the passing will take place, in compliance with international rules and regulations such as the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs). To determine different vessel encounters, the GPS positions of the user vessel and the target vessel are retrieved. Reference positions on all four sides of the user vessel and target vessel are created as described above.

[0056] The different passing manoeuvres are determined by referencing the offset coordinates. The offset coordinates represent positional deviations or distances from a reference point. The reference point is typically the midpoint or a specific location on the user vessel. By referencing these offset coordinates of a target vessel relative to the user vessel, the alignment of the vessels can be accurately determined with respect to each other. These coordinates help identify whether the target vessel is ahead, astern, or abeam (to the side) of the user vessel. If the offset coordinates indicate that the target vessel is primarily in the forward direction of the user vessel's heading, the manoeuvre is categorized as 'passing ahead'. If the offset coordinates show that the target vessel is located behind the user vessel, it is identified as 'passing astern'. If the offset coordinates indicate that the target vessel is alongside the user vessel, within a specified lateral distance, the manoeuvre is classified as 'passing side by side'.

[0057] Based on Fig. 6, the system/method applies one of the penalty categories to the vessel encounters – unsafe navigation, near miss, and collision. Different safety thresholds are applied based on the user vessel's operational context and proximity to the target vessel. For example, the user vessel may be a container ship or a tanker ship with a length ranging from 201-250 metres. In a 'passing ahead' situation, for a container ship, a distance below 1 nautical mile (1,852 m) may be considered unsafe navigation, below 0.3 nautical miles (556 m) may be considered a near miss, and below 0.07 nautical miles (130 m) may trigger collision conditions. In a 'passing ahead' situation for tanker ships, a distance below 0.3 nautical miles (556 m) may be considered unsafe navigation, below 0.1 nautical miles (185 m) may be considered a near miss, and below 0.07 nautical miles (130 m) may trigger collision conditions. In a 'passing astern' situation, for container ships, a distance below 0.5 nautical miles (926 m) may be deemed unsafe, below 0.1 nautical miles (185 m) may be a near miss, and below 0.03 nautical miles (56 m) may trigger collision conditions. In a 'passing astern' situation for tanker ships, a distance below 0.1 nautical miles (185 m) may be considered unsafe, below 0.05 nautical miles (93 m) may be a near miss, and below 0.03 nautical miles (56 m) may trigger collision conditions. In a 'passing side by side' situation, for container ships, a distance below 0.5 nautical miles (926 m) may be considered unsafe navigation, below 0.2 nautical miles (370 m) may be a near miss, and below 0.02 nautical miles (37 m) may trigger collision conditions. In a 'passing side by side' situation, for tanker ships, a distance below 0.1 nautical miles (185 m) may be considered unsafe navigation, below 0.05 nautical miles (93 m) may be a near miss, and below 0.02 nautical miles (37 m) may trigger collision conditions.

[0058] FIG. 7 shows an example of the CPA settings interface (70). The CPA settings interface (70) allows instructors to edit the predefined distances for CPA, facilitating the creation of bespoke training scenarios. Such customisation ensures that the assessment criteria align with specific training objectives, thereby providing targeted and constructive feedback to students. The system may provide recommended CPA and the instructor may use the predefined settings. Examples of other parameters that may be changed include vessel type and vessel length.

[0059] Assessment of safe distance from navigational aids

[0060] FIG. 8 shows the simulator agnostic performance evaluation method for assessing safe distances from navigational aids (80). In an embodiment, the plurality of objects comprise one or more target navigational aids and wherein the trainer selectable assessment

criteria comprises a trainer selectable navigational aid assessment criteria. Step 81 comprises extracting GPS position data for the student vessel and the one or more target navigational aids. Step 82 comprises determining a nearest neighbour navigational aid of the one or more target navigational aids with respect to the student vessel. Step 82 further comprises calculating distances between the student vessel and the nearest neighbour navigational aid. Step 83 comprises assessing if one of the distances between the student vessel and the nearest neighbour navigational aid is less than the trainer selectable navigational aid assessment criteria. If one of the distances between the student vessel and the nearest neighbour navigational aid is less than the trainer selectable navigational aid assessment criteria, then a penalty event is added in step 84.

[0061] Navigational aids facilitate safe and efficient navigation for mariners. Navigational aids may include at least one of buoys, beacons, lighthouses, and navigational marks. The performance evaluation method/system may be customised to focus on one type of navigational aid. The performance evaluation method/system may be customised to focus on maintaining safe distances from navigational aids while anchoring at pilot boarding. This may involve the user vessel passing at least one navigational aid and conducting operations at pilot boarding grounds. The size, draft, and manoeuvrability of the user vessel may be factors when determining safe distances from the navigational aids. For example, larger vessels may require more space to navigate safely around navigational aids compared to smaller vessels.

[0062] In an embodiment, step 83 comprises determining if penalty points have been assessed for one of the distances between the student vessel and the nearest neighbour navigational aid being less than the trainer selectable navigational aid assessment criteria, and assessing penalty points if penalty points have not been assessed for any of the distances between the student vessel and the nearest neighbour navigational aid being less than the trainer selectable navigational aid assessment criteria.

[0063] In an embodiment, determining the nearest neighbour navigational aid in step 82 comprises determining the nearest neighbour navigational aid of the one or more target navigational aids with respect to the student vessel in accordance with a k-d tree algorithm.

[0064] In an embodiment, the trainer selectable navigational aid assessment criteria comprises one or more navigational aid assessment criteria based on a minimum navigational aid passing distance.

[0065] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (80) as described herein with reference to FIG. 8. All operations and features as described herein with reference to FIG. 8 are likewise applicable to System 1 and have similar effects.

[0066] FIG. 9, shows the penalty categories applied by the system/method for a navigational aid encounter, for example a passing buoy encounter. Similar to the approach taken with assessing encounters in FIG. 6, the system applies the same three penalty categories, unsafe navigation, near miss, and collision. For example, if the distance between

the user vessel and the navigational aid is below 0.3 nautical miles (556 m) it may be considered unsafe navigation, below 0.2 nautical miles (370 m) may be considered a near miss, and below 0.02 nautical miles (37 m) may trigger collision conditions.

[0067] Assessment of safe distance during anchorage at pilot boarding grounds

[0068] Referring to FIG. 10, in an embodiment, the simulator agnostic performance evaluation method, wherein the plurality of objects comprise one or more target vessels and the pilot boarding grounds and wherein the trainer selectable assessment criteria comprises a trainer selectable pilot boarding ground assessment criteria (100). Step 101 comprises extracting GPS position data for the student vessel and the pilot boarding grounds. Step 102 comprises determining whether an anchor chain of the student vessel is deployed within the pilot boarding grounds. This may be determined based on the GPS position data. When the anchor chain of the student vessel is deployed within the pilot boarding grounds, step 103 comprises determining nearest neighbour vessels of the one or more target vessels. Step 103 comprises calculating distances between the student vessel and the nearest neighbour vessels. Step 104 comprises determining if at least one of the distances between the student vessel and the nearest neighbour vessels is less than the trainer selectable pilot boarding ground assessment criteria. If one of the distances between the student vessel and the nearest neighbour vessels is less than the trainer selectable pilot boarding ground assessment criteria, then a penalty event is added in step 105.

[0069] When anchoring or maneuvering near navigational aids or at pilot boarding grounds, consideration of the swing circle or swinging radius of the user vessel is required. The swing circle or swinging radius is the area the vessel covers as it oscillates around the anchor's pivot point. The swing circle may be influenced by wind, current, and tidal conditions. It is important to ensure that the swing circle does not overlap with another vessel's swing circle, navigational channels, navigational aids or any other objects. As standard practice, maintaining a significant distance from other vessels during anchoring is advised to avoid potential collisions or entanglements.

