

DESCRIPTION

TITLE OF INVENTION

DRAWING VERIFICATION SYSTEM, CLIENT APPARATUS, PROGRAM, AND RECORDING MEDIUM

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TECHNICAL FIELD

[0001] The present invention relates to a drawing verification system, a client apparatus, a program, and a recording medium and, more particularly, to a technique of implementing verification of drawing information designed based on
10 facility specifications by using presentation of views of binocular stereoscopic vision.

BACKGROUND ART

[0002] When newly introducing a facility machine to be installed in a factory or establishing a new factory in which a facility machine is introduced, a facility
15 specification document is created in advance in consideration of a product to be made using the facility machine, an installation place in the production factory, and the like, and an order is placed with the manufacturing company of the facility machine. The manufacturing company creates design drawings including the facility machine and its layout so as to satisfy requested
20 specifications based on the facility specification document of the production facility and the like.

[0003] The design drawings of the production facility are created as electronic data (drawing data: drawing information) using a design tool such as CAD, and shared with the orderer. Based on the drawing data, the orderer and the
25 manufacturing company verify whether, for example, the requested facility specifications are satisfied. To perform such verification more constructively, there is recently proposed a system that changes drawing information while the

orderer and the manufacturing company communicate with each other in real time via a network (PTL 1).

CITATION LIST

PATENT LITERATURE

5 [0004]

PTL 1: Japanese Patent Laid-Open No. 2001-195438

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] The above-described verification referring to drawing data is performed
10 before construction regarding introduction of a facility machine. Particularly when, for example, drawing data are 2D design drawings, it is difficult for a person unfamiliar with design drawings to grasp the layout of a plurality of facility machines, traffic lines, and the like. This problem may be slightly solved if the orderer could directly visit a production facility to be introduced. However,
15 for example, considering the fact that an order is placed and received across countries, this requires costs such as the cost and time of travel and is not practical.

[0006] The present invention has been made to solve the above-described problems, and provides a drawing verification system, a client apparatus, a program, and a recording medium for preferably implementing verification of
20 drawing information composed based on facility specifications.

SOLUTION TO PROBLEM

[0007] In order to achieve the aforementioned problem, the present invention provides a drawing verification system comprising a server apparatus that establishes a session pertaining to verification of drawing information composed
25 based on a facility specification, and a plurality of client apparatuses that connect to the session via a network and perform information communication, wherein the verification in the session is performed by laying out rendering object information

used to render an object included in the drawing information in a virtual 3D space based on layout information that corresponds to the drawing information and indicates a position and posture of the object, the server apparatus comprises: management means for managing state information indicating a state of the 3D space that is a verification target of the session which is established upon receiving a session start request from one of the plurality of client apparatuses; first reception means for receiving information of a verification input made at each of the plurality of client apparatuses participating in the session; change means for changing the state information upon receiving the information of the verification input by the first reception means; and first transmission means for transmitting, to the client apparatuses connected to the session, shared information necessary to render the 3D space based on the state information, and each of the plurality of client apparatuses comprises: second reception means for connecting to the session and receiving the shared information transmitted by the first transmission means; construction means for constructing at least part of the 3D space based on the shared information received by the second reception means, the rendering object information, and the layout information; decision means for deciding a position and direction of a viewpoint at which the constructed 3D space is rendered; output means for sequentially rendering and outputting views of binocular stereoscopic vision of the constructed 3D space rendered based on the viewpoint decided by the decision means; presentation means for presenting the views of binocular stereoscopic vision rendered and output by the output means; input means for accepting the verification input; and second transmission means for transmitting, to the server apparatus, the information of the verification input accepted by the input means.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] With this arrangement, the present invention can preferably implement

verification of drawing information composed based on facility specifications.

BRIEF DESCRIPTION OF DRAWINGS

[0009] Fig. 1 is a view showing the arrangement of a drawing verification system according to embodiments and modifications of the present invention;

5 Fig. 2 is a block diagram showing the functional arrangement of a server apparatus 100 according to the embodiments and modifications of the present invention;

 Fig. 3 is a block diagram showing the functional arrangement of a client apparatus 200 according to the embodiments and modifications of the present
10 invention; and

 Fig. 4 is a flowchart exemplifying verification processing executed in regard to verification of drawing information in the drawing verification system according to the embodiments and modifications of the present invention.

DESCRIPTION OF EMBODIMENTS

15 [0010] [First Embodiment]

 Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention, and limitation is not made to an invention that requires a combination of all features described in the embodiments. Two or more
20 of the multiple features described in the embodiments may be combined as appropriate. Furthermore, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.

[0011] The following embodiment will explain an example in which the present invention is applied to, as an example of a drawing verification system, a drawing
25 verification system including a server apparatus that establishes a session pertaining to verification of drawing information composed based on facility specifications, and a plurality of client apparatuses that connect to the session via

a network and perform information communication. However, the present invention is applicable to a system constituted by arbitrary devices that provide a function pertaining to verification of drawing information to a plurality of communication-connected devices.

5 [0012] <<Arrangement of Drawing Verification System>>

Fig. 1 is a view showing the arrangement of the drawing verification system according to the embodiment of the present invention.

[0013] As shown in Fig. 1, the drawing verification system is constituted so that a plurality of client apparatuses 200 can be connected to a server apparatus 100
10 via a network 300. In the embodiment, when the server apparatus 100 receives a session start request from an arbitrary client apparatus 200, it establishes a session in which the plurality of client apparatuses 200 can participate, and implement transmission/reception of information between the client apparatuses 200 participating in the session. As will be described later in detail, the server
15 apparatus 100 receives information from any one of the client apparatuses 200 during the session, performs predetermined processing, and if necessary, transmits the information after the processing to the other client apparatuses 200 participating in the session. The server apparatus 100 can implement information communication and information synchronization between the
20 participating client apparatuses 200 and share the same information.

