

VISUALIZATION SYSTEM AND SUSPENSION STATE DETECTION SET

BACKGROUND

[0001] Field

[0002] The present invention relates to a visualization system that visualizes a state of a suspended load during a lifting operation in a virtual space, and a suspended load state detection set for the visualization system.

[0003] Description of Related Art

[0004] Japanese Laid-Open Patent Publication No. 2014-131940 discloses a suspended object turning device that turns an object suspended by wires to determine the position of the suspended object in a turning direction. In this suspended object turning device, a gimbal shaft that tiltably supports a flywheel is integrated with a gimbal frame that rotatably supports the flywheel. The suspended object turning device turns the suspended object using a gyro effect generated when the flywheel is tilted while rotating about a center axis.

[0005] When landing the suspended object on an unloading location, an operator needs to operate the suspended object turning device. Further, a slinger may guide the suspended object to a target location using a guide rope attached to the suspended object. In this manner, as disclosed in Japanese Laid-Open Patent Publication No. 2023-156107, it takes time and labor to unload a suspended object.

[0006] Accordingly, Japanese Laid-Open Patent Publication No. 2023-156107 discloses a lifting support system that includes a controller connected to a suspended object turning device that suspends an object. The controller obtains positioning information from each of a plurality of positioning devices mounted at different locations on the suspended object turning device. The controller uses the positioning information to identify the present

position of the suspended object turning device, and instructs turning of the suspended object turning device in accordance with the present position and a landing direction of the suspended object.

SUMMARY

[0007] During a lifting operation using a crane or the like, there may be a case in which only some workers can check the state of a suspended load at a construction site. For example, if the suspended load is in a blind spot of an operator of the crane or the like, the operator cannot check the state of the suspended load.

[0008] In such a situation in which only a limited number of persons can monitor the suspended load, a dangerous state of the suspended load may be overlooked. There is a need for an environment where the work can be performed more safely.

[0009] An objective of the present invention is to provide a visualization system that allows for sharing of a work status by reflecting a state of a suspended load during a lifting operation in a virtual space in order to ensure an environment where a work can be performed more safely.

[0010] In the present invention, a visualization system is for visualizing a state of a suspended load during a lifting operation in a virtual space. The visualization system includes a controller, an orientation detector, and a shape obtainer. The controller is configured to control the virtual space. The orientation detector is configured to detect an orientation of the suspended load. The shape obtainer is configured to obtain a shape of the suspended load. The orientation detector detects the orientation of the suspended load by detecting an orientation of a specific direction of the suspended load shape. The controller performs a suspended load state reflecting process that reflects the state of the suspended

load in a virtual suspended load in the virtual space. The virtual suspended load corresponds to the suspended load. In response to a change in the orientation of the specific direction, the suspended load state reflecting process reflects the change in the orientation of the specific direction in a displayed shape of the virtual suspended load in the virtual space by changing a virtual orientation of a virtual specific direction of the virtual suspended load to conform to the orientation of the specific direction. The virtual specific direction corresponds to the specific direction.

[0011] In the present invention, a suspended load state detection set is for reflecting a state of a suspended load during a lifting operation in a virtual space. The set includes a positioning device and a shape detection device. The positioning device is arranged on a lifting beam or the suspended load and is configured to detect a position and an orientation of the suspended load. The shape detection device is arranged at a position allowing for detection of a shape of the suspended load.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a diagram illustrating a visualization system in accordance with a first embodiment.

[0013] Fig. 2 is a diagram illustrating a crane and its related portions in accordance with the first embodiment.

[0014] Fig. 3 is a diagram of a portion encircled by the dotted line shown in Fig. 2 as viewed in the direction of the arrow in Fig. 2.

[0015] Fig. 4 is a diagram showing a hardware configuration of a site terminal in accordance with the first embodiment.

[0016] Fig. 5 is a diagram illustrating setting inputs on a display in accordance with the

first embodiment.

[0017] Fig. 6 is a diagram illustrating a suspended load state detection set in accordance with a second embodiment.

[0018] Fig. 7 is a perspective view of a suspended load state detection set in accordance with a third embodiment.

[0019] Fig. 8 is a side view of the suspended load detection set in accordance with the third embodiment.

DETAILED DESCRIPTION

[0020] Modes (hereafter referred to as embodiments) in accordance with the present invention will now be described in detail with reference to the accompanying drawings.

[0021] Same reference numerals or reference characters are given to those elements that are the same throughout the description of the embodiments.

[0022] A visualization system 1 in accordance with a first embodiment will be described with reference to Figs. 1 to 5.

[0023] Fig. 1 is a diagram illustrating the visualization system 1 in accordance with the first embodiment.

[0024] In Fig. 1, reference numerals and reference characters related to a crane 2 are mostly omitted to facilitate illustration. Refer to Fig. 2 for the reference numerals and reference characters of the crane 2.

[0025] Fig. 2 is a diagram illustrating the crane 2 and its related portions in accordance with the first embodiment.

[0026] The crane 2 shown in Fig. 2 also includes a structure for suspending a suspended load SL.

[0027] In Fig. 2, reference numerals and reference characters related to the structure including the suspended load SL are mostly omitted. Refer to Fig. 3 for the reference numerals and reference characters of the structure including the suspended load SL.

[0028] Fig. 3 is a diagram of a portion encircled by the dotted line shown in Fig. 2 as viewed in the direction of the arrow in Fig. 2

[0029] When a lifting operation is performed using the crane 2 or the like at a construction site CS, the visualization system 1 visualizes the state of the suspended load SL in a virtual space to allow for sharing of the status of the lifting operation. This enables more appropriate risk predictions.

[0030] In the present embodiment, a crawler type crane is used as the crane 2. Alternatively, the crane may be a hall type crane, a non-moving jib crane, or the like.

[0031] As shown in Fig. 1, the visualization system 1 of the present embodiment includes a site terminal 3, a remote terminal 4, a design terminal 5, a suspended load detection set 6 (refer to Fig. 3), and a cloud server 7. The site terminal 3 is used by an operator or the like. The remote terminal 4 is used by a construction worker or the like in a monitoring center MC or the like. The design terminal 5 is arranged in a design room DO or the like. The suspended load state detection set 6 is used for reflecting the state of the suspended load SL during a lifting operation (refer to Figs. 2 and 3) in a virtual space. The cloud server 7 reproduces the status of a construction site in the virtual space.

[0032] The crane 2 (communication unit 23C, described later), the site terminal 3, the remote terminal 4, the design terminal 5, and the cloud server 7 are connected to one another via the Internet IN in a manner allowing for communication, which will be described later.