[0070] In an embodiment, determining the nearest neighbour vessels in step 103 comprises determining nearest neighbour vessels of the one or more target vessels with respect to the student vessel in accordance with a k-d tree algorithm

[0071] In an embodiment, step 104 comprises determining if penalty points have been assessed for at least one of the distances between the student vessel and the nearest neighbour vessels being less than the trainer selectable pilot boarding ground assessment criteria, and assessing penalty points at step 105 if penalty points have not been assessed for any of the distances between the student vessel and the nearest neighbour vessels being less than the trainer selectable pilot boarding ground assessment criteria.

[0072] In an embodiment, the trainer selectable pilot boarding ground assessment criteria comprises one or more pilot boarding ground assessment criteria based on a user vessel distance to maintain from another vessel when waiting for a pilot at the pilot boarding grounds or embarking/disembarking a pilot at the pilot boarding grounds.

[0073] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code

(4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (100) as described herein with reference to FIG. 10. All operations and features as described herein with reference to FIG. 10 are likewise applicable to System 1 and have similar effects.

[0074] FIG. 11 shows an example of the safe distance settings interface (110). The distance settings interface allows instructors to edit the predefined minimum distances for target navigational aids and/or pilot boarding ground. Other minimum distances that may be edited include minimum distances when passing danger areas. Danger areas may include wreck and shoal.

[0075] Assessment of compliance with navigational signalling requirements

[0076] FIG. 12 shows the simulator agnostic performance evaluation method for assessing navigational signalling criteria (120). Step 121 comprises extracting GPS position data for the user vessel and the plurality of objects. The plurality of objects may comprise a target vessel. In an embodiment, the trainer selectable assessment criteria comprises a trainer selectable navigation signalling compliance criteria. When assessing penalty points, step 121 comprises extracting data comprising at least one of visibility data, timing data, and vessel status data. Visibility is determined by how far the user can see ships ahead. For example, if the user cannot see ships/landmarks beyond 10 nautical miles, this condition may be categorised as low visibility. The timing data may be the virtual daytime or nighttime in the virtual environment. Step 122 comprises identifying environmental conditions comprising at least one of visibility condition, day/night condition and a navigational situation between the user vessel and the target vessel. The distance between the user vessel and nearest neighbour vessel may be calculated. Step 123 comprises collecting navigation signalling data used by the user vessel. The navigation signalling data comprises at least one of navigation lights, sound signals and day shapes. Step 124 comprises assessing penalty points based on the extracted data, environmental conditions, navigation signalling data and the trainer selectable navigation signalling compliance criteria. Penalty points are added in step 125 if there is incorrect usage of navigation signalling. A navigation signalling compliance assessment based on the penalty points may be generated.

[0077] Compliance with navigational signalling requirements as per COLREGs navigation signalling is important for maintaining maritime safety. Navigational signals are essential for clear identification and positioning of vessels during daytime, nighttime, and in conditions of poor visibility, allowing for safe and informed navigation decisions. Visibility data from the simulator is important for assessing real-time environmental conditions. The visibility data refers to the virtual visibility in the virtual environment. The visibility may be set by the instructor. The visibility may be set as a percentage representing the amount of fog and/or rain, which may then be converted to nautical miles of visibility. The visibility set may be applied within the simulation universally. The visibility data is processed to determine the visibility conditions for determining the appropriate signalling and manoeuvres for the assessment criteria. Similarly, the virtual timing may be set by the instructor. For example, the instructor may set daytime or nighttime for the simulation exercise. The instructor may set different times of day or night, for example sunrise, or dusk.

[0078] In an embodiment, at step 123 the navigation signalling data collected comprises at least one of navigation lights, sound signals, and day shapes. Navigation signalling compliance is assessed in step 124 by the user communicating its manoeuvres accurately by using appropriate sound signals or navigation lights according to the prevailing visibility conditions and timing. Navigation lights may include at least one of masthead lights, sidelights, and stern lights. Day shapes are geometric shapes displayed on vessels during daylight to communicate specific operational statuses. For example, day shapes may indicate vessels engaged in diving, and dredging. Day shapes are also used to signal conditions like anchoring, being not under command, and restricted manoeuvrability. For example, two vertical balls indicate a vessel not under command, a single ball indicate that a vessel is anchored, a ball-diamond-ball configuration indicates a vessel that is restricted in its ability to manoeuvre, and a cylinder represents a vessel constrained by its draft. The user display of the correct day shapes for the vessels current conditions are also assessed in step 124. Penalty points are assessed in step 125 if there are deviations or failures to adhere to day shapes signalling protocols as unsafe navigation events. The penalty points added for deviations and failures may be modified by the instructor. The instructor may choose to use the default penalty points, for example, 5 penalty points for unsafe navigation, 10 penalty points for near-miss, and 50 penalty points for collision. The instructor may edit the default number of penalty points for unsafe navigation.

[0079] In an embodiment, the navigational situation identified in step 122 is one of overtaking, head-on, give-way, and crossing. Calculating the distances between the user vessel and nearby vessels identify the navigational situation. If the user vessel and the other vessel are on reciprocal or nearly reciprocal courses, where the user vessel and the other vessel are moving in towards each other along the same line, this usually indicates a head-on situation. Analysing the angle of the stern of the user vessel relative to the other vessel allows the system/method to determine if an overtaking action is occurring. When one vessel is approaching another vessel from behind in a 22.5 degree arc or more from the stern (or 22.5 degrees abaft the beam) then an overtaking situation is occurring. In crossing scenarios, the relative bearing and headings of the two vessels are assessed from GPS position data. If the paths of the vessels intersect is not a head-on or overtaking situation then a crossing situation is occurring. In a give-way situation, the give-way vessel is identified. The give-way vessel is the vessel, either the user vessel or the other vessel, that has the other vessel on its starboard side. The give-way vessel is responsible for avoiding the stand-on vessel.

[0080] During daylight in an overtaking situation, the overtaking vessel should maintain clear visibility of the stern of the vessel being overtaken to accurately judge the overtaking angle. Vessels signal their intentions during the day using sound signals. An overtaking vessel should use specific sound signals to indicate its manoeuvre. One short blast signals an intention to overtake on the starboard side, meaning the overtaking vessel will pass on the port side of the vessel being overtaken. Two short blasts signal an intention to overtake on the port side, meaning the overtaking vessel will pass on the starboard side of the vessel being overtaken.

[0081] During nighttime, navigation lights are used for indicating a vessel's status and intentions. In an overtaking situation at night, the overtaking vessel should see only the stern light of the vessel being overtaken, without the sidelights being visible. The stern light

has a white light visible only from behind the vessel. The masthead lights are white lights visible from the front and sides, providing an indication of the overtaking vessel's presence and orientation. The sidelights are red for the port side and green for the starboard side. The sidelights are visible on the sides of the vessel. The sidelights help other vessels determine the direction the overtaking vessel is heading.

[0082] Under low visibility conditions, sound signals are used in overtaking situations. Two prolonged blasts followed by one short blast indicates the vessel overtaking on the starboard side of the vessel being overtaken. Two prolonged blasts followed by two short blasts indicates the vessel overtaking on the port side of the vessel being overtaken.

[0083] A head-on situation is recognized when one vessel can see the other directly ahead or nearly ahead. When two power-driven vessels are on reciprocal or nearly reciprocal courses and risk collision, each vessel must alter their course to starboard so that they pass on the port side of each other. During daytime, the vessels observe each other's corresponding aspects. If there is any uncertainty about the existence of this situation, the vessel must assume a head-on situation is occurring and take the appropriate actions to avoid a collision. To ensure safe passing and clear communication, vessels in a potential head-on situation should use designated sound signals. One short blast signals an intention to alter course to starboard, meaning the vessel intends to pass on the port side of the oncoming vessel. Two short blasts indicate an intention to alter course to port, meaning the vessel intends to pass on the starboard side of the oncoming vessel. Three short blasts indicate that the vessel is operating astern propulsion.