[0014] A session established in the drawing verification system according to the embodiment is a verification session in which drawing information composed (created) based on predetermined facility specifications so as to satisfy the facility specifications is verified. The drawing information is, for example, drawing data
25 composed (created) for a target establishment to include at least information of a facility machine to be installed and information of the layout of the facility machine in the establishment. In the verification session, the user of each client

apparatus 200 can visually observe, in the form of binocular stereoscopic vision, a virtual 3D space simulating the establishment indicated by the drawing information. As an apparatus that implements information presentation by binocular stereoscopic vision, a HMD (Head-Mounted Display) 210 is connected
5 to each client apparatus 200.

[0015] When the plurality of client apparatuses 200 participate in the verification session, verification is possible between the client apparatuses 200 using drawing information copied based on the same drawing information. At this time, a 3D space pertaining to the drawing information can be visually checked from
10 independent viewpoints in the respective participating client apparatuses 200, implementing simultaneous verification by a plurality of users. In the verification in which the plurality of client apparatuses 200 participate, for example, even speech communication may be possible.

[0016] To enable such verification, the client apparatus 200 in the drawing
15 verification system according to the embodiment holds drawing information pertaining to a facility to be verified. The drawing information is composed of rendering object information that may be 3D CAD data pertaining to a facility machine to be installed in a target establishment or 3D model data obtained by converting the 3D CAD data, layout information indicating the layout of each
20 facility machine to be installed, and authority information such as the authority to permit participation in a verification session or the authority necessary for participation. That is, the client apparatus 200 can issue a session start request and participate in the verification session based on the premise that it holds drawing information including authority information indicating that participation
25 is permitted. The authority information necessary for the session start request and participation in the verification session is availably prepared or provided together with drawing information via, for example, a telecommunication line or a

portable recording medium such as a USB memory, CD-R, or DVD-R, and is recorded on a recording medium 202 of the client apparatus 200.

[0017] In the client apparatus 200 participating in the verification session, a 3D space pertaining to drawing information is rendered from a viewpoint

5 corresponding to each eyeball in a view of binocular stereoscopic vision, in order to present the 3D space. More specifically, at least part of the 3D space corresponding to the drawing information is constructed by laying out 3D model data pertaining to rendering object information included in the drawing information in the 3D space based on the layout information. The constructed
10 3D space is rendered based on a separately decided position and direction of the viewpoint for each eyeball, thereby generating images that are presented using the HMD 210 and implement binocular stereoscopic vision.

[0018] The 3D model data pertaining to rendering object information is provided for each facility machine. When the rendering object information is 3D CAD
15 data, the 3D model data may be generated by converting the 3D CAD data in the client apparatus 200. The 3D CAD data is data of a large information amount such as a large number of vertices because a fine shape definition is made in accordance with its application purpose and all parts constituting a facility machine are separable. When rendering a 3D space in which a plurality of
20 facility machines are laid out, 3D CAD data requires an enormous calculation amount of rendering processing and a long processing time, and is not practical because the 3D CAD data excessively includes planes that need not be rendered and parts that cannot be seen externally, and has a large number of vertices of planes to be rendered. Hence, the 3D CAD data undergoes conversion
25 processing such as removal of parts that do not influence the expression of the outer appearance, thinning of the number of vertices, change of cohesion information, replacement with a simple stereoscopic shape, and reduction of the

numbers of parts and vertices by integration of a plurality of parts. As a result, simplified 3D model data is obtained and used for rendering processing.

[0019] Note that the rendering object information is not limited to 3D CAD data or 3D model data, and may include various texture data applied to the 3D model data, motion information that defines a motion of at least some parts during operation, and the like. The rendering object information may include a rendering program such as a shader applied to 3D model data, and designation information of calculation data used in the rendering program such as the light source type, light source intensity, and light source vector. The layout information may include information of a light source installed in an establishment.

[0020] The server apparatus 100 manages information of a 3D space pertaining to drawing information in order to synchronize verification contents between the client apparatuses 200 participating in a verification session. In the embodiment, the client apparatus 200 renders a 3D space pertaining to drawing information, and the server apparatus 100 manages only information pertaining to synchronization of verification. The server apparatus 100 only needs to hold at least layout information out of the drawing information prior to the start of the verification session.

[0021] The server apparatus 100 manages state information indicating the state of the 3D space pertaining to the drawing information during the verification session, and sequentially updates the state information based on operations (verification inputs) performed for verification in the client apparatuses 200. Information (shared information) about the change that occurred in the state information is transmitted to the client apparatuses 200 participating in the verification session, and is reflected in 3D spaces being constructed in the client apparatuses 200. Therefore, all the participating client apparatuses 200

implement the appreciation of the rendering object information in which the pieces of drawing information saved in the client apparatuses 200 are synchronized based on the 3D spaces in similar states.

[0022] <Arrangement of Server Apparatus>

5 Next, the functional arrangement of the server apparatus 100 according to the embodiment will be described in detail with reference to the block diagram of Fig. 2. In the following description, constituent elements that implement similar functions in the server apparatus 100 and the client apparatus 200 will be discriminated by adding a prefix "server" to the constituent elements of the server
10 apparatus 100.

[0023] A server control unit 101 is, for example, a CPU and controls the operation of each block of the server apparatus 100. More specifically, the server control unit 101 controls the operation of each block by, for example, reading out the operation program of each block or a program pertaining to
15 provision of a verification session that is recorded on a server recording medium 102, deploying it in a server memory 103, and executing it.