[0033] Also, the crane 2 is connected to the site terminal 3 in a manner allowing for communication without the Internet IN.

[0034] As shown in Fig. 2, the crane 2 includes a main body 21, an actuator 22, an operation detector 23, and a construction status detector 24. The actuator 22 includes an arm 22A arranged on the main body 21 in a manner allowing for raising and lowering. The operation detector 23 detects an overall operation state of the crane 2. The construction status detector 24 detects the status of a construction subject corresponding to construction progress.

[0035] The main body 21 includes a crawler type traveling body 21A and a turning body 21B. The turning body 21B is arranged on the traveling body 21A with a turner in between in a manner allowing for turning. The turning body 21B includes an operator compartment or the like.

[0036] The actuator 22 is a portion operated to transfer (lift) construction materials or the like. The actuator 22 includes the above-described arm 22A and a hook 22B arranged at a distal end of the arm 22A in a manner allowing for vertical movement. The arm 22A has a basal end connected to the turning body 21B in a manner allowing for raising and lowering of the arm 22A with respect to the turning body 21B.

[0037] In the present embodiment, the arm 22A only includes a boom. However, there is no limitation to such a structure, and the arm 22A may include a jib having a basal end connected to the distal end of the boom in a manner allowing for raising and lowering.

[0038] The hook 22B is connected to a wire rope WR1 extending from a winch (not shown) disposed at a rear part of the turning body 21B. The hook 22B is configured to be moved vertically at the distal end of the arm 22A in accordance with winding up or down of the wire rope WR1 by the winch.

[0039] Hereinafter, a side of the turning body 21B facing the arm 22A with respect to a turning center of the turning body 21B will be referred to as the front of the turning body

21B, and a side of the turning body 21B opposite to the arm 22A with respect to the turning center will be referred to as the rear of the turning body 21B. The turning body 21B is oriented in a direction extending from the rear to the front of the turning body 21B.

[0040] The operation detector 23 includes a pair of global navigation satellite system (GNSS) receivers 23A, a tilt sensor 23B, a communication unit 23C. The GNSS receivers 23A are arranged at a rear part of the turning body 21B. The GNSS receivers 23A are configured to detect the position of the main body 21, the orientation of the turning body 21B, or the like. The tilt sensor 23B is configured to detect tilting of the arm 22A. The communication unit 23C is configured to receive detection results from the GNSS receivers 23A and the tilt sensor 23B, and transmit the detection results to the cloud server 7.

[0041] In the present embodiment, the GNSS receivers 23A and the tilt sensor 23B have a functionality of performing wireless communication through Wi-Fi[®] or the like. Alternatively, the GNSS receivers 23A and the tilt sensor 23B may have a functionality of performing wired communication as long as detection results can be transmitted to the communication unit 23C.

[0042] In the present embodiment, the GNSS receivers 23A and the tilt sensor 23B are configured to be connected to a power supply by power cables. Alternatively, the GNSS receivers 23A and the tilt sensor 23B may each include a built-in rechargeable battery (battery).

[0043] Preferably, the GNSS receivers 23A and the tilt sensor 23B are connected by power cables to a power supply included in the crane 2, so that these devices do not have to be charged separately.

[0044] At the rear part of the turning body 21B, the left and right GNSS receivers 23A are separated from each other in a left-right direction with respect to a front-rear axis of the

turning body 21B. The two GNSS receivers 23A are separated from the front-rear axis by substantially the same distance.

[0045] The front-rear axis of the turning body 21B refers to an axis extending from the rear to the front of the turning body 21B through the turning center of the turning body 21B. The left-right direction is a horizontal direction of the turning body 21B that is orthogonal to the front-rear axis. Hereinafter, the right side of the turning body 21B as viewed from the rear toward the front of the turning body 21B will be referred to as the right side (or, the right) of the turning body 21B, and the left side in this case will be referred to as the left side (or, the left) of the turning body 21B.

[0046] Fig. 2 shows the crane 2 as viewed from the right side of the turning body 21B, and thus only the GNSS receiver 23A on the right side can be seen. However, another GNSS receiver 23A is also arranged on the left side of the turning body 21B, overlapping the GNSS receiver 23A on the right side in a direction extending toward the far side when viewing the drawing.

[0047] The left and right GNSS receivers 23A are each fixed on an installation mount. The GNSS receivers 23A are arranged on the turning body 21B in a detachable manner by a magnetic force of a magnet disposed on the bottom of the mount. In this manner, the GNSS receivers 23A may be readily mounted on a crane that does not include the GNSS receivers 23A.

[0048] The left and right GNSS receivers 23A each detect latitude, longitude, and altitude. These detection results may be used to calculate a direction extending from the left GNSS receiver 23A to the right GNSS receiver 23A, thereby obtaining the orientation of the turning body 21B. For example, the direction extending from the left GNSS receiver 23A to the right GNSS receiver 23A is rotated by 90 degrees counterclockwise about a middle point between

the left and right GNSS receivers 23A. Such a direction is a direction in which the front part of the turning body 21B, facing the arm 22A, is positioned with respect to the middle point.

[0049] Once the left and right GNSS receivers 23A are mounted, the positional relationship between the left and right GNSS receivers 23A and the basal end of the arm 22A (part connected to the turning body 21B) does not change.

[0050] Accordingly, the position of the basal end of the arm 22A can be calculated based on the detection results of the positions of the left and right GNSS receivers 23A as long as the positional relationship between the left and right GNSS receivers 23A and the basal end of the arm 22A when the left and right GNSS receivers 23A are mounted is obtained in advance.

[0051] Therefore, a base point of raising/lowering motions of the arm 22A (part connected to the turning body 21B) may be obtained from the detection results of the position and the orientation from the left and right GNSS receivers 23A.

[0052] In actuality, the mounting positions of the GNSS receivers are determined in advance for each model of the crane 2, and the detection results are reflected in the virtual space as if the detections are performed at the same mounting positions on a virtual crane VR2 (described later) in the cloud server 7.

[0053] The mounting positions do not have to be determined in advance. The GNSS receivers may be mounted on arbitrary positions, and then detection positions corresponding to the mounting positions may be set on the virtual crane VR2 in the cloud server 7.

[0054] Furthermore, the latitudes and longitudes obtained by the left and right GNSS receivers 23A may be used to detect the position of the crane 2, and changes in the latitudes and longitudes may be used to detect the movement of the crane 2.