[0084] At nighttime, a head-on situation is indicated by the masthead lights of the other vessel appearing in a line or nearly in a line and/or both sidelights being visible. Both vessels should clearly display their navigation lights as a means of communication.

[0085] In low or restricted visibility conditions, vessels use sound signals to communicate their presence and actions during a head-on situation. For a power-driven vessel making way through the water, the correct sound signal is one prolonged blast at intervals of not more than two minutes.

[0086] During a give way situation, the give-way vessel must take action to avoid a collision. To avoid collision, the give-way vessel may alter its course, slow down, or stop. These actions should be decisive and noticeable to the stand-on vessel, ensuring clear communication of intentions. The stand-on vessel is obligated to maintain its course and speed to ensure predictability and facilitate the give-way vessel's manoeuvres. If it becomes apparent that the give-way vessel is failing to take adequate action, the stand-on vessel must then take evasive action to prevent a collision.

[0087] During daytime, the sound signals for a give-way situation in a head-on encounter are essentially the same as the general manoeuvring signals used to communicate intentions between vessels. During nighttime, different vessels use distinct light configurations to signal their presence, type, size, and status. The light configurations help other vessels understand how to navigate relative to the user vessel. Power-driven vessels may display a masthead light, sidelights, and a stern light. Sailing vessels display sidelights and a stern light. Sailing vessels may show red over green all-around lights at the masthead. Fishing vessels may display green over white all-around lights while they are trawling, or red over

white all-around lights for other fishing activities. Vessels not under command or restricted in ability to manoeuvre may display two all-around red lights in a vertical line; or a vertical line of three lights, red, white, and red. Anchored vessels may display one all-around white light, with additional lights if the vessel is over 50 meters in length. Vessels aground may display two all-around red lights in a vertical line, along with an all-around white light.

[0088] In low or restricted visibility conditions, specific sound signals are used to indicate the give-way intention and status of vessels. Power-driven vessels underway emit one prolonged blast every two minutes. Sailing vessels, not under command, restricted in ability to maneuver, and fishing vessels emit one prolonged blast followed by two short blasts every two minutes. Vessels at anchor sound a rapid ringing of the bell for about five seconds every minute. If the vessel is over 100 meters in length, a gong may be sounded in the stern for about five seconds. Vessels aground sound a pattern of three distinct strokes on the bell before and after rapid ringing of the bell.

[0089] A crossing situation occurs when two power-driven vessels are on courses that intersect in such a way that there is a risk of collision unless one or both vessels take evasive action. The vessel that has the other on its starboard side (the give-way vessel) must take action to avoid crossing ahead of the other vessel (the stand-on vessel).

[0090] During daytime in a crossing situation, vessels must rely on visual observation to safely navigate crossing situations. No specific sound signals are required under clear visibility conditions for crossing. Vessels should ensure their actions are clear and predictable to avoid confusion with the stand-on vessel.

[0091] During nighttime in a crossing situation, vessels use navigation lights to indicate their presence and heading. Power-driven vessels display a masthead light, sidelights (red for port and green for starboard), and a stern light. Vessels at anchor display an all-around white light. The lights help identify the type of vessel and its orientation, to allow vessels to assess crossing situations and taking appropriate action.

[0092] In conditions of low or restricted visibility in a crossing situation, sound signals may be used to indicate a vessel's presence and manoeuvres. Power-driven vessels should emit one prolonged blast every two minutes if they are moving to indicate their presence.

[0093] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (120) as described herein with reference to FIG. 12. All operations and features as described herein with reference to FIG. 12 are likewise applicable to System 1 and have similar effects.

[0094] Assessment of compliance with marine very high frequency (VHF) communication guide

[0095] FIG. 13 shows the simulator agnostic performance evaluation method wherein the trainer selectable assessment criteria comprise a trainer selectable marine VHF communication compliance criteria (130). Step 131 comprises extracting audio input sent

from the user vessel. The audio input may be sent to a target vessel or to a target shore station for example. Step 132 comprises assessing communication content by converting the audio input to text using automatic speech to recognition (ASR). Step 133 comprises checking a VHF channel selected by the user vessel. Penalty points are assessed based on the communication content, VHF channel selected, and trainer selectable marine VHF communication compliance criteria. Step 134 comprises, assessing penalty points when the incorrect VHF channel is used. For example, 30 penalty points may be added for the use of incorrect VHF channel. The system may provide default penalty points for incorrect VHF channel usage. The instructor may adjust the number of penalty points added for use of incorrect VHF channel. A VHF communication compliance assessment based on the penalty points may be generated.

[0096] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (130) as described herein with reference to FIG. 13. All operations and features as described herein with reference to FIG. 13 are likewise applicable to System 1 and have similar effects.

[0097] Marine VHF communication is a safety tool in maritime operations, enabling clear and reliable communication between different vessels, and between vessels and shore stations. Assessing the user's VHF communication skills is essential to ensure effective handling of routine, emergency, and navigational communications, thereby enhancing safety and operational efficiency at sea. Compliance may be assessed in step 133 based on the accuracy of the VHF channel selected by the user vessel, the appropriateness of the communication content for the selected channel, and the comprehensiveness of the communication for the reported cases.

[0098] FIG. 14 shows a VHF checklist of the VHF channels and the purpose of the types of communication the channels are used for.

[0099] Assessment of speed management in varying traffic densities

[0100] FIG. 15 shows the simulator agnostic performance evaluation method, wherein the trainer selectable assessment criteria comprises a trainer selectable speed assessment criteria based on traffic density (150). In an embodiment, the plurality of objects comprises the at least one target vessel. The student vessel is monitored and assessed for its ability to maintain its speed within pre-defined thresholds under different traffic densities. When assessing penalty points, step 151 comprises extracting GPS position data of the student vessel. Traffic density data may be extracted and may be determined based on the number of vessels within a specified radial distance from the student vessel. Traffic density may be defined as low, medium, or high. For example, traffic density may be defined by the number of vessels within a radius of five times the size of the student vessel. In step 152, high traffic density may be defined as when there are more than five vessels within a radius of five times the size of the student vessel. In step 154, low traffic density may be defined as when there are fewer than two vessels within a radius of five times the size of the student vessel. In step 156, medium traffic density may be defined as when neither high nor low

density is recorded or when there are between two and five vessels within a radius of five times the size of the student vessel. Steps 153, 155, and 156 comprise determining the speed assessment criteria based on the traffic density. Step 157 comprises determining a speed of the student vessel based on the GPS position data. Step 157 comprises assessing penalty points if the speed of the student vessel is higher than the trainer selectable speed assessment criteria. When the speed of the student vessel is higher than the trainer selectable speed assessment criteria, a penalty event is generated in step 158. A speed management assessment based on the penalty points may be generated.

[0101] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (150) as described herein with reference to FIG. 15. All operations and features as described herein with reference to FIG. 15 are likewise applicable to System 1 and have similar effects.

[0102] Assessment of speed management in varying visibility conditions

[0103] FIG. 16 shows the simulator agnostic performance evaluation method, wherein the trainer selectable assessment criteria comprise a trainer selectable speed assessment criteria based on visibility condition (160). The user vessel is monitored and assessed for its ability to maintain its speed within pre-defined thresholds under different visibility conditions based on visible distance in nautical miles. When assessing penalty points, step 161 comprises extracting GPS position data of the user vessel and the visibility condition data. Visibility is categorised into two levels, low visibility and normal visibility. In step 162, low visibility may be defined as conditions where rain or fog is set to more than 30%. If visibility is not classified as low visibility, then it may be classified as normal visibility. Steps 163 and 164 comprise determining the trainer selectable speed assessment criteria based on the visibility condition data. Step 165 comprises determining a speed of the user vessel based on the GPS position data and whether the speed of the user vessel is higher than the trainer selectable speed assessment criteria. Penalty points is assessed if the speed of the user vessel is higher than the trainer selectable speed assessment criteria. When the speed of the user vessel is higher than the trainer selectable speed assessment criteria, a penalty event is generated in step 166. A speed management assessment based on the penalty points may be generated.