[0024] The server recording medium 102 is a recording device such as a nonvolatile memory or HDD that can permanently hold data. The server recording medium 102 records parameters and the like necessary for the operation
20 of each block, in addition to the operation program of each block of the server apparatus 100 and the program pertaining to provision of a verification session. The server memory 103 is a storage device such as a volatile memory that is used to temporarily store data. The server memory 103 is used as the deploying area of each program and also as a storage area for temporarily storing data and the
25 like output in the operation of each block.

[0025] For a verification session during establishment and a terminated verification session, a management unit 104 manages the state information of a

3D space pertaining to corresponding drawing information. Details of the state information will be described later. The management unit 104 manages information obtained by sequentially adding changes based on information of verification inputs during the verification session to initial state information

5 composed based on drawing information-based layout information. When there is a change in the state information under management, the management unit 104 generates shared information in order to synchronize 3D spaces pertaining to drawing information constructed in the respective client apparatuses 200.

[0026] In a verification session, a state change unit 105 changes state

10 information managed by the management unit 104 based on information of a verification input to the participating client apparatus 200.

[0027] A server communication unit 106 is a communication interface of the server apparatus 100 for communicating with another apparatus. The server communication unit 106 connects to an external device via the network 300 by a

15 predetermined wired or wireless communication method, and transmits/receives data.

[0028] <Arrangement of Client Apparatus>

Next, the functional arrangement of the client apparatus 200 according to the embodiment will be described in detail with reference to the block diagram of

20 Fig. 3.

[0029] A control unit 201 is, for example, a CPU and controls the operation of each block of the client apparatus 200. More specifically, the control unit 201 controls the operation of each block by, for example, reading out the operation program of each block or a program pertaining to participation in a verification

25 session that is recoded on a recording medium 202, deploying it in a memory 203, and executing it.

[0030] The recording medium 202 is a recording device such as a nonvolatile

memory or HDD that can permanently hold data. The recording medium 202 records parameters and the like necessary for the operation of each block, in addition to the operation program of each block of the client apparatus 200 and the program pertaining to participation in a verification session. The memory
5 203 is a storage device such as a volatile memory that is used to temporarily store data. The memory 203 is used as the deploying area of each program and also as a storage area for temporarily storing data and the like output in the operation of each block.

[0031] A construction unit 204 constructs a 3D space pertaining to rendering
10 drawing information during participation in a verification session. The 3D space constructed by the construction unit 204 need not include the entire 3D space indicated by the drawing information, and suffices to be a state in which at least rendering objects falling within the visual field range of a viewpoint, at which rendering is performed, are laid out. More specifically, the construction unit 204
15 specifies, based on information of a set viewpoint position, predetermined objects (for example, facility machine and illumination) that are defined by layout information to be laid out in a construction range corresponding to the viewpoint. Then, the construction unit 204 deploys rendering object information pertaining to the specified objects in, for example, the memory 203, and lays out the objects in
20 a virtual 3D space based on the layout information, thereby constructing at least part of the 3D space managed in the server apparatus 100.

[0032] As described above, in the drawing verification system according to the embodiment, the state of a 3D space changes based on verification inputs to the respective client apparatuses 200 participating in a verification session. For this
25 reason, the construction unit 204 is assumed to construct a 3D space while also reflecting shared information received when the state of the 3D space changes in the server apparatus 100. The 3D space is constructed in each client apparatus

200 in accordance with its viewpoint direction.

[0033] Although the construction unit 204 constructs a 3D space in the embodiment, the practice of the present invention is not limited to this. A 3D space may be constructed by a rendering unit 206 (to be described later) or

5 implemented by another arrangement.

[0034] A decision unit 205 decides the position and direction of a viewpoint at which rendering is performed for a constructed 3D space. In the embodiment, the appreciation of a 3D space in a verification session is performed using views of binocular stereoscopic vision, so the decision unit 205 decides positions and
10 directions for the respective left- and right-eye viewpoints. The position and direction of the viewpoint may be decided in accordance with, for example, at least either of detection of an operation input pertaining to the movement (change of at least either translation or rotation) of the viewpoint and detection of the movement (translation and rotation in a real space) of the head of a user wearing
15 the HMD 210. At this time, the decision unit 205 decides the positions and directions of the left- and right-eye viewpoints by reflecting the detected movement with respect to an intermediate point between the two viewpoints, and shifting the viewpoints each by half the interocular distance in the baseline length direction.

20 [0035] The rendering unit 206 is, for example, a rendering device such as a GPU. The rendering unit 206 renders a 3D space constructed pertaining to drawing information based on the viewpoints decided by the decision unit 205, and generates images pertaining to one frame of a view for binocular stereoscopic vision. The images of one frame generated by the rendering unit 206 are
25 sequentially output to the HMD 210 (to be described later) and presented.

[0036] An operation input unit 207 is, for example, a user interface of the client apparatus 200, such as a controller, a mouse, or a keyboard provided for a

verification input in a verification session. When the operation input unit 207 detects an operation input from the user, it transmits a control signal corresponding to the operation input to the control unit 201. In the embodiment, the viewpoint is changed in accordance with the position of the head of the user of the client apparatus 200 who wears the HMD 210. The operation input unit 207 detects a sensor output from a sensor 211 of the HMD 210 or information obtained by converting the sensor output into a predetermined format.

[0037] A communication unit 208 is a communication interface of the client apparatus 200 for communicating with another apparatus. The communication unit 208 connects to an external device via the network 300 by a predetermined wired or wireless communication method, and transmits/receives data.