[0055] The detection results (datasets) of the position and the orientation from the left and

right GNSS receivers 23A are transmitted from the communication unit 23C to the cloud server 7 via the Internet IN.

[0056] This allows the cloud server 7 to obtain the base point of raising/lowering motions of the arm 22A, the directions of raising/lowering motions of the arm 22A, and the position and moving state of the crane 2.

[0057] The tilt sensor 23B is arranged on the arm 22A in a detachable manner by a belt, a tape, or the like. The tilt sensor 23B detects an inclination angle (tilt angle) of the arm 22A.

[0058] In this manner, the tilt sensor 23B may be readily mounted on a crane that does not include the tilt sensor 23B.

[0059] The length of the arm 22A is known, and the base point of raising/lowering motions of the arm 22A and a direction in which the arm 22A is oriented (orientation of the turning body 21B) are obtained as described above. Therefore, a direction and a mode in which the arm 22A extends with reference to the base point of raising/lowering motions of the arm 22A can be calculated from the detection result (tilt angle) obtained by the tilt sensor 23B.

[0060] Furthermore, in a case in which the arm 22A includes a jib having a basal end connected to the distal end of the boom in a manner allowing for raising and lowering, the tilt sensor 23B may also be arranged on the jib to obtain a mode in which the arm 22A, having the boom and the jib, extends forward.

[0061] Specifically, since the part of the boom connected to the basal end of the jib is known, the basal end of the jib (base point of raising/lowering motions) can be obtained from the base point of raising/lowering motions of the arm 22A and the tilt angle of the boom. In addition, since the length of the jib is known, a mode in which the jib extends forward can be obtained from the tilt angle of the jib, in the same manner as the boom.

[0062] The detection result (dataset) of the tilt angle from the tilt sensor 23B is transmitted from the communication unit 23C to the cloud server 7 via the Internet IN.

[0063] This allows the cloud server 7 to obtain a mode in which the arm 22A extends forward, in other words, a mode in which the arm 22A moves, with reference to the base point of raising/lowering motions of the arm 22A.

[0064] In the present embodiment, a gyroscope (not shown) is also provided in a control box (not shown) that accommodates a control panel (not shown) of the crane 2 installed near the operator compartment of the turning body 21B. The gyroscope allows for detection of an inclination of the entire crane 2.

[0065] Thus, the tilt angle detected by the tilt sensor 23B can be corrected taking into consideration the inclination of the entire crane 2. A dataset indicating the inclination angle of the entire crane 2 detected by the gyroscope (not shown) is also transmitted from the communication unit 23C to the cloud server 7 via the Internet IN.

[0066] This allows the cloud server 7 to recognize the movement of the arm 22A taking into consideration the inclination of the entire crane 2.

[0067] The communication unit 23C is a communication interface that performs communication with the GNSS receivers 23A, the tilt sensor 23B, and the construction status detector 24 (e.g., wireless or wired communication), communication with the site terminal 3 (e.g., wireless communication), and communication with the suspended load state detection set 6 (e.g., wireless or wired communication), as well as communication via the Internet IN.

[0068] As described above, the communication unit 23C receives detection results (datasets) from the GNSS receivers 23A, the tilt sensor 23B, and the construction status detector 24, and transmits the detection results to the cloud server 7.

[0069] Further, the communication unit 23C receives from the suspended load state

detection set 6 a detection result (dataset), which is obtained for reflecting the state of the suspended load SL during a lifting operation in the virtual space, and transmits the detection result to the cloud server 7.

[0070] When the cloud server 7 receives the datasets from the communication unit 23C, the virtual space is controlled based on the received datasets in a following manner.

[0071] As shown in Fig. 2, in the present embodiment, the construction status detector 24 is a 3D-LiDAR (light detection and ranging) sensor arranged at the distal end of the arm 22A. The construction status detector 24 obtains structures in a construction subject as three-dimensional point cloud data.

[0072] In the present embodiment, the construction status detector 24 is arranged at the distal end of the arm 22A. However, the construction status detector 24 does not have to be disposed at the distal end of the arm 22A as long as the construction status detector 24 captures installation of a frame body, such as a beam, a column, or the like, in accordance with the construction progress.

[0073] The distal end of the arm 22A is a suitable location for arrangement of the construction status detector 24 since installation of a frame body or the like will be readily captured.

[0074] In the present embodiment, the 3D-LiDAR sensor has a functionality of performing wireless communication through Wi-Fi® or the like. Alternatively, the 3D-LiDAR sensor may have a functionality of performing wired communication as long as a detection result can be transmitted to the communication unit 23C.

[0075] In the present embodiment, the 3D-LiDAR sensor is configured to be connected to a power supply by a power cable. Alternatively, the 3D-LiDAR sensor may include a built-in rechargeable battery (battery).

[0076] Preferably, the 3D-LiDAR sensor is connected by a power cable to a power supply included in the crane 2, so that the 3D-LiDAR sensor does not have to be charged separately.

[0077] When a frame body, such as a beam, a column, or the like, is installed in accordance with the construction progress, the 3D-LiDAR sensor obtains point cloud data. The point cloud data is a detection result (dataset) obtained by detecting the status of the construction subject corresponding to the construction progress. The point cloud data is transmitted via the communication unit 23C to the cloud server 7.

[0078] In a case in which the 3D-LiDAR sensor is arranged at the distal end of the arm 22A of the crane 2, the three-dimensional point cloud data by the 3D-LiDAR sensor, which is defined by X, Y, and Z coordinates, are converted into latitudes, longitudes, and altitudes based on the position (latitude, longitude, and altitude) of the distal end of the arm 22A of the crane 2 to recognize the position (latitude, longitude, and altitude) where a structure is formed in accordance with the construction progress.

[0079] The position of the distal end of the arm 22A of the crane 2 may be obtained from the base point of raising/lowering motions of the arm 22A, the tilt angle of the arm 22A, the length of the arm 22A, and the direction in which the arm 22A is oriented.

[0080] The length of the arm 22A is known, and the base point of raising/lowering motions of the arm 22A, the tilt angle of the arm 22A, and the direction in which the arm 22A is oriented are detected by the GNSS receivers 23A and the tilt sensor 23B as described above. These detection results are transmitted to the cloud server 7 and shared in the cloud server 7.

[0081] This allows the cloud server 7 to convert the three-dimensional point cloud data by the 3D-LiDAR sensor defined by X, Y, and Z coordinates into latitudes, longitudes, and altitudes, and recognize the status of the construction subject corresponding to the

construction progress, such as the position and the height at which a structure is formed.