[0104] In another embodiment, there is provided a performance evaluation system (System 1 of FIG. 1B) for evaluating user performance of maritime simulator training, comprising: at least one processor (2); and at least one memory (3) including computer program code (4), the at least one memory (3) and the computer program code (4) configured to, with the at least one processor (2), cause the system (System 1) at least to implement the method (160) as described herein with reference to FIG. 16. All operations and features as described herein with reference to FIG. 16 are likewise applicable to System 1 and have similar effects.

[0105] Assessment report

[0106] In an embodiment, assessing the penalty points comprises assessing unsafe navigation penalty points, assessing near miss penalty points, assessing incorrect marine VHF communication, and/or assessing collision penalty points. In another embodiment, when assessing the penalty points, the system is caused to assess unsafe navigation penalty points, assess near miss penalty points, assess incorrect marine VHF communication, and/or assess collision penalty points. Referring to FIG. 17, a final assessment report (170) may be automatically generated after the completion of a simulation exercise. The final assessment report (170) may provide an overall score reflecting the user's performance, with detailed information on instances where penalties were incurred based on the trainer selectable assessment criteria. For example, the final assessment report (170) may include at least one or more of the following: real life dates and times for the exercise, dates and times for the simulation event, the conditions/events in the simulation assessed, the navigation elements assessed, the assessment values, the actual values, whether the user complied with the requirements, and the penalty points. The final assessment report (170) may provide insights to identify training gaps and areas for enhancement, thereby informing future training strategies. In an embodiment, the performance evaluation method/system may incorporate new technologies, new assessment criteria, and new training scenarios as maritime practices evolve.

[0107] Remote navigation training method/system

[0108] Referring to FIG. 18A, there is provided a remote navigation training method (180). In step 181, the method establishes a network connection between a navigation simulator and a remote site. In step 182, the method transmits audio input and video images via the network connection between the navigation simulator and the remote site. In step 183, the method receives user control inputs from the remote site and sends the user control inputs to the navigation simulator. In step 184 the method evaluates a user performance of maritime simulator training via the simulator agnostic performance evaluation method as disclosed herein. The simulator agnostic performance evaluation method facilitates a seamless process during remote simulation exercises. The system may use VPNs to establish a secure and reliable connection between the remote sites and navigation simulator in step 181. It also employs a server to authenticate client credentials before establishing a direct connection, enhancing security and reliability. After establishing the connection, the method may continually transmit audio input, video images and user control inputs between the remote site and the navigation simulator, i.e. continually perform steps 182 to 184. The method may perform steps 182 to 184 simultaneously.

[0109] In another embodiment, there is provided a remote navigation training system. Referring to FIG. 18A, the remote navigation training system (System 185), comprises: at least one processor (186); and at least one memory (187) including computer program code (189), the at least one memory (187) and the computer program code (189) configured to, with the at least one processor (186), cause the system to: implement the method (180) as described herein with reference to FIG. 18A. All operations and features as described herein with reference to FIG. 18A are likewise applicable to System 185 and have similar effects.

[0110] The remote navigation training system/method may be integrated across different platforms and technologies within the maritime training industry. For example, the remote navigation training system/method may be implemented for a Kongsberg Digital K-Sim

VTs simulator. The remote navigation training system/method may be adapted for different models or different fields such as aviation or manufacturing. Compatibility with various maritime simulators promotes interoperability allowing the potential for widespread standardisation and collaboration across the maritime training industry. Training providers may leverage their existing simulator infrastructure and incorporate the remote navigation training system/method.

[0111] FIG. 18C shows the interaction between a remote navigation training system and performance evaluation system, highlighting how data flows and decisions are managed across the platform and tool. The remote navigation training system integrates remote training with a performance evaluation system to enhance maritime simulator training. This integration allows for a comprehensive simulated training environment that replicates real-world scenarios while providing objective assessments of student performance as described herein. The system's architecture supports simultaneous operation of both components, ensuring that data from remote training sessions are directly utilized for performance evaluations.

[0112] When a remote training session begins, the performance evaluation system captures data from the user's vessel and other objects within the simulator. This data may include exercise state, vessel parameters, and GPS position information within the virtual environment. The data is then transmitted to the Net API server via a TCP socket stream and subsequently stored in a database. Following storage, the data undergoes processing and is utilized to generate customized reports based on the instructor's settings as described herein.

[0113] FIG. 19 shows an example of the deployment and utilization of the remote navigation training system at the remote site. The remote navigation training system may be configured to connect remotely to the navigation simulator via an internet connection. The remote navigation training system may be configured to connect to at least one screen at a remote site to display the same simulation views as the navigation simulator. The remote site may be set up with standard computers to display all available equipment from the navigation simulator, such as radar and ECDIS, through an internet connection. Certain simulated views may be combined on a single screen. Control instrumentation may be on a touchscreen display. The remote site may be tailored based on specific training needs or training scenario. The instructor may oversee the training at the remote site or at the navigation simulator site.

[0114] The remote training system/method may automatically load the correct screen configurations upon startup and continuously attempt to connect to the simulator without manual intervention, ensuring a seamless user experience. The remote navigation training system may be configured to turn on or power on the navigation simulator. The remote navigation training system may be configured to turn off or power down the navigation simulator. This automation reduces the need for a person to be present at the navigation simulator site to manage the equipment. The remote navigation training system require at least one simulator to connect to. The simulator may connect to more than one remote navigation training system running on more than one licence.

[0115] Referring to FIG. 20, to enable direct network connections between remote sites and the simulator site, the remote navigation training system establishes peer-to-peer (P2P)

network connections using Network Address Translation (NAT) and UDP hole punching techniques. NAT is a technique that remaps IP addresses by modifying network address information in the IP header of packets as they transit across traffic routing devices. NAT helps conserve IP addresses and enhances security by masking internal network structures. However, remote sites and simulator sites may struggle to communicate directly when establishing P2P connections.

[0116] In one embodiment, the remote navigation training system may use UDP hole punching to establish direct P2P connections between the remote site and the simulator site. P2P have low latency and low bandwidth usage. In a standard network setup according to IEEE guidelines, when two points, for example PointA and PointB communicate, PointB is responsible for managing necessary reconnections to maintain the link. However, the remote navigation training system often involves connections to multiple remote sites. For example, more than two points may need to connect to a central point, PointB. Having PointB manage all reconnections may be overwhelming and inefficient with multiple connections. To improve efficiency and manage more complex connections, a novel element called an Introducer (PointI) may be implemented to manage the connections. PointI acts as a central coordinator, handling the network traffic and reconnections for all the points, thereby distributing the network load more evenly and enhancing overall system scalability and efficiency. This approach is a custom adaptation, diverging from standard IEEE protocols, and handles the unique challenges of connecting multiple remote training sites. For multiple remote sites, an introducer server broadcasts the data after receiving it from the host, the simulator site, which frees up the simulator site to prepare the next frame, significantly reducing potential lag. UDP hole punching enables direct connections for high-quality audio and video transmission between remote sites and simulation site. A remote site may connect directly to the simulator site through a server acting as an introducer. This method optimizes network resources and improves the quality of connections, making it ideal for applications requiring real-time communication across NAT environments.