[0038] The HMD 210 is a display device that presents a view of binocular stereoscopic vision pertaining to verification of drawing information in a verification session according to the embodiment. Although the HMD 210 is used as a display device that presents a view of binocular stereoscopic vision in the embodiment, the practice of the present invention is not limited to this, and the HMD 210 can be any device capable of presenting information by binocular stereoscopic vision. In the embodiment, the HMD 210 includes the sensor 211 that can be an acceleration sensor or a gyro sensor, and can detect the movement of the head of the user (wearing the HMD 210) during the presentation of a view pertaining to a verification session. However, the practice of the present invention is not limited to this, and the movement of the head of the user may be derived by detecting a marker provided on the HMD 210 by an externally provided detection device such as an image sensor and analyzing the marker.

[0039] <<Verification Session>>

Functions provided in a verification session and an operation mode in the drawing verification system having the above-described arrangement according to

the embodiment will be described below.

[0040] In a verification session, functions pertaining to various verifications and adjustments including a change of the layout of a facility machine in a 3D space pertaining to common drawing information and a change to another facility

5 machine are provided for the drawing information to the client apparatuses 200 connected to the session. In the embodiment, the state of the 3D space pertaining to the drawing information is temporarily changed by the functions and shared between the client apparatuses 200 connected to the verification session.

[0041] The user of each client apparatus 200 participating in the verification
10 session is laid out as an avatar in the 3D space and represented as a rendering object visible from the viewpoint of another client apparatus 200. The position and posture of at least the head of the avatar in the 3D space are configured to be synchronized with a viewpoint at which binocular stereoscopic vision is provided in the client apparatus 200 corresponding to the avatar. In providing the
15 functions pertaining to verification and adjustment, this configuration implements a smooth communication between users such that a portion receiving attention from each user or a rendering object subjected to discussion can be easily grasped.

[0042] The behavior of each avatar is controlled by transmitting, to the server apparatus 100, viewpoint information indicating a viewpoint set in the client
20 apparatus 200, changing, by the state change unit 105 based on the viewpoint information, the state of a corresponding avatar out of state information managed by the management unit 104, and transmitting the contents of the change as shared information to each client apparatus 200. In the client apparatus 200 that has received the shared information, the construction unit 204 constructs (changes) a
25 3D space in which the position and posture of a corresponding avatar are changed and the avatar is laid out so as to achieve a state indicated by the shared information, and the rendering unit 206 renders the 3D space. By this

information sharing, the state of a verification performed in the client apparatus 200 participating in the verification session is presented to even the other client apparatuses 200.

[0043] In the verification session according to the embodiment, a function of
5 indicating and selecting a rendering object or an arbitrary portion of the rendering object laid out in a 3D space is provided in each client apparatus 200. The presentation mode of the indicated/selected target is controlled so that the target can be identified. Even a change of the presentation mode is shared as shared information, similar to the avatar, and can be presented in all the client
10 apparatuses 200 participating in the verification session. This function can more easily notify the other client apparatuses 200 of a status of the verification. The presentation mode in which a indicated/selected target can be identified may be, for example, a mode in which the rendering color of the target is changed (including a change of the color, increase in color tone, or emission of light), a
15 mode in which a predetermined index object such as a pointer is arranged near, or a mode in which the target is indicated using the hand of the avatar or the like.

[0044] In the drawing verification system according to the embodiment, drawing information subjected to verification is used to verify an establishment in a state in which facility machines are laid out based on facility specifications. The
20 drawing verification system provides the user of the client apparatus 200 via a view of binocular stereoscopic vision with an appreciation experience as if he/she performed a verification in the establishment. In other words, the rendering objects of the establishment and laid-out facility machines in the view of binocular stereoscopic vision presented to the user via the HMD 210 are
25 appreciated in an actual size, that is, the same size as that in the real world. More specifically, the drawing verification system according to the embodiment is configured to adjust at least either of the camera parameter (angle of view) of

rendering in each client apparatus 200 and the scaling of 3D model data of a rendering object so that the object in the real world is presented to the field of view of the user in the same size as that when viewed from a positional relationship corresponding to the viewpoint.

5 [0045] <Verification Input>

Next, a verification input indicating an input of changing the state of a 3D space pertaining to drawing information in the client apparatus 200 participating in such a verification session will be explained.

[0046] The verification input includes an operation input for instructing a change
10 of an object laid out in an establishment defined by drawing information into another object. The operation input includes, for example, selection of an object laid out in a 3D space and selection of an object to be laid out instead of the selected object from an object list. Here, an object is not limited to a mode in which one whole facility machine is changed and may include, for example, a
15 mode in which some assemblies of a facility machine are changed to other compatible assemblies. Alternatively, the verification input may be an operation input for instructing the layout of a new object in a region where no object is laid out.

[0047] The verification input includes an operation input for instructing a change
20 of at least either the position or posture of an object laid out in an establishment defined by drawing information. The operation input includes, for example, selection of an object laid out in a 3D space and instruction of a position or posture of the object after change. The change may include a change of an interior element of the establishment such as a change of the height of the floor
25 surface on which an object is laid out, or a change of the shape of the wall surface.

[0048] The verification input includes information (discussion information) of each input (text or speech) pertaining to a discussion between users performed in

a verification session, such as a text chat or speech communication for an object laid out in an establishment defined by drawing information or an interior element of the establishment. In other words, the verification input (discussion information) in this mode is equivalent to a log of contents of a discussion performed while appreciating a 3D space pertaining to drawing information. The verification input may include, for example, an evaluation of facility specifications pertaining to drawing information, and the contents of exchange of opinions about a change of the state of the 3D space based on the verification input pertaining to the change.