[0082] The site terminal 3 includes a tablet terminal that can be carried into the operator compartment of the crane 2 and used by the operator of the crane 2.

[0083] There may be more than one site terminal 3 for construction workers other than the operator.

[0084] Specifically, the site terminal 3 is a terminal capable of displaying an image of the virtual space in which the state of the suspended load SL during a lifting operation is reflected. For example, when the suspended load SL is in a blind spot of the operator, the operator can use the site terminal 3 to check the state of the suspended load SL in a preferred manner.

[0085] Fig. 4 is a diagram showing a hardware configuration of the site terminal 3 in accordance with the first embodiment.

[0086] As shown in Fig. 4, the site terminal 3 includes a central processing unit (CPU) 31, random-access memory (RAM) 32, read-only memory (ROM) 33, a display 34, and a communication unit 35, which are connected via a bus 36 in a manner accessible to one another.

[0087] An integrated circuit or the like may be used instead of the CPU 31, RAM 32, and ROM 33.

[0088] The CPU 31 is a central processing unit that deploys programs stored in the ROM 33 to the RAM 32, and executes various types of control and arithmetic processing according to the programs.

[0089] The RAM 32 is a volatile memory that temporarily stores various types of data, calculation results by the CPU 31, or the like.

[0090] The ROM 33 is a non-volatile memory that stores programs or the like (e.g.,

application for the visualization system 1 of the present embodiment).

[0091] The display 34 is a touch panel type display device capable of responding to various setting inputs.

[0092] In addition to the functionality of showing the image of the virtual space, the display 34 may be used to determine settings for using the visualization system 1, which will be described below.

[0093] The settings for using the visualization system 1 will now be described with reference to Fig. 5.

[0094] Fig. 5 is a diagram illustrating setting inputs on the display 34 in accordance with the first embodiment.

[0095] When the display 34 is touched and an application for the visualization system 1 is activated, the display 34 establishes communication connection with the cloud server 7 and shows an input window 341.

[0096] The input window 341 is provided with buttons (“Model”, “Site”, “Load”, or the like) selectable by a touch operation.

[0097] When “Site” button is selected by a touch operation, for example, a setting window 341A, such as that in the dotted balloon, is shown on the display 34 for setting of the site of a construction work.

[0098] Then, when the name or the like of a construction work is selected from a drop-down list and “End” button is touched, an image of the virtual space that reproduces the construction site corresponding to the selected name is shown on the display 34.

[0099] Specifically, the selected name is transmitted from the communication unit 35 to the cloud server 7, and upon receipt of the name, the cloud server 7 starts transmitting to the site terminal 3 the image of the virtual space of the construction site corresponding to the

received name.

[0100] Then, the communication unit 35 receives the image of the virtual space transmitted from the cloud server 7, and the received image of the virtual space is shown on the display 34 of the site terminal 3.

[0101] When “Model” button is selected by a touch operation, a setting window 341B, such as that in the dotted balloon, is shown on the display 34 for setting of the model of the crane 2.

[0102] The crane 2 is recognized by a recognized crane reflecting process. When a controller (not shown) of the crane 2 is activated, detection results of the GNSS receivers 23A and the tilt sensor 23B are transmitted from the communication unit 23C to the cloud server 7. Upon receipt of the detection results, the cloud server 7 reflects the detection results so that the virtual crane VR2 corresponding to the recognized crane 2 is displayed in the virtual space in accordance with the position, orientation, or the like of the crane 2.

[0103] After activation of the application for the visualization system 1, “UN” is shown for the virtual crane VR2 of which “Model” has not been selected. The graphical representation of “UN” may be touched with a finger F, and “Model” of the crane 2, which corresponds to the virtual crane VR2, may be selected from a drop-down list shown in the setting window 341B. When “End” is touched to complete this setting, “UN” is no longer shown.

[0104] The information of the selected “Model” is transmitted from the communication unit 35 to the cloud server 7 together with pixel coordinates (coordinates of pixels constituting the screen of the display 34) of the touched virtual crane VR2 on the display 34.

[0105] Upon receipt of the pixel coordinates and the “Model” information, the cloud server 7 determines that the virtual crane VR2 in the image of the virtual space located at a

position corresponding to the received pixel coordinates of the display 34 is touched, and performs a crane information reflecting process that reflects (applies) the information of the type of the crane 2 selected by “Model” in the selected virtual crane VR2.

[0106] Specifically, a database DB, which will be described later, stores information (datasets) on the actual sizes of the main body 21, the arm 22A, and the like in association with “Model”. The crane information reflecting process reflects (applies) the actual size of the main body 21, the arm 22A, and the like in the virtual crane VR2.

[0107] When “Load” button is selected by a touch operation, a setting window 341C, such as that in the dotted balloon, is shown on the display 34 for setting of the type of the suspended load SL.

[0108] The type of materials for the frame bodies, such as beams, columns, or the like, are decided at the designing stage of a construction work. Accordingly, a drop-down menu that shows a list of materials is prepared in advance.

[0109] The material to be lifted may be selected from a drop-down list, and the virtual crane VR2 corresponding to the crane 2 that lifts the material may be touched. When this setting is ended, the information of the selected “Material” is transmitted together with the pixel coordinates (coordinates of the pixels constituting the screen of the display 34) of the touched virtual crane VR2 on the display 34.

[0110] Upon receipt of the pixel coordinates and the “Material” information, the cloud server 7 determines that the virtual crane VR2 in the image of the virtual space located at a position corresponding to the received pixel coordinates of the display 34 is touched, and recognizes that the crane 2 corresponding to the virtual crane VR2 starts a lifting operation of the material selected by “Load”.

[0111] In the present embodiment, the material to be lifted is selected using the setting

window 341C for setting of the type of the suspended load SL. Alternatively, for example, a camera that captures an image of the suspended load SL may be arranged, and the type of the material to be lifted may be automatically identified through image recognition based on a feature, such as a shape. In this manner, the information of the suspended load may be set without using the setting window 341C.

[0112] When “End” is touched, the setting window 341A, the setting window 341B, or the setting window 341C are no longer shown on the display 34.

[0113] The communication unit 35 is a wireless communication interface that performs communication with an external device or the like.

[0114] As described above, the communication unit 35 transmits the settings or the like determined by operations performed on the display 34 to the cloud server 7 via the Internet IN, and receives the image of the virtual space transmitted from the cloud server 7.

[0115] The remote terminal 4 is a terminal used by a construction worker or the like at a location remote from the construction site CS, such as a monitoring center MC, to share the status of a lifting operation. Accordingly, the remote terminal 4 includes a display 41 (e.g., a monitor) that shows the image of the virtual space.