[0117] FIG. 20 shows an example of the P2P network connection of the remote navigation training system. Before hole punching, the remote site and the simulator site are initially unable to establish a direct connection due to the NAT translating their internal IP addresses to a public IP address. The remote site and simulator site sits behind a NAT, which obscures their true IP addresses. For example, the remote site may have an Internal IP 10.0.0.1, Port 1234 and public IP 155.99.25.11, Port 62000; and the simulator site may have an Internal IP 10.0.1.3, Port 1234 and Public IP 155.99.25.11, Port 62005.

[0118] The hole punching process comprises a connection request, an information exchange, and sending UDP datagrams. During the connection request, the remote site sends a request to the server to connect with the simulator site. The server records the public and private endpoints of the remote site and the simulator site. The server then shares the public and private endpoint information of the remote site and the simulator site with each other during information exchange. The remote site and the simulator site then have each other's public IP addresses and ports. UDP datagrams are then sent. The remote site and the simulator site then begin sending UDP packets to the public endpoints provided. These packets 'punch' holes through the NAT, establishing a pathway for direct communication.

[0119] After hole punching, the NAT devices create a mapping for the session based on the exchanged packets, allowing direct communication between the remote site and the simulator site through their NAT-mapped endpoints. The connection is maintained without further intervention from the server, significantly optimizing the communication pathway. The system may run with as low as 5 Kbps of bandwidth while providing smooth framerates.

[0120] FIG. 21 shows the remote navigation training method transmitting audio input (200 and 210). Step 201 comprises obtaining audio input from a sender site. The remote navigation training method comprises an audio compression technology, Custom Adaptive Differential Pulse Code Modulation (CADPCM). By minimizing data transmission size, CADPCM allows audio communication over constrained networks and in low-bandwidth environments. The audio input may be received from a microphone at the simulator site and/or the remote site. Step 202 comprises predicting an audio sample based on the audio input, and calculating a prediction error between the audio sample and the audio input. CADPCM may employ a predictive algorithm that estimates future audio samples based on previously received samples. Step 203 comprises quantizing and encoding the prediction error. The difference between the actual sample and the predicted sample, a prediction error, is computed, which is typically smaller and simpler to encode than the original audio data. The prediction error may be quantized to fewer levels, reducing its complexity. This quantized value is then encoded using a fixed number of bits, making the data suitable for efficient network transmission. Step 204 comprises compressing the audio sample and the prediction error as compressed audio data. Step 205 comprises sending the compressed audio data to the receiver site via the network connection. The audio data may be further compressed using additional techniques such as converting the audio from stereo to mono, reducing the data by eliminating redundant information across channels. The audio data may be compressed by reducing the sample rate and bit rate to decrease the data quantity, thereby reducing the transmission load. The audio data may be further compressed by converting from 32-bit to 16-bit integers, which effectively halves the data size without significantly compromising audio quality.

[0121] Step 211 comprises receiving the compressed audio data from the sender site. The audio data may be received through the P2P connection at the remote site and/or simulator site. Upon receipt, the compressed audio data undergoes a reverse process to reconstruct the original audio quality. Step 212 comprises decoding and dequantizing the compressed audio data. Step 213 comprises reconstructing the audio input based on the audio sample and the prediction error. The encoded data is decoded back to the quantized prediction error. Dequantization reconstructs the prediction error to its approximate original form. Utilizing the reconstructed prediction error and previous samples, the system recalculates the audio samples, restoring the audio to its near-original state. Step 214 comprises outputting the audio input at the receiver site. The decompressed audio may be outputted at the remote site and/or simulation site for playback. By integrating advanced differential encoding and quantization techniques, the technique ensures that audio transmissions are efficient and maintain high quality, even under bandwidth constraints. This technology is important for applications requiring reliable and continuous audio communication in low-bandwidth scenarios. The process may be symmetrically designed to operate at both the remote site and the simulator site, supporting efficient two-way communication. When the user is at the remote site speaking, then the remote site is the sender site and the simulator

site is the receiver site. Alternatively, the instructor may give instructions to user, in this case the navigation simulator site is the sender site and the remote site is the receiver site. For example, the user may be at the remote site and the instructor at the simulator site. The remote navigation training system may allow for two-way voice communication between the instructor and the student.

[0122] In another embodiment, there is provided a remote navigation training system (System 185 of FIG.18B), comprising: at least one processor (186); and at least one memory (187) including computer program code (189), the at least one memory (187) and the computer program code (189) configured to, with the at least one processor (186), cause the system (System 185) to: implement the method (200 and 210) as described herein with reference to FIG. 21. All operations and features as described herein with reference to FIG. 21 are likewise applicable to System 185 and have similar effects.

[0123] FIG. 22 shows the remote navigation training method transmitting video images (220). Step 221 comprises receiving a video image. The video image may be received by the virtual mirror driver. The video may be received through DirectX access via the video graphic card's driver, also known as a virtual mirror driver. The virtual mirror driver is a component that efficiently reads and processes video data from the graphics driver. The virtual mirror optimizes screen capture and data transmission by interacting directly with the display hardware or the operating system's graphics subsystem. Data transmission efficiency is enhanced over constrained network environments. The virtual mirror driver captures and transmits only the dynamic changes occurring on the screen, such as movement of windows or updates in content, rather than the entire screen repeatedly. Step 222 comprises computing a checksum of the received video image. Step 223 comprises determining whether the checksum of the received video image match the checksum of a previous video image. To detect changes in the screen content, the system calculates a checksum for the current video image and compares it with the checksum of the previously sent video image. A mismatch in checksums indicates a change in the screen content. Step 224 comprises sending the video image to the remote site if the checksum of the received video image does not match the checksum of the previous video image. Only frames with detected changes, i.e. mismatching checksums, are transmitted to the client. This selective capture method reduces the amount of data that needs to be transmitted, thereby decreasing network bandwidth usage and enhancing the responsiveness of remote site sessions. Refresh rates are based on availability and screen data are only transmitted when changes occur on the navigation simulator screen. This minimizes CPU and network resource usage, reducing lag and improving refresh rates compared to traditional video conferencing tools which typically transmit all video images. The method may use a fixed frame rate setting or an adaptive frame rate that automatically adjusts to maximize available bandwidth. In another embodiment, the video image may be divided into smaller zones and the method transmits only the smaller zones that have changed. This may potentially speed up data transmission and refresh rates. Maritime simulations are typically less bandwidth-intensive as video changes during navigation is gradual compared with video conferencing, for example. The remote navigation training system may incorporate a heartbeat mechanism to maintain a consistent connection check with the remote site and the simulator site. If video transmission stops due to a crash or shutdown, the cessation of the heartbeat indicates the remote site is down. This system addresses the challenges related to narrow bandwidth

environments in maritime training simulations and ensures efficient video data transmission and maintains system stability even under limited network conditions.

[0124] In another embodiment, there is provided a remote navigation training system (System 185 of FIG. 18B), comprising: at least one processor (186); and at least one memory (187) including computer program code (189), the at least one memory (187) and the computer program code (189) configured to, with the at least one processor (186), cause the system (System 185) to: implement the method (220) as disclosed herein with reference to FIG. 22. All operations and features as described herein with reference to FIG. 22 are likewise applicable to System 185 and have similar effects.

[0125] In an embodiment, there is provided a computer readable medium comprising instructions which when executed by a processor cause the processor to perform the simulator agnostic performance evaluation method as described above. The performance evaluation method provides a standardized method to assess student performance, minimizing the subjectivity associated with human assessors or instructors and ensuring consistency. Instructors may modify assessment parameters to align with specific training goals and environmental conditions, enhancing the relevance and applicability of assessments to real-world situations. The performance evaluation method/system is equipped to evaluate a broad spectrum of scenarios and parameters. The performance evaluation method/system is flexible and customizable adapting to specific training needs and environmental conditions, enhancing the relevance and effectiveness of assessments.