10 [0049] In addition, an avatar corresponding to each client apparatus 200 is also an element that is laid out in a 3D space and managed in a verification session though the avatar is not directly indicated by drawing information. The verification input includes rendering viewpoint information (or an input pertaining to a change of the viewpoint) decided based on an input (operation input of

15 directly changing the viewpoint or a sensing output from the sensor 211) pertaining to a change of the viewpoint in the corresponding client apparatus 200, and information indicating a status of a verification target indication/selection.

[0050] Information of a verification input to each client apparatus 200 is associated with identification information for identifying the client apparatus 200

20 (or its user) and then transmitted to the server apparatus 100. That is, the verification input information is transmitted to the server apparatus 100 in a state in which the client apparatus 200 that has accepted the input can be identified.

[0051] <Management of State Information>

When the server apparatus 100 receives the transmitted verification input

25 information, the state change unit 105 changes state information pertaining to the verification session that is managed by the management unit 104. As for the verification input information other than discussion information, it is controlled to

change the state of the rendering object of a facility machine or avatar laid out in a 3D space into a state instructed by the information. As for verification input information of discussion information, it is controlled to lay out and present, for example, at a corresponding position in a 3D space, an object displaying

5 discussion contents in the list form so that the object can be confirmed.

[0052] In the drawing verification system according to the embodiment, the server apparatus 100 manages only the state of a 3D space for drawing information subjected to verification in a verification session, and does not change the drawing information. That is, state information is changed, but the change is

10 not reflected in drawing information and is merely a temporal change performed to verify drawing information. This verification is performed to check whether currently composed drawing information preferably satisfies facility specifications, whether a trouble (for example, interference) occurs when an establishment is constructed based on the drawing information, or whether there is

15 room for improvement after performing a verification.

[0053] In the drawing verification system according to the embodiment, as for a verification session performed for one drawing information, state information includes history information indicating a history of changes or the like performed based on verification inputs. The history information is managed in association

20 with information for identifying the drawing information so that changes of the drawing information based on the verification and items to be verified can be checked after the end of the session.

[0054] As described above, in the drawing verification system according to the embodiment, the history information includes at least one of the change history of

25 an object, the change history of the position and direction of an object, and the minutes based on discussion information. The history information is composed so that changes, remarks, and the like caused by verification inputs to the client

apparatuses 200 can be referred to in time-series. When changing the drawing information based on this information, the destination to confirm the contents of a change can be specified, and the locus of responsibility pertaining to the change can be clarified.

- 5 [0055] The history information is not limited to a mode in which the history of changes to state information corresponding to drawing information is managed in every verification session. For example, history information composed for a terminated verification session may be composed so that a verification can be performed while switching reflection/non-reflection in state information for every
10 history when performing a verification session again based on the same drawing information.

[0056] <Shared Information>

- When state information managed by the management unit 104 is changed based on verification input information, the server apparatus 100 transmits shared
15 information to each client apparatus 200 so that the construction unit 204 of the client apparatus 200 connected to a verification session reflects the change in a 3D space constructed for rendering. The shared information need not indicate all changes from initial state information managed based on layout information of drawing information, and suffices to indicate a difference from state information
20 of an immediately preceding state at the change timing of each state information. The construction unit 204 of each client apparatus 200 can update the 3D space that has already constructed based on the received shared information, thereby constructing a local 3D space while reflecting the change that occurred based on the verification input by the client apparatus 200 connected to the verification
25 session. As a result, the verification can be performed while pieces of drawing information saved in the respective client apparatuses 200 are synchronized based on 3D spaces synchronized between the client apparatuses 200 connected to the

verification session.

[0057] At the time of establishing a verification session, state information is based on only layout information of drawing information, and no shared information need be transmitted. When the client apparatuses 200 participate in the verification session and perform a verification, the states of avatars pertaining to the users of the respective client apparatuses 200 need to be updated. Therefore, during the verification session, information and indication/selection status information are basically transmit from each client apparatus 200 to the server apparatus 100 as verification input information. Based on the information, the state of the corresponding avatar in the state information is updated. Then, the server apparatus 100 transmits shared information pertaining to the update to each client apparatus 200.

[0058] When another verification input for verifying the drawing information is done, the state change unit 105 updates the state information based on information of the verification input, and the management unit 104 includes information indicating the changes that occurred in the state information in the shared information and has it transmit to each client apparatus 200.

[0059] In the embodiment, to facilitate understanding of the mechanism, an example will be explained as one aspect, in which information of a verification input to each client apparatus 200 is first transmitted to the server apparatus 100 and reflected in state information by the state change unit 105, and shared information indicating the change is transmitted to all the client apparatuses 200 connected to the verification session and is reflected in 3D spaces constructed by the construction units 204. That is, to completely synchronize the 3D spaces rendered in each client apparatus 200, all pieces of information that change the state information occurred in the verification session are once reflected in the state information managed in the server apparatus 100, and then the 3D spaces locally

constructed in each client apparatus 200 is updated to synchronize with the state information. However, it is also possible that the verification input made at a given client apparatus 200 is applied to a locally constructed 3D space without intervention of shared information, and shared information pertaining to a change
5 of state information occurred based on the verification input information is transmitted to only the remaining client apparatuses 200 except the given client apparatus 200.