[0116] Fig. 1 shows a case in which a personal computer is used as the remote terminal 4. However, the remote terminal 4 may be a terminal with only the display 41.

[0117] Basically, the hardware configuration of the remote terminal 4 is similar to that of the site terminal 3 and thus will not be described in detail.

[0118] The design terminal 5 is a terminal for designing a construction subject, specifically, a terminal for constructing a three-dimensional model of a construction subject in a completed state (e.g., building information modeling (BIM)/construction information modeling, management (CIM)).

[0119] In the present embodiment, a three-dimensional model of the construction subject in a completed state that is combined with three-dimensional map data (also referred to as “three-dimensional construction site model”) is transmitted to the cloud server 7 via the Internet IN, and is stored in the database DB.

[0120] The three-dimensional construction site model is assigned with a construction name or the like, and this name is included in the drop-down list displayed in the above-described input window 341.

[0121] When a name is selected from the list displayed in the input window 341 and “End” is touched, based on the selected name, an image of the virtual space of the three-dimensional construction site model is read by the cloud server 7 and shown on the display 34.

[0122] The database DB also stores the most recent three-dimensional construction site model reflecting the construction progress. In this case, when a name is selected from the list displayed in the input window 341 and “End” is touched, based on the selected name, the cloud server 7 reads the most recent three-dimensional construction site model from the database DB. Thus, the display 34 shows the image of the virtual space reflecting the construction progress.

[0123] The three-dimensional map data and the three-dimensional model do not have to be combined by the design terminal 5.

[0124] For example, the site terminal 3 may obtain three-dimensional map data (also referred to as 3D map data) including the periphery of a construction site from a map information providing service (e.g., Google Maps[®]) on the Web, and transmit the three-dimensional map data to the cloud server 7 for composition.

[0125] In the present embodiment, when constructing a three-dimensional model of a

construction subject in a completed state with the design terminal 5, the design terminal 5 transmits three-dimensional shape data of the materials to be used and the “Material” information to the cloud server 7 via the Internet IN. The cloud server 7 stores the received three-dimensional shape data of the materials and the “Material” information in the database DB in association with each other.

[0126] The “Material” information includes, for example, an identifier, such as a product number or the like assigned to the material for identification. In the present embodiment, such an identifier is used for association with the three-dimensional shape data of the material.

[0127] Specifically, the identifier is used as a file name of the stored three-dimensional shape data of the material. Accordingly, the three-dimensional shape data for the suspended load SL corresponding to the “Material” information may be retrieve by reading the data having the same file name as the “Material” information (identifier).

[0128] Therefore, when the cloud server 7 receives the “Material” information, which is selected with the site terminal 3 in advance and transmitted to the cloud server 7, the cloud server 7 can obtain the shape of the suspended load SL based on the “Material” information.

[0129] The suspended load state detection set 6 will now be described with reference to Fig. 3.

[0130] As shown in Fig. 3, the suspended load state detection set 6 includes a lifting beam 61 and an orientation detector 62. The orientation detector 62 is arranged on the lifting beam 61 in a detachable manner and detects the orientation of the suspended load SL.

[0131] The lifting beam 61 includes a rod-shaped lifting beam main body 61A, a hook-side lifting bail 61B, and a pair of suspended load-side lifting bails 61C. The hook-side lifting bail 61B is located at a longitudinal center of the lifting beam main body 61A at a side

facing the hook 22B. The suspended load-side lifting bails 61C are located at opposite sides of the longitudinal center of the lifting beam main body 61A at a side facing the suspended load SL. The suspended load-side lifting bails 61C are separated from the longitudinal center of the lifting beam main body 61A by substantially the same distance.

[0132] In the present embodiment, the hook 22B is connected to the hook-side lifting bail 61B via a load cell LC that measures weights. Alternatively, the hook 22B may be directly connected to the hook-side lifting bail 61B.

[0133] The orientation detector 62 includes a pair of GNSS receivers 62A (also referred to as positioning devices) and a pair of mounts 62B. At the side of the lifting beam main body 61A facing the hook 22B, the two GNSS receivers 62A are arranged at opposite sides of the center (suspension center axis CA) of the lifting beam main body 61A in a longitudinal direction (left-right direction in the drawings). The two GNSS receivers 62A are separated from the suspension center axis CA by substantially the same distance. Each mount 62B includes a magnet arranged on its bottom surface for mounting the GNSS receiver 62A to the lifting beam main body 61A.

[0134] The suspension center axis CA is a vertical axis extending through a suspension center of the hook 22B.

[0135] The GNSS receiver 62A is the same as the GNSS receiver 23A except in that the GNSS receiver 62A includes a built-in rechargeable battery (battery).

[0136] In the present embodiment, the mount 62B allows for attachment and detachment of the GNSS receiver 62A. Instead of the mount 62B, the lifting beam main body 61A may include a structure for receiving the GNSS receiver 62A.

[0137] In the present embodiment, the GNSS receivers 62A are mounted on the lifting beam main body 61A. Instead, GNSS receivers 62A' may be mounted on the suspended load

SL, as indicated by the dotted lines.

[0138] In the same manner as the GNSS receivers 62A, the two GNSS receivers 62A' may be arranged at opposite sides of the suspension center axis CA at positions separated from the suspension center axis CA by the substantially the same distance.

[0139] A load is slung such that the center of gravity G of the suspended load SL is substantially located on the suspension center axis CA so as to avoid the suspended load SL from slipping off from wire ropes WR2, which suspend the suspended load SL, and ensure a safe lifting operation. Thus, a manner in which the wire ropes WR2 suspend the suspended load SL with respect to the lifting beam main body 61A is generally determined in advance.

[0140] Accordingly, when a load is suspended by the wire ropes WR2, a direction extending along the shape of the suspended load SL (also referred to as the suspended load shape) that is parallel to the longitudinal direction of the lifting beam main body 61A is defined as a specific direction.

[0141] In this case, the orientation of the specific direction may be detected as the orientation from one GNSS receiver 62A toward the other GNSS receiver 62A, and these detection results (datasets), such as latitudes, longitudes, and altitudes, obtained by the two GNSS receivers 62A are transmitted via the communication unit 23C to the cloud server 7.

[0142] This allows the cloud server 7 to obtain the orientation of the specific direction of the suspended load SL by calculating the orientation of the specific direction based on the received detection results from the two GNSS receivers 62A.