[0126] A detailed and complete assessment of user competency across various maritime operations may be provided as shown in the final assessment report (170). Data is continuously collected during simulation exercises and processed post-exercise to produce semi-real-time, detailed reports on user performance. A final assessment report (170) may be provided within five minutes from the completion of the simulation exercise, facilitating immediate feedback and continuous improvement. Regular maintenance schedules, including data archiving and performance checks, may manage data effectively and ensure system reliability.

[0127] The remote navigation training site may replicate the simulator site environment remotely with identical screens and two-way voice communication, as if the user were at the simulator site.

[0128] The remote navigation training system may replicate training exercises in sea areas available within the actual simulator. The remote navigation training system may be updated to increase the number of supported sea areas, thereby broadening training and assessment options.

[0129] The need for users to travel is reduced by enabling remote training sites anywhere with a stable internet and electrical supply, even onboard ships. This convenience lowers costs, reduces carbon emissions, and alleviates logistical concerns for students and employers. Remote training sites can be set up at a much lower cost than a traditional simulator site setup. Ordinary computing equipment may be used at the remote site, rather than full simulator equipment. As the remote navigation training system is more easily accessible than actual simulation sites, users' training requirements are met more frequently, improving their skills. Users can train for specific scenarios relevant to their

upcoming duties, such as training in simulated expected conditions, at a destination port offering practical and timely training. These simulated conditions may include weather, terrain, and/or traffic conditions. The remote navigation training system/method and the performance evaluation system/method allows for increased number of training sessions as travel reductions make more students available, improving the efficiency of the actual simulator and instructors' time, improving cost recovery for training providers.

[0130] The remote navigation training method/simulator may be compatible with existing maritime simulators, ensuring broad applicability and easing integration challenges. By delivering accurate, timely, and relevant assessments, the quality of maritime training is improved, leading to better-prepared seafarers and improved navigation safety.

[0131] The remote navigation training system/method operates independently of third-party services, using its own tailored solution and backend infrastructure. This integration ensures greater system reliability with fewer outages and eliminates the additional costs associated with third-party subscriptions.

[0132] Online surveys with shipping companies and associations were conducted, which yielded 179 responses to develop a baseline of common maritime practices, which reflects actual shipboard practices in Singapore waters. The survey covered key parameters that are crucial in maritime navigation, including vessel speed, CPA, UKC and near misses or dangerous passing incidents.

[0133] Real-world practices have been implemented as part of the assessment criteria. The incorporation of actual maritime practices ensures that the performance evaluation method/system provides a realistic and relevant evaluation of users' performance, closely mirroring the challenges they would encounter in actual navigational scenarios.

[0134] To validate the effectiveness and reliability of the embodiments as described above, the performance evaluation method/system was deployed at the Integrated Simulation Centre at the Singapore Maritime Academy (SMA). Fifteen Captains (instructors at SMA) utilized the performance evaluation method/system extensively during student training sessions. The engagement of these experienced maritime professionals has been crucial, as their practical insights and feedback have directly informed enhancements to the performance evaluation methods/system, ensuring alignment with real-world maritime operations. This rigorous validation process has involved over 100 students and has provided qualitative and quantitative data. Instructors reported improvement in training efficiency and student understanding. Specifically, the performance evaluation method/system has generated comprehensive assessment reports used to debrief students, significantly reducing penalty events and enhancing training outcomes.

[0135] Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical

quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0136] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “calculating”, “determining”, “generating”, “outputting”, or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0137] The present specification also discloses system for performing the operations of the methods. Such system may be specially constructed for the required purposes, or may comprise a general purpose computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other system. Various general purpose machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialised system to perform the required method steps may be appropriate. The structure of a conventional general purpose computer will appear from the description below.

[0138] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0139] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a general purpose computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a general-purpose computer effectively results in a system that implements the steps of the preferred method.

[0140] In an implementation, a server may be generally described as a physical device comprising at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the physical device to perform the requisite operations.

[0141] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The

present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

[0142] The term “comprising” as used in this specification and claims means “consisting at least in part of”. When interpreting each statement in this specification and claims that includes the term “comprising”, features other than that or those prefaced by the term may also be present. Related terms such as “comprise” and “comprises” are to be interpreted in the same manner.

[0143] As used herein the term “and/or” means “and” or “or”, or both.

[0144] While exemplary embodiments have been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist.

[0145] It should further be appreciated that the exemplary embodiments are only examples, and are not intended to limit the scope, applicability, operation, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements and method of operation described.

Claims

1. A simulator agnostic performance evaluation method for evaluating user performance of maritime simulator training, the method comprising:
 - extracting GPS position data for a user vessel and for a plurality of objects approached by the user vessel during the maritime simulator training, wherein the plurality of objects comprise at least one of a target vessel, a target navigational aid, and pilot boarding grounds;
 - assessing penalty points based on the extracted GPS position data and trainer selectable assessment criteria; and
 - generating a competence assessment report based on the penalty points.
2. The simulator agnostic performance evaluation method according to claim 1, wherein extracting GPS position data for the user vessel comprises extracting GPS positions for the user vessel at times during the maritime simulator training separated by a predetermined time interval.
3. The simulator agnostic performance evaluation method according to claim 2, wherein the predetermined time interval is 0.25 seconds or less.
4. The simulator agnostic performance evaluation method according to any one of claims 1 to 3, wherein assessing penalty points comprises assessing penalty points based further on under keel clearance (UKC) determined from the extracted GPS position data and trainer selectable UKC assessment criteria.
5. The simulator agnostic performance evaluation method according to claim 4, wherein the trainer selectable UKC assessment criteria comprises one or more of minimum UKC when making way in depth of water of more than two times draft of the user vessel, minimum UKC when making way in depth of water of less than two times draft of the user vessel, and minimum UKC when the user vessel is at anchor.
6. The simulator agnostic performance evaluation method according to any one of claims 1 to 5, wherein the plurality of objects comprise a target vessel and wherein the trainer selectable assessment criteria comprises a trainer selectable closest point of approach (CPA) assessment criteria, and wherein assessing penalty points comprises:
 - calculating a CPA between the user vessel and the target vessel during a passing manoeuvre by the user vessel; and
 - assessing penalty points if the CPA between the user vessel and the target vessel during the passing manoeuvre is less than the trainer selectable CPA assessment criteria.
7. The simulator agnostic performance evaluation method according to claim 6, wherein the trainer selectable CPA assessment criteria comprises one or more CPA assessment criteria based on traffic density and/or visibility.
8. The simulator agnostic performance evaluation method according to claim 6 or 7, wherein calculating the CPA between the user vessel and the target vessel during the passing manoeuvre comprises:
 - calculating all distances between each of multiple reference points for the user vessel and each of multiple reference points for the target vessel during the passing manoeuvre; and

identifying a lowest one of the calculated distances as the CPA between the user vessel and the target vessel during the passing manoeuvre.

9. The simulator agnostic performance evaluation method according to claim 8, wherein the multiple reference points for the user vessel are determined in response to at least one dimension of the user vessel, and wherein the multiple reference points for the target vessel are determined in response to at least one dimension of the target vessel.

10. The simulator agnostic performance evaluation method according to any one of claims 6 to 9, wherein the passing manoeuvre is one of passing manoeuvres comprising of passing ahead, passing astern, and passing side by side.

11. The simulator agnostic performance evaluation method according to any one of claims 1 to 10, wherein the plurality of objects comprise one or more target navigational aids and wherein the trainer selectable assessment criteria comprises a trainer selectable navigational aid assessment criteria, and wherein assessing penalty points comprises:

determining a nearest neighbour navigational aid of the one or more target navigational aids with respect to the user vessel;

calculating distances between the user vessel and the nearest neighbour navigational aid; and

assessing penalty points if one of the distances between the user vessel and the nearest neighbour navigational aid is less than the trainer selectable navigational aid assessment criteria.