[0060] <<Verification Processing>>

Verification processing executed in regard to verification by the server
10 apparatus 100 and the client apparatuses 200 connected to a verification session when the session is established in the drawing verification system according to the embodiment will be explained in detail with reference to the flowchart of Fig. 4. Processing corresponding to the flowchart can be implemented by, for example, reading out corresponding processing programs respectively stored in the server
15 recording medium 102 and the recording medium 202 by the server control unit 101 and the control unit 201, deploying them in the server memory 103 or the memory 203, and executing them. Note that the verification processing starts when, for example, the client apparatus 200 is connected to an established verification session, a 3D space based on drawing information is constructed in
20 the client apparatus 200, and the process proceeds to a sequence in which a view of binocular stereoscopic vision can be presented.

[0061] In step S401, the control unit 201 determines whether a verification input has been done. Whether a verification input has been done may be determined in accordance with whether an operation input for instructing a change to another
25 object, an operation input for instructing a change of the position and posture of an object, or as for an input of discussion information, a corresponding input has been done. The verification input pertaining to viewpoint information or a status

of the indication/selection for a verification target may be determined in accordance with, for example, whether an input causing a change from a state in a previous frame has been done. If the control unit 201 determines that a verification input has been done, it shifts the process to step S402. If the control
5 unit 201 determines that no verification input has been done, it shifts the process to step S406.

[0062] In step S402, the control unit 201 transmits the verification input information to the communication unit 208 in association with identification information of the client apparatus 200, and controls the communication unit 208
10 to transmit the verification input information to the server apparatus 100.

[0063] In step S403, the server control unit 101 of the server apparatus 100 determines whether the server apparatus 100 has received the verification input information during a predetermined processing period such as one frame from the client apparatus 200 connected to the verification session. If the server control
15 unit 101 determines that the verification input information has been received from one of the client apparatuses 200 during the predetermined processing period, it shifts the process to step S404. If the server control unit 101 determines that no verification input information has been received from any client apparatus 200 during the predetermined processing period, it determines that the processing on
20 the server apparatus 100 side pertaining to this frame is completed, waits till the timing when processing pertaining to the next frame starts, and performs again the processing of this step for the next frame.

[0064] Note that state changes may compete against each other such that pieces of verification input information received from the plurality of client apparatuses
25 200 during a predetermined processing period have contents targeting the same object. In such a case, the server control unit 101 can control to process first received verification input information out of the pieces of verification input

information received from the plurality of client apparatuses 200 during the predetermined processing period without executing processing based on the remaining received pieces of verification input information from the remaining client apparatuses 200.

5 [0065] In step S404, the state change unit 105 changes state information managed by the management unit 104 based on the received verification input information under the control of the server control unit 101. More specifically, the state change unit 105 changes the state of a target object in a 3D space based on the received verification input information, and changes the state information
10 by adding, to history information, a change history based on the verification input information and the identification information associated with the verification input information.

[0066] In step S405, under the control of the server control unit 101, the management unit 104 composes shared information pertaining to the change of
15 the state information performed in step S404 and transmits the shared information to the server communication unit 106, and the server communication unit 106 transmits it to the client apparatuses 200 connected to the verification session.

[0067] In the client apparatus 200, the control unit 201 waits till a predetermined processing timing on the assumption that the shared information will be received,
20 and then determines, in step S406, whether the client apparatus 200 has received shared information from the server apparatus 100. If the control unit 201 determines that shared information has been received, it shifts the process to step S407. If the control unit 201 determines that no shared information has been received, it shifts the process to step S408.

25 [0068] In step S407, under the control of the control unit 201, the construction unit 204 constructs a 3D space in which a change based on the received shared information is added.

[0069] In step S408, under the control of the control unit 201, the decision unit 205 decides a viewpoint at which rendering pertaining to this frame is performed. In the processing of this step, if an input pertaining to a change of the viewpoint is performed, the viewpoint is decided by changing it to a state in which the input is reflected. If an input pertaining to a change of the viewpoint is not done, the decision unit 205 decides, as the viewpoint, one at which rendering pertaining to the previous frame has been performed.

[0070] In step S409, under the control of the control unit 201, the rendering unit 206 renders the constructed 3D space based on the viewpoint decided in step S408, and generates images pertaining to one frame of the view of binocular stereoscopic vision.

[0071] In step S410, the control unit 201 transmits the images generated in step S409 to the HMD 210, controls the HMD 210 to present them, and returns the process to step S401 in order to perform the processing for the next frame.

[0072] As described above, the drawing verification system according to the embodiment can preferably implement verification of drawing information through the presentation of a view of binocular stereoscopic vision in a synchronized 3D space in a verification session in which the plurality of client apparatuses 200 participate.

[0073] In the embodiment, a verification input that changes the state of a 3D space pertaining to drawing information is a change to a layout object, a change of the layout position and posture of an object, an input of discussion information, or a change of viewpoint information and a status of indication/selection. However, the practice of the present invention is not limited to this. For example, the verification input may be an operation input pertaining to selection of a verification item in a mode in which a plurality of types of verification items for performing a visual verification are provided in advance in regard to verification

of drawing information. In this mode, when an operation input pertaining to selection of a verification item is done in the client apparatus 200 participating in a verification session, the state change unit 105 changes state information so as to present a view of binocular stereoscopic vision including a graphical interface for the verification item.

[0074] The verification items may include, for example, at least one of a change of an object such as a facility machine to be laid out, the layout of an object, setting (zoning) of a region where an object is laid out, confirmation of the traffic line of a product or object user based on the layout of an object, setting of the temperature condition of the operation environment of an object, the layout of an air-conditioner in an establishment, an illumination condition set at the time of operating an object, the layout of an illumination in the establishment, the maintainability of objects, a camera installation location in the establishment, and setting of the angle of view of an installed camera. For example, when a verification item pertaining to a change of an object is selected, a graphical user interface for deciding an object after change is laid out in a 3D space and presented as a view of binocular stereoscopic vision to the user of each client apparatus 200.