[0143] Therefore, based on a changing orientation of the specific direction, the cloud server 7 may perform an orientation reflecting process that reflects a virtual suspended load shape in the virtual space to conform to an orientation of a virtual specific direction of a virtual suspended load, which corresponds to the specific direction of the suspended load SL.

Specifically, in response to a change in the orientation of the specific direction of the suspended load SL, the cloud server 7 reflects the change in the orientation of the specific direction in the displayed shape of the virtual suspended load in the virtual space by changing a virtual orientation of the virtual specific direction of the virtual suspended load to conform to the orientation of the specific direction.

[0144] At a time when the suspended load SL is connected to the lifting beam 61 by the wire ropes WR2, distances from the two GNSS receivers 62A to the suspended load SL are determined. Accordingly, for example, when the site terminal 3 transmits the distances to the cloud server 7, the cloud server 7 can obtain the height of the suspended load SL based on the received detection results from the GNSS receivers 62A.

[0145] In a case in which the two GNSS receivers 62A, serving as the orientation detectors 62, are directly arranged on the suspended load SL, the height does not need to be corrected.

[0146] The cloud server 7 may also obtain the latitude and longitude of the suspended load SL based on the received detection results from the two GNSS receivers 62A.

[0147] Based on the received detection results from the two GNSS receivers, the cloud server 7 may perform a position reflecting process that reflects the position of the suspended load SL in a virtual position of the virtual suspended load in the virtual space, which corresponds to the suspended load SL. The detection results indicate the changing position of the suspended load SL, including the changing height (the position in the height direction). That is, in response to a change in the position of the suspended load SL, the cloud server 7 reflects the change in the position of the suspended load SL in the virtual position by changing the virtual position of the virtual suspended load in the virtual space to conform to the position of the suspended load SL.

[0148] As described above, the suspended load state detection set 6 is used for reflecting the state of the suspended load SL during a lifting operation in the virtual space.

[0149] The cloud server 7 includes the database DB and a virtual computer that implements the functionalities of a physical computer with software.

[0150] In the present embodiment, the cloud server 7 uses the virtual computer.

[0151] However, instead of the cloud server 7, a physical server including a physical computer capable of performing processing in the same manner as the cloud server 7 may be used.

[0152] The database DB is a data storage region prepared by a provider offering cloud computing service, and stores the three-dimensional construction site model, in which the three-dimensional model of the construction subject in a completed state is reflected in the 3D map data, the three-dimensional shape data of the materials to be used, or the like.

[0153] The database DB also stores the most recent three-dimensional construction site model reflecting the status of the construction site (construction progress) reproduced in the virtual space.

[0154] Thus, the data of the virtual space in the most recent state of the construction progress may be read from the database DB when restarting construction the next day.

[0155] Furthermore, the database DB stores dimension data on the actual sizes of the main body 21, the arm 22A, and the like of the crane 2 associated with the “Model” information.

[0156] The “Model” information indicates, for example, the model name of the crane 2. In the present embodiment, the model name is associated with the dimension data on the actual sizes of the main body 21, the arm 22A, and the like of the crane 2.

[0157] Specifically, the model name is used as a file name of the stored dimension data on the actual sizes of the main body 21, the arm 22A, and the like of the crane 2. Accordingly,

the dimension data on the actual sizes of the main body 21, the arm 22A, and the like of the crane 2, which corresponds to the crane 2 having the “Model” information, may be retrieved by reading the data having the same file name as the “Model” information (model name).

[0158] The virtual computer includes a cloud communication unit 71 and a spatial controller 72 as functional elements implemented by software. The spatial controller 72 controls the virtual space.

[0159] The cloud communication unit 71 is a functional interface having a communication functionality for performing communication with an external device or the like.

[0160] The cloud communication unit 71 receives, for example, a detection result obtained by the operation detector 23 that detects the overall operation state of the crane 2, a detection result obtained by the construction status detector 24 that detects the status of the construction subject corresponding to the construction progress, as well as the “Model” information, the “Material” information, or a name, such as a construction name, transmitted from the site terminal 3.

[0161] In addition, the cloud communication unit 71 receives from the suspended load state detection set 6 a detection result, which is obtained for reflecting the state of the suspended load SL during a lifting operation in the virtual space.

[0162] Based on the received detection results, the cloud communication unit 71 transmits an image of the virtual space, in which the status of the construction site (overall operation of the crane 2, the state of the suspended load SL, and the status of the construction subject) is reflected, to the site terminal 3, the remote terminal 4, or the like.

[0163] The spatial controller 72 executes overall control for reproducing the status of a construction site in the virtual space in the cloud. The spatial controller 72 mainly performs (A) a recognized crane reflecting process, (B) a crane information reflecting process, (C) a

construction status reflecting process, (D) a crane operation state reflecting process, and (E) a suspended load state reflecting process.

[0164] (A) Recognized Crane Reflecting Process

[0165] The recognized crane reflecting process is performed when the controller (not shown) of the crane 2 is activated, detection results of the GNSS receivers 23A and the tilt sensor 23B are transmitted from the communication unit 23C to the cloud server 7, and the cloud server 7 receives the detection results. As described above, the recognized crane reflecting process is a process that displays the virtual crane VR2, which corresponds to the crane 2, in the virtual space in accordance with the position, orientation, or the like of the crane 2.

[0166] (B) Crane Information Reflecting Process

[0167] The crane information reflecting process is performed when the pixel coordinates and the “Model” information are transmitted from the site terminal 3 to the cloud server 7, and the cloud server 7 receives the pixel coordinates and the “Model” information. As described above, the crane information reflecting process is a process that obtains from the database DB the information (data) on the actual sizes of the main body 21, the arm 22A, and the like associated with “Model”, and reflects the actual sizes of the main body 21, the arm 22A, and the like of the crane 2 in the main body, the arm 22A, and the like of the virtual crane VR2 located at a position corresponding to the received pixel coordinates of the display 34.

[0168] (C) Construction Status Reflecting Process

[0169] The construction status reflecting process is performed when a detection result of the construction status detector 24 is transmitted from the communication unit 23C to the cloud server 7, and the cloud server 7 receives the detection result.

[0170] More specifically, as described above, the image of the virtual space of the construction site corresponding to the name, such as the construction name, which is set by the site terminal 3 and shown on the display 34, is an image based on the three-dimensional construction site model stored in the database DB.

[0171] Such a three-dimensional construction site model includes the three-dimensional model (e.g., BIM/CIM) of the construction subject in a completed state. However, in a state prior to initiation of the construction, an image of a virtual construction subject VRB (refer to Fig. 5) in the virtual space, which corresponds to the construction subject, is displayed in a transparent (or translucent) state as if the virtual construction subject VRB does not exist in the virtual space.