12. The simulator agnostic performance evaluation method according to claim 11, wherein assessing penalty points further comprises:

determining if penalty points have been assessed for one of the distances between the user vessel and the nearest neighbour navigational aid being less than the trainer selectable navigational aid assessment criteria; and

assessing penalty points if penalty points have not been assessed for any of the distances between the user vessel and the nearest neighbour navigational aid being less than the trainer selectable navigational aid assessment criteria.

13. The simulator agnostic performance evaluation method according to claim 11 or 12, wherein determining the nearest neighbour navigational aid comprises determining the nearest neighbour navigational aid of the one or more target navigational aids with respect to the user vessel in accordance with a k-d tree algorithm.

14. The simulator agnostic performance evaluation method according to any one of claims 11 to 13, wherein the trainer selectable navigational aid assessment criteria comprises one or more navigational aid assessment criteria based on a minimum navigational aid passing distance.

15. The simulator agnostic performance evaluation method according to any one of claims 1 to 14, wherein the plurality of objects comprise one or more target vessels and the pilot boarding grounds and wherein the trainer selectable assessment criteria comprises a trainer selectable pilot boarding ground assessment criteria, and wherein assessing penalty points comprises:

determining whether an anchor chain of the user vessel is deployed within the pilot boarding grounds;

when the anchor chain of the user vessel is deployed within the pilot boarding grounds, determining nearest neighbour vessels of the one or more target vessels;

calculating distances between the user vessel and the nearest neighbour vessels; and

assessing penalty points if at least one of the distances between the user vessel and the nearest neighbour vessels is less than the trainer selectable pilot boarding ground assessment criteria.

16. The simulator agnostic performance evaluation method according to claim 15, wherein determining nearest neighbour vessels comprises determining nearest neighbour vessels of the one or more target vessels with respect to the user vessel in accordance with a k-d tree algorithm.

17. The simulator agnostic performance evaluation method according to claim 15 or 16, wherein assessing penalty points further comprises:

determining if penalty points have been assessed for one of the distances between the user vessel and the nearest neighbour vessels being less than the trainer selectable pilot boarding ground assessment criteria; and

assessing penalty points if penalty points have not been assessed for any of the distances between the user vessel and the nearest neighbour vessels being less than the trainer selectable pilot boarding ground assessment criteria.

18. The simulator agnostic performance evaluation method according to any one of claims 15 to 17, wherein the trainer selectable pilot boarding ground assessment criteria comprises one or more pilot boarding ground assessment criteria based on a user vessel distance to maintain from another vessel when waiting for a pilot at the pilot boarding grounds or embarking/disembarking a pilot at the pilot boarding grounds.

19. The simulator agnostic performance evaluation method according to claim 1 wherein the trainer selectable assessment criteria comprises a trainer selectable navigation signalling compliance criteria, wherein assessing penalty points comprises:

extracting data comprising at least one of visibility data, timing data, and vessel status data;

identifying environmental conditions comprising at least one of visibility condition, day/night condition and a navigational situation between the user vessel and the target vessel;

collecting navigation signalling data used by the user vessel;

assessing penalty points based on the extracted data, environmental conditions, navigation signalling data and the trainer selectable navigation signalling compliance criteria; and

generating a navigation signalling compliance assessment based on penalty points.

20. The simulator agnostic performance evaluation method according to claim 19, wherein the navigational situation is one of overtaking, head-on, give away, and crossing.

21. The simulator agnostic performance evaluation method according to claim 19 or 20, wherein the navigation signalling data comprises at least one of navigation lights, sound signals, and day shapes.

22. The simulator agnostic performance evaluation method according to claim 1, wherein the trainer selectable assessment criteria comprise a trainer selectable marine Very High Frequency (VHF) communication compliance criteria, assessing penalty points comprises:

- extracting audio input sent from the user vessel;
- assessing communication content by converting the audio input to text using automatic speech to recognition (ASR);

- checking a VHF channel selected by the user vessel;
- assessing penalty points based on the communication content, the VHF channel selected, and the trainer selectable marine VHF communication compliance criteria; and
- generating a VHF communication compliance assessment based on penalty points.

23. The simulator agnostic performance evaluation method according to claim 1, wherein the trainer selectable assessment criteria comprises a trainer selectable speed assessment criteria, assessing penalty points comprises:

- extracting a traffic density and/or visibility condition data;
- determining the trainer selectable speed assessment criteria based on the traffic density and/or visibility condition data;
- determining a speed of the user vessel based on the GPS position data;
- assessing penalty points if the speed of the user vessel is higher than the trainer selectable speed assessment criteria; and
- generating a speed management assessment based on penalty points.

24. The simulator agnostic performance evaluation method according to claim 23, wherein the traffic density is determined based on the number of vessels within a specified radial distance from the user vessel.

25. The simulator agnostic performance evaluation method according to any one of claims 1 to 24, wherein assessing the penalty points comprises assessing unsafe navigation penalty points, assessing near miss penalty points, assessing incorrect marine VHF communication, and/or assessing collision penalty points.

26. A remote navigation training method, comprising:

- establishing a network connection between a navigation simulator and a remote site;
- transmitting audio input and video images via the network connection between the navigation simulator and the remote site;
- receiving user control inputs from the remote site and sending the user control inputs to the navigation simulator; and
- evaluating a user performance of maritime simulator training via the simulator agnostic performance evaluation method according to any one of claims 1 to 25.

27. The remote navigation training method in accordance with claim 26, wherein the transmission of audio input comprises:

- obtaining the audio input from a sender site;
- predicting an audio sample based on the audio input;
- calculating a prediction error between the audio sample and the audio input;
- quantizing and encoding the prediction error;
- compressing the audio sample and the prediction error as a compressed audio data;

sending the compressed audio data to a receiver site via the network connection;
receiving the compressed audio data from the sender site;
decoding and dequantizing the compressed audio data;
reconstructing the audio input based on the audio sample and the prediction error; and
outputting the audio input at the receiver site.

28. The remote navigation training method according to claim 26 or 27, further comprising:
receiving a video image;
computing a checksum of the received video image;
sending the video image to the remote site if the checksum of the received video image
does not match the checksum of a previous video image.

29. A computer readable medium comprising instructions which when executed by a
processor cause the processor to perform the simulator agnostic performance evaluation method
according to any one of claims 1 to 25.

30. A performance evaluation system for evaluating user performance of maritime
simulator training comprising:
at least one processor; and
at least one memory including computer program code,
the at least one memory and the computer program code configured to, with the at
least one processor, cause the system at least to:
receive maritime simulator training data;
extract GPS position data for a user vessel and for a plurality of objects
approached by the user vessel during the maritime simulator training, wherein
the plurality of objects comprise at least one of a target vessel, a target
navigational aid, and pilot boarding grounds;
assess penalty points based on the extracted GPS position data and trainer
selectable assessment criteria; and
generate a competence assessment report based on the penalty points.

31. The performance evaluation system according to claim 30, wherein when extracting the
GPS position data for the user vessel, the system is caused to extract GPS positions for the user
vessel at times during the maritime simulator training separated by a predetermined time
interval.

32. The performance evaluation system according to claim 31, wherein the predetermined
time interval is 0.25 seconds or less.

33. The performance evaluation system according to any one of claims 30 to 32, wherein
when assessing penalty points, the system is caused to assess penalty points based further on
UKC determined from the extracted GPS position data and trainer selectable UKC assessment
criteria.

34. The performance evaluation system according to claim 33, wherein the trainer
selectable UKC assessment criteria comprises one or more of minimum UKC when making way
in depth of water of more than two times draft of the user vessel, minimum UKC when making

way in depth of water of less than two times draft of the user vessel, and minimum UKC when the user vessel is at anchor.