[0075] [Second Embodiment]

In the above-described first embodiment, the server apparatus 100 holds layout information out of drawing information, manages only information of a 3D space pertaining to the drawing information, and at the end of a verification session, manages history information in association with information for identifying the drawing information. However, the practice of the present invention is not limited to this.

[0076] For example, a server apparatus 100 may manage drawing information, and upon receiving verification input information or at the end of a session,

update the drawing information to a state in which a change occurred in state information is reflected. That is, a change of drawing information based on a verification performed in a verification session may be reflected in the drawing information by the server control unit 101 without requiring any work by the designer as a result of the performed verification, instead of the designer working on it, for example, by referring to history information after the verification session has ended.

[0077] [First Modification]

In the mode in which drawing information is held in the server apparatus 100 and can be changed, as in the above-described second embodiment, CAD data of an installed machine or the like needs to be stored in the server apparatus 100 for the change. In other words, drawing information and 3D CAD data necessary to compose the drawing information are held in the server apparatus 100. Each client apparatus 200 need not store drawing information and hold rendering object information so that it can cope with a change of a layout object.

[0078] Thus, the client apparatus 200 may be provided with only authority information pertaining to a verification session via a recording medium including the authority information and if necessary, receive, from the server apparatus 100 via a communication unit 208, rendering object information and layout information necessary to present a view of binocular stereoscopic vision used in the verification system. In this mode, when a layout object is changed to another object, shared information may include rendering object information pertaining to the other object and be provided to the client apparatus 200.

[0079] [Second Modification]

In the mode in which drawing information is substantially editable by a verification session, like the above-described second embodiment and first modification, for example, layout information composed by combining and laying

out rendering objects may be set in advance as a template for, for example, a plurality of types of objects necessary to implement a specific production function so that the objects can be laid out in verification of drawing information. The layout information can be laid out in a 3D space in a mode in which objects are replaced with others or a mode in which objects are newly laid out at the time of verification.

[0080] Such layout information may not always meet design specifications, or may not match the size of an installation region. Even after a verification input pertaining to the layout is done, an adjustment can be made, including a change of the position and posture of a rendering object pertaining to the combination or replacement of some objects. Particularly considering a mode in which variations of different scales are provided for some facility machines or the latest updated models and the like are provided, the layout information may not satisfy ever-changing needs of an orderer.

[0081] Hence, when a change of the same content is performed by more than a predetermined number of times on a rendering object laid out based on layout information pertaining to the same template, the server control unit 101 may reflect the change in the layout information so that the reflected object can be laid out in verification. When a verification session is performed for drawing information already composed using the layout information, it may be adjusted to make a proposal to change an object at the target position in the session.

[0082] [Other Embodiments]

The invention is not limited to the foregoing embodiments, and various variations/changes are possible within the spirit of the invention.

The drawing verification system according to the present invention can be implemented by a program of causing one or more computers to function as each device of the drawing verification system. The program can be

provided/distributed by recording it on a computer-readable recording medium or via a telecommunication line.

CLAIMS

1. A drawing verification system comprising a server apparatus that establishes a session pertaining to verification of drawing information composed based on a facility specification, and a plurality of client apparatuses that connect
5 to the session via a network and perform information communication,
wherein the verification in the session is performed by laying out rendering object information used to render an object included in the drawing information in a virtual 3D space based on layout information that corresponds to the drawing information and indicates a position and posture of the object,
10 the server apparatus comprises:
management means for managing state information indicating a state of the 3D space that is a verification target of the session which is established upon receiving a session start request from one of the plurality of client apparatuses;
first reception means for receiving information of a verification input
15 made at each of the plurality of client apparatuses participating in the session;
change means for changing the state information upon receiving the information of the verification input by the first reception means; and
first transmission means for transmitting, to the client apparatuses connected to the session, shared information necessary to render the 3D space
20 based on the state information, and
each of the plurality of client apparatuses comprises:
second reception means for connecting to the session and receiving the shared information transmitted by the first transmission means;
construction means for constructing at least part of the 3D space based on
25 the shared information received by the second reception means, the rendering object information, and the layout information;
decision means for deciding a position and direction of a viewpoint at

which the constructed 3D space is rendered;

output means for sequentially rendering and outputting views of binocular stereoscopic vision of the constructed 3D space rendered based on the viewpoint decided by the decision means;

5 presentation means for presenting the views of binocular stereoscopic vision rendered and output by the output means;

input means for accepting the verification input; and

second transmission means for transmitting, to the server apparatus, the information of the verification input accepted by the input means.

10 2. The drawing verification system according to claim 1, wherein the verification input accepted by the input means includes at least one of a change instruction of an object laid out in the constructed 3D space, a change instruction of at least one of a position and posture of an object laid out in the 3D space, and discussion information indicating contents of a discussion conducted for
15 verification of the drawing information, and

the management means manages, by including in the state information based on a change of the state information according to the information of the verification input by the change means, history information indicating at least one of a change history of the object laid out in the 3D space, a change history of at
20 least one of the position and posture of the object laid out in the 3D space, and a minute generated based on the discussion information.

3. The drawing verification system according to claim 2, wherein the second transmission means transmits the information of the verification input in association with identification information indicating the client apparatus to which
25 the verification input has been input, or a user of the client apparatus, and
information pertaining to each verification input is associated with the identification information corresponding to the verification input in the history

information.

4. The drawing verification system according to any one of claims 1 to 3, wherein the information of the verification input is composed by including viewpoint information indicating a position and direction of a viewpoint of the view of binocular stereoscopic vision presented in the client apparatus,
- 5 the shared information is composed by including the pieces of viewpoint information received from the plurality of client apparatuses participating in the session, and
- the construction means lays out an avatar based on the viewpoint
- 10 information pertaining to other client apparatus in the constructed 3D space.