[0172] Then, a portion of the virtual construction subject VRB in the virtual space is displayed in a non-transparent state that is visually recognizable in correspondence with a position where point cloud data appears from the detection result of the construction status detector 24. In this manner, the structure appears in the image of the virtual space.

[0173] That is, the construction status reflecting process is a process that reflects the construction progress of the construction subject in the virtual construction subject VRB in the virtual space, which corresponds to the construction subject, based on the detection result of the construction status detector 24.

[0174] In the present embodiment, the construction status reflecting process is a real-time process that receives the detection result of the construction status detector 24 at a frequency of once per second or more, and reflects the construction progress of the construction subject in the virtual construction subject VRB in the virtual space, which corresponds to the construction subject, at a frequency of once per second or more.

[0175] (D) Crane Operation State Reflecting Process

[0176] The crane operation state reflecting process is performed when a detection result of the operation detector 23 (the two GNSS receivers 23A and the tilt sensor 23B) is transmitted from the communication unit 23C to the cloud server 7, and the cloud server 7 receives the detection result. As described above, the crane operation state reflecting process is a process that reflects the position and the movement state of the crane 2 and the operation of the arm 22A in the position and the movement state of the virtual crane VR2 and the operation of the arm 22A in the virtual space, which corresponds to the crane 2.

[0177] In the present embodiment, the crane operation state reflecting process is a real-time process that receives the detection result of the operation detector 23 at a frequency of once per second or more, and reflects the detection result in the position and the movement state of the virtual crane VR2 and the operation of the arm 22A in the virtual space, which corresponds to the crane 2, at a frequency of once per second or more.

[0178] (E) Suspended Load State Reflecting Process

[0179] The suspended load state reflecting process is performed when a detection result of the orientation detector 62 (the pair of GNSS receivers 62A) is transmitted from the communication unit 23C to the cloud server 7, and the cloud server 7 receives the detection result. The suspended load state reflecting process includes the orientation reflecting process and the position reflecting process, which are described above.

[0180] Specifically, based on the changing orientation of the specific direction, the suspended load state reflecting process includes the orientation reflecting process that reflects the virtual suspended load shape in the virtual space to conform to the orientation of the virtual specific direction of the virtual suspended load, which corresponds to the specific direction of the suspended load SL. The changing orientation of the specific direction includes a change in the orientation of the specific direction of the shape of the suspended

load SL (suspended load shape) that is parallel to the longitudinal direction of the lifting beam main body 61A detected by the orientation detector 62.

[0181] In the present embodiment, a direction parallel to the longitudinal direction of the lifting beam main body 61A is defined as the specific direction. However, when a direction orthogonal to the longitudinal direction of the lifting beam main body 61A is defined as the specific direction, a direction extending from one GNSS receiver 62A toward the other GNSS receiver 62A may be rotated by ninety degrees to obtain the direction parallel to the longitudinal direction of the lifting beam main body 61A. Therefore, the specific direction is not limited to a direction parallel to the longitudinal direction.

[0182] As described above, the virtual suspended load shape (three-dimensional shape data for the suspended load SL) may be obtained by reading data having the same file name as the “Material” information (identifier) from the database DB.

[0183] Based on the “Material” information (identifier) set in the setting window 341C, which is shown on the display 34 of the site terminal 3 for setting of the suspended load SL, the spatial controller 72 obtains the virtual suspended load shape (three-dimensional shape data for the suspended load SL) from the database DB and reflects the virtual suspended load shape in the virtual suspended load. Thus, the spatial controller 72 serves as a shape obtainer of the present embodiment.

[0184] The suspended load state reflecting process further performs the position reflecting process that changes the virtual position of the virtual suspended load in the virtual space to conform to the position of the suspended load SL based on the changing position of the suspended load SL (a change in the position, including the altitude, of the suspended load SL detected by the orientation detector 62).

[0185] In the present embodiment, the suspended load state reflecting process is a real-

time process that receives the detection result of the orientation detector 62 at a frequency of once or more per second, and reflects the state of the suspended load SL (the position, including the height, and the direction in which the suspended load SL is oriented) during a lifting operation in the state of the virtual suspended load in the virtual space at a frequency of once or more per second.

[0186] As described above, with the present embodiment, the suspended load state reflecting process reflects the state of the suspended load SL during a lifting operation in the virtual space for visualization. This allows for sharing of the state of the suspended load SL during a lifting operation among the workers, thereby ensuring an environment where the work can be performed more safely.

[0187] Furthermore, in the present embodiment, the actual operations of the crane 2 or the like are also reflected in the virtual crane VR2 in the virtual space, which corresponds to the crane 2, so that the state of the suspended load will not change alone. This constructs an image of the virtual space that is more natural.

[0188] A visualization system 1 in accordance with a second embodiment will now be described with reference to Fig. 6.

[0189] The basic configuration of the second embodiment is the same as that of the first embodiment. Thus, the portions that are the same as those of the first embodiment will not be described in detail and the description will focus on the differences.

[0190] In the first embodiment, the site terminal 3 is operated to set the “Material” information (identifier). However, in the second embodiment, the suspended load state detection set 6 used for reflecting the state of the suspended load SL during a lifting operation in the virtual space further includes a shape detection device 63 that detects the shape of the suspended load, thereby eliminating the need to operate the site terminal 3.

[0191] Fig. 6 is a diagram illustrating the suspended load state detection set 6 in accordance with a second embodiment.

[0192] As shown in Fig. 6, the suspended load state detection set 6 of the present embodiment further includes the shape detection device 63, in addition to the lifting beam 61 and the orientation detector 62. The orientation detector 62 is arranged on the lifting beam 61 in a detachable manner, and detects the orientation of the suspended load SL. The shape detection device 63 is arranged on the lifting beam 61 at a position allowing for detection of the shape of the suspended load SL, and detects the shape of the suspended load SL.

[0193] The shape detection device 63 of the present embodiment is a 3D-LiDAR sensor arranged on the lifting beam main body 61A at a side facing the suspended load SL. For example, the 3D-LiDAR sensor is offset from a position directly above the suspended load SL in a direction orthogonal to the specific direction of the suspended load SL.

[0194] Specifically, the lifting beam main body 61A includes a pair of installation portions 61D at a central part of the lifting beam main body 61A in the longitudinal direction. The two installation portions 61D respectively extend outward from two opposite surfaces of the lifting beam main body 61A in a horizontal direction orthogonal to the suspension center axis CA.