35. The performance evaluation system according to any one of claims 30 to 34, wherein the plurality of objects comprise a target vessel and wherein the trainer selectable assessment criteria comprises a trainer selectable CPA assessment criteria, and wherein when assessing penalty points, the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:

calculate a CPA between the user vessel and the target vessel during a passing manoeuvre by the user vessel; and

assess penalty points if the CPA between the user vessel and the target vessel during the passing manoeuvre is less than the trainer selectable CPA assessment criteria.

36. The performance evaluation system according to claim 35, wherein the trainer selectable CPA assessment criteria comprises one or more CPA assessment criteria based on traffic density and/or visibility.

37. The performance evaluation system according to claim 35 or 36, wherein when calculating the CPA between the user vessel and the target vessel during the passing manoeuvre, the system is caused to:

calculate all distances between each of multiple reference points for the user vessel and each of multiple reference points for the target vessel during the passing manoeuvre; and

identify a lowest one of the calculated distances as the CPA between the user vessel and the target vessel during the passing manoeuvre.

38. The performance evaluation system according to claim 37, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to determine the multiple reference points for the user vessel in response to at least one dimension of the user vessel, and determine the multiple reference points for the target vessel in response to at least one dimension of the target vessel.

39. The performance evaluation system according to any one of claims 35 to 38, wherein the passing manoeuvre is one of passing manoeuvres comprising of passing ahead, passing astern, and passing side by side.

40. The performance evaluation system according to any one of claims 30 to 39, wherein the plurality of objects comprise one or more target navigational aids and wherein the trainer selectable assessment criteria comprises a trainer selectable navigational aid assessment criteria, and wherein when assessing penalty points, the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:

determine a nearest neighbour navigational aid of the one or more target navigational aids with respect to the user vessel;

calculate distances between the user vessel and the nearest neighbour navigational aid; and

assess penalty points if one of the distances between the user vessel and the nearest neighbour navigational aid is less than the trainer selectable navigational aid assessment criteria.

41. The performance evaluation system according to claim 40, wherein when assessing penalty points, the system is further caused to:
- determine if penalty points have been assessed for one of the distances between the user vessel and the nearest neighbour navigational aid being less than the trainer selectable navigational aid assessment criteria; and
 - assess penalty points if penalty points have not been assessed for any of the distances between the user vessel and the nearest neighbour navigational aid being less than the trainer selectable navigational aid assessment criteria.
42. The performance evaluation system according to claim 40 or 41, wherein when determining the nearest neighbour navigational aid, the system is caused to determine the nearest neighbour navigational aid of the one or more target navigational aids with respect to the user vessel in accordance with a k-d tree algorithm.
43. The performance evaluation system according to any one of claims 40 to 42, wherein the trainer selectable navigational aid assessment criteria comprises one or more navigational aid assessment criteria based on a minimum navigational aid passing distance.
44. The performance evaluation system according to any one of claims 30 to 43, wherein the plurality of objects comprise one or more target vessels and the pilot boarding grounds and wherein the trainer selectable assessment criteria comprises a trainer selectable pilot boarding ground assessment criteria, and wherein when assessing penalty points, the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:
- determine whether an anchor chain of the user vessel is deployed within the pilot boarding grounds;
 - when the anchor chain of the user vessel is deployed within the pilot boarding grounds, determine nearest neighbour vessels of the one or more target vessels;
 - calculate distances between the user vessel and the nearest neighbour vessels; and
 - assess penalty points if at least one of the distances between the user vessel and the nearest neighbour vessels is less than the trainer selectable pilot boarding ground assessment criteria.
45. The performance evaluation system according to claim 44, wherein when determining nearest neighbour vessels, the system is caused to determine the nearest neighbour vessels of the one or more target vessels with respect to the user vessel in accordance with a k-d tree algorithm.
46. The performance evaluation system according to claim 44 or 45, wherein when assessing penalty points, the system is further caused to:
- determine if penalty points have been assessed for one of the distances between the user vessel and the nearest neighbour vessels being less than the trainer selectable pilot boarding ground assessment criteria; and
 - assess penalty points if penalty points have not been assessed for any of the distances between the user vessel and the nearest neighbour vessels being less than the trainer selectable pilot boarding ground assessment criteria.

47. The performance evaluation system according to any one of claims 44 to 46, wherein the trainer selectable pilot boarding ground assessment criteria comprises one or more pilot boarding ground assessment criteria based on a user vessel distance to maintain from another vessel when waiting for a pilot at the pilot boarding grounds or embarking/disembarking a pilot at the pilot boarding grounds.
48. The performance evaluation system according to claim 30, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:
- extract data comprising at least one of visibility data, timing data, and vessel status data;
 - identify environmental conditions comprising at least one of visibility condition, day/night condition and a navigational situation between the user vessel and the target vessel;
 - collect navigation signalling data used by the user vessel;
 - assess penalty points based on the extracted data, environmental conditions, navigation signalling data and the trainer selectable navigation signalling compliance criteria; and
 - generate a navigation signalling compliance assessment based on penalty points.
49. The performance evaluation system according to claim 48, wherein the navigational situation is one of overtaking, head-on, give away, and crossing.
50. The performance evaluation system according to claim 48 or 49, wherein the navigation signalling data comprises at least one of navigation lights, sound signals, and day shapes.
51. The performance evaluation system according to claim 30, wherein the trainer selectable assessment criteria comprise a trainer selectable marine VHF communication compliance criteria, wherein when assessing penalty points, the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:
- extract audio input sent from a user vessel;
 - assess communication content by converting the audio input to text using ASR;
 - check a VHF channel selected by the user vessel;
 - assess penalty points based on the communication content, the VHF channel selected, and the trainer selectable marine VHF communication compliance criteria; and
 - generate a VHF communication compliance assessment based on penalty points.
52. The performance evaluation system according to claim 30, wherein the trainer selectable assessment criteria comprises a trainer selectable speed assessment criteria, wherein when assessing penalty points, the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:
- extract a traffic density and/or visibility condition data;
 - determine the trainer selectable speed assessment criteria based on the traffic density and/or visibility condition data;
 - determine a speed of the user vessel based on the GPS position data;
 - assess penalty points if the speed of the user vessel is higher than the trainer selectable speed assessment criteria; and
 - generate a speed management assessment based on penalty points.

53. The performance evaluation system according to claim 52, wherein the traffic density is determined based on the number of vessels within a specified radial distance from the user vessel.
54. The performance evaluation system according to any one of claims 30 to 53, wherein when assessing the penalty points, the system is caused to assess unsafe navigation penalty points, assess near miss penalty points, assess incorrect marine VHF communication, and/or assess collision penalty points.
55. A remote navigation training system, comprising:
at least one processor; and
at least one memory including computer program code,
the at least one memory and the computer program code configured to, with the at least one processor, cause the system to:
establish a network connection between a navigation simulator and a remote site;
transmit audio input and video images via the network connection between the navigation simulator site and the remote site;
receive user control inputs from the remote site and send the user control inputs to the navigation simulator; and
evaluate a user performance of maritime simulator training via the performance evaluation system according to any one of claims 30 to 54.
56. The remote navigation training system of claim 55, wherein when transmitting the audio input, the at least one memory and the computer program code are configured to, with the at least one processor, cause the system to:
obtain the audio input from a sender site;
predict an audio sample based on the audio input;
calculate a prediction error between the audio sample and the audio input;
quantize and encode the prediction error;
compress the audio sample and the prediction error as a compressed audio data;
send the compressed audio data to a receiver site via the network connection;
receive the compressed audio data from the sender site;
decode and dequantize the compressed audio data;
reconstruct the audio input based on the audio sample and the prediction error; and
output the audio input at the receiver site.
57. The remote navigation training system according to claim 55 or 56, wherein the system is further caused to:
receive a video image;
compute a checksum of the received video image;
send the video image to the remote site if the checksum of the received video image does not match the checksum of a previous video image.