5. The drawing verification system according to any one of claims 1 to 4, wherein when a change of the state information by the change means occurs, the shared information includes a difference of the state information pertaining to the change.

- 15 6. The drawing verification system according to any one of claims 1 to 5, wherein at least one of a parameter of the viewpoint pertaining to a rendering output of the view of binocular stereoscopic vision and scaling of 3D model data included in the rendering object information is set to a value that enables the view of binocular stereoscopic to allow viewing of an object represented by the
- 20 rendering object information at actual size.

7. The drawing verification system according to any one of claims 1 to 6, wherein the rendering object information includes 3D model data that is for an object represented by the rendering object information and that is composed based on CAD data of the object included in the drawing information.

- 25 8. The drawing verification system according to any one of claims 1 to 7, wherein the rendering object information is composed by including motion information that defines motions of at least some objects represented by the

rendering object information.

9. The drawing verification system according to any one of claims 1 to 8, wherein in the session, at least one of a change of an object, a layout of an object, zoning, a traffic line, a temperature condition, an air-conditioner layout, an illumination condition, an illumination layout, maintainability, a camera installation location, and a camera angle-of-view setting is provided as a verification item of the drawing information, and
- 5 in response to the input means detecting the verification input pertaining to selection of the verification item in the client apparatus, the view of binocular stereoscopic vision including display for the verification item is presented in the plurality of client apparatuses connected to the session.
- 10 10. The drawing verification system according to any one of claims 1 to 9, wherein the drawing information includes at least the rendering object information and the layout information corresponding to the drawing information,
- 15 each of the plurality of client apparatuses further comprises first recording means for storing the drawing information, and
- the construction means constructs at least part of the 3D space based on the shared information, and the rendering object information and the layout information that are stored in the first recording means.
- 20 11. The drawing verification system according to claim 10, wherein the rendering object information is stored in each of the plurality of client apparatuses.
12. The drawing verification system according to claim 10 or 11, wherein the drawing information includes authority information indicating whether to permit participation in the session, and
- 25 when the drawing information including the authority information that permits participation in the session is stored in the first recording means, each of the plurality of client apparatuses is controlled to connect to the session.

13. The drawing verification system according to claim 10 or 11, wherein the server apparatus further comprises second recording means for storing the layout information corresponding to the drawing information, and
- the management means manages the state of the 3D space based on the layout information stored in the second recording means and the state information.
14. The drawing verification system according to any one of claims 1 to 9, wherein the drawing information includes at least the rendering object information and the layout information corresponding to the drawing information, and
- the server apparatus further comprises:
- second recording means for storing the drawing information; and
- update means for updating the drawing information stored in the second recording means based on the information of the verification input received by the first reception means.
15. The drawing verification system according to claim 14, wherein the server apparatus further comprises third transmission means for transmitting, to the client apparatus, at least the rendering object information and the layout information that are stored in the second recording means when the client apparatus connects to the session,
- each of the plurality of client apparatuses further comprises:
- third reception means for receiving the rendering object information and the layout information that are transmitted from the third transmission means; and
- first recording means for storing the rendering object information and the layout information that are received by the third reception means, and
- the construction means constructs at least part of the 3D space based on the shared information, and the rendering object information and the layout information that are stored in the first recording means.
16. The drawing verification system according to claim 15, wherein when a

change instruction is made for an object laid out in the 3D space, the first transmission means transmits the shared information including rendering object information pertaining to the object after the change.

17. The drawing verification system according to any one of claims 14 to 16,
5 wherein layout information composed of combinations and layouts of rendering object information for multiple types of objects is predefined as a template to be able to use in verification of the session, and

the server apparatus further comprises adjustment means for performing, when the same changes are made by more than a predetermined number of times
10 to layout information based on the same template in a plurality of the sessions, at least one of changing the layout information and proposing a change in a session for verifying the drawing information that adopts the layout information.

18. A client apparatus that connects and performs information communication via a network to a session pertaining to verification of drawing
15 information designed based on a facility specification,

wherein the verification in the session is performed by laying out rendering object information used to render an object included in the drawing information in a virtual 3D space based on layout information that corresponds to the drawing information and indicates a position and posture of the object,

20 the client apparatus comprises:

reception means for receiving shared information necessary to render the 3D space in which verification is performed in the session;

construction means for constructing at least part of the 3D space based on the shared information received by the reception means, the rendering object
25 information, and the layout information;

decision means for deciding a position and direction of a viewpoint at which the constructed 3D space is rendered;

output means for sequentially rendering and outputting views of
binocular stereoscopic vision of the constructed 3D space rendered based on the
viewpoint decided by the decision means;

presentation means for presenting the views of binocular stereoscopic
5 vision rendered and output by the output means;
input means for accepting a verification input; and
transmission means for transmitting information of the verification input
accepted by the input means.

19. The client apparatus according to claim 18, wherein the drawing
10 information includes at least the rendering object information and the layout
information corresponding to the drawing information, and authority information
indicating whether to permit participation in the session,

each of the client apparatuses further comprises:
recording means for storing the drawing information; and
15 control means for controlling to connect to the session when the drawing
information stored in the recording means includes the authority information that
permits participation in the session, and

the construction means constructs at least part of the 3D space based on
the shared information, and the rendering object information and the layout
20 information that are stored in the recording means.

20. A program for causing a computer to function as each means of the client
apparatus according to claim 18 or 19.

21. A computer-readable recording medium that records the program
according to claim 20.
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