[0195] The 3D-LiDAR sensor serving as the shape detection device 63 is arranged on the surface of each of the installation portions 61D facing the suspended load SL.

[0196] In other words, the shape detection device 63 of the present embodiment is the two 3D-LiDAR sensors respectively offset from a position directly above the suspended load SL in a horizontal direction orthogonal to the specific direction of the suspended load SL (toward the far side and the near side in Fig. 6) with respect to the suspension center axis CA. The shape detection device 63 detects substantially the overall shape of the suspended

load SL by capturing the suspended load SL in a manner looking diagonally downward to the left and the right.

[0197] As described above, in the second embodiment, the shape obtainer is the shape detection device 63 (3D-LiDAR sensor) arranged on the lifting beam 61 at a position allowing for detection of the shape of the suspended load SL.

[0198] Another 3D-LiDAR sensor, serving as the shape detection device 63, may be added to detect the shape of the suspended load SL more accurately. For example, the additional 3D-LiDAR sensor detects the shape of the suspended load SL by capturing the suspended load SL in a manner looking diagonally upward from a location on the turning body 21B of the crane 2.

[0199] The shape detection device 63 serves as a shape detector of the second embodiment. The detection result obtained by the shape detection device 63 is transmitted from the communication unit 23C to the cloud server 7, and is reflected in the virtual suspended load shape of the virtual suspended load by the orientation reflecting processing.

[0200] The positional relationship between the two GNSS receivers 62A and the two shape detection devices 63 (3D-LiDAR sensors) is known at the time of installation. Accordingly, the three-dimensional point cloud data may be converted into positions (latitudes, longitudes, and altitudes), in the same manner as the construction status detector 24.

[0201] In this manner, in the second embodiment, the shape detection device 63 that detects the shape of the suspended load SL is added to eliminate the need to set the “Material” information (identifier) and store the three-dimensional shape data of the virtual suspended load shape, which is the shape of the virtual suspended load corresponding to the suspended load SL, in the database DB.

[0202] In the above embodiment, the 3D-LiDAR sensor is described as the shape detection device 63 that detects the shape of the suspended load SL. Alternatively, for example, the shape detection device 63 may be a stereo camera or the like that detects the shape of the suspended load SL, including the size of the suspended load SL or the like.

[0203] Furthermore, the shape detection device 63 may include both the 3D-LiDAR sensor and the stereo camera.

[0204] A visualization system 1 in accordance with a third embodiment will now be described with reference to Figs. 7 and 8.

[0205] The basic configuration of the second embodiment is the same as that of the third embodiment. Thus, the portions that are the same as those of the second embodiment will not be described in detail and the description will focus on the differences.

[0206] Fig. 7 is a perspective view of the suspended load state detection set 6 in accordance with the third embodiment.

[0207] Fig. 8 is a side view of the suspended load detection set 6 in accordance with the third embodiment.

[0208] As shown in Figs. 7 and 8, the third embodiment differs from the second embodiment in that the lifting beam main body 61A of the lifting beam 61 includes a container structure that incorporates a turning mechanism (not shown) for turning the suspended load SL (not shown) and a rechargeable battery (not shown) for driving the turning mechanism.

[0209] As shown in Fig. 8, the shape detection device 63 is arranged on an outer bottom surface of the container structure. Further, a plurality of rechargeable batteries (batteries) configured to be used in an automobile or the like are incorporated.

[0210] In the turning mechanism (not shown), a gimbal shaft that tiltably supports a

flywheel is integrated with a gimbal frame that rotatably supports the flywheel. The turning mechanism uses a gyro effect generated when the flywheel is tilted while rotating about a center axis. For example, an entire part located lower than a rotatable portion of the hook 22B of the crane 2 is turned. This part includes the lifting beam main body 61A.

[0211] As described above, in the third embodiment, the orientation of the suspended load SL can be actively controlled, and a large number of large-sized batteries are disposed in the lifting beam main body 61A. Since the orientation detector 62 and the shape detection device 63 are supplied with electric power from the batteries, these devices do not need to be charged separately.

[0212] The present invention has been described above based on specific embodiments. The present disclosure, however, is not limited to the embodiments described above.

[0213] For example, the lifting beam 61 described in the first and second embodiments, which does not include the turning mechanism for the suspended load SL, may be provided with a 12-volt rechargeable battery (battery) that is configured to be used in an automobile or the like and has a relatively large charging capacity. This allows the lifting beam 61 to supply power to the orientation detector 62 and the shape detection device 63.

[0214] In this manner, the present disclosure is not limited to the embodiments. Modifications and improvements of the embodiments are also included in the technical scope of the disclosure, as will be apparent to those skilled in the art from the description of the claims.

WHAT IS CLAIMED IS:

1. A visualization system for visualizing a state of a suspended load during a lifting operation in a virtual space, the visualization system comprising:

a controller configured to control the virtual space;
an orientation detector configured to detect an orientation of the suspended load;
and

a shape obtainer configured to obtain a shape of the suspended load, wherein:
the orientation detector detects the orientation of the suspended load by detecting an orientation of a specific direction of the suspended load shape;

the controller performs a suspended load state reflecting process that reflects the state of the suspended load in a virtual suspended load in the virtual space, the virtual suspended load corresponding to the suspended load; and

in response to a change in the orientation of the specific direction, the suspended load state reflecting process reflects the change in the orientation of the specific direction in a displayed shape of the virtual suspended load in the virtual space by changing a virtual orientation of a virtual specific direction of the virtual suspended load to conform to the orientation of the specific direction, the virtual specific direction corresponding to the specific direction.

2. The visualization system according to claim 1, wherein:
the orientation detector is further configured to detect a position including a height of the suspended load; and

in response to a change in the position, the suspended load state reflecting process

reflects the change in the position in a virtual position of the virtual suspended load in the virtual space by changing the virtual position to conform to the position of the suspended load.

3. The visualization system according to claim 1 or 2, further comprising:
a lifting beam, wherein
the orientation detector is a positioning device arranged on the lifting beam, and
the shape obtainer is a shape detection device arranged on the lifting beam at a position allowing for detection of the shape of the suspended load.

4. A suspended load state detection set for reflecting a state of a suspended load during a lifting operation in a virtual space, the set comprising:
a positioning device arranged on a lifting beam or the suspended load and configured to detect a position and an orientation of the suspended load; and
a shape detection device arranged at a position allowing for detection of a shape of the suspended load.

5. The set according to claim 4, further comprising:
the lifting beam,
wherein the positioning device and the shape detection device are arranged on the lifting beam.