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INFORMATION PROCESSING APPARATUS CONTROLLING STATE TRANSITION OF CONTENT DISPLAYED IN VIRTUAL SPACE, INFORMATION PROCESSING METHOD, AND STORAGE MEDIUM

Abstract

An information processing apparatus that enables a user to safely and comfortably experience content displayed in a virtual space. The information processing apparatus, which displays a virtual space on a head mounted display worn by a user, acquires a play area of the user as a first play area, detects an obstacle in a real space in the first play area and generates obstacle information indicating a positional relationship between the detected obstacle and the first play area, acquires user information from the user, executes state transition determination of determining whether content to be displayed in the virtual space can transition to a next state on basis of the obstacle information and the user information, and makes a notification according to a result of the state transition determination.

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Background/Summary

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an information processing apparatus, an information processing method, and a storage medium, and particularly to an information processing system controlling state transition of content displayed in a virtual space, an information processing method, and a storage medium.

Description of the Related Art

[0002] In recent years, a technology called virtual reality (VR) for experiencing immersion in a virtual space created by a computer different from reality has been widely used. There are many pieces of content, displayed in the virtual space, to which the VR technology is applied (hereinafter, VR content). For example, while a head mounted display (HMD) is worn on the head and a screen displayed on the HMD is viewed, a controller or the like is operated to play a game. When the HMD is worn in this way, the real world becomes invisible, and thus the user's sense of immersion in the virtual space increases. In VR content in which a remote user, a non player character (NPC), or the like is displayed in the HMD and a sports battle is played, the user wearing the HMD can also play a game in a play area set on the virtual space.

[0003] For example, Japanese Laid-Open Patent Publication (kokai) No. 2018-029968 discloses a technology in which, when a user wears an HMD and enjoys a virtual space, the HMD causes a game to transition to a primary stop state when receiving a game suspension signal, and then causes the game to transition to a restart state when receiving a game restart signal.

[0004] However, in the technology of Japanese Laid-Open Patent Publication (kokai) No. 2018-029968, since the state transition of the game is performed in response to reception of a signal such as the game suspension signal or the game restart signal, there is a problem in that the state transition of the game is performed in a state where the safety of the user is not secured.

SUMMARY OF THE INVENTION

[0005] The present invention provides an information processing apparatus that enables a user to safely and comfortably experience content displayed in a virtual space, an information processing method, and a storage medium.

[0006] Accordingly, the present invention provides an information processing apparatus according to claim **1** displaying a virtual space on a head mounted display worn by a user, comprises one or more processors and/or circuitry configured to acquire a play area of the user as a first play area, detect an obstacle in a real space in the first play area and generate obstacle information indicating a positional relationship between the detected obstacle and the first play area, acquire user information from the user, execute state transition determination of determining whether content to be displayed in the virtual space can transition to a next state on basis of the obstacle information and the user information, and make a notification according to a result of the state transition determination.

[0007] Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a diagram showing a hardware configuration example of an information processing apparatus according to a first embodiment of the present invention.

[0009] FIG. **2** is a block diagram showing a functional configuration according to the first embodiment of the present invention of the information processing apparatus.

[0010] FIG. **3** is a diagram showing an example of state transition control of VR content according to the first embodiment of the present invention.

[0011] FIG. **4** is a flowchart of state transition control processing of VR content according to the first embodiment of the present invention.

[0012] FIGS. **5**A and **5**B are diagrams showing variations of state transition control of VR content according to the first embodiment of the present invention.

[0013] FIGS. **6**A to **6**C are diagrams showing examples of HMD display according to the first embodiment of the present invention.

[0014] FIGS. **7**A and **7**B are diagrams showing examples of an obstacle and a play area in a three-dimensional space.

[0015] FIG. **8** is a block diagram showing a functional configuration according to a second embodiment of the present invention of the information processing apparatus.

[0016] FIG. **9** is a diagram showing an example of state transition control of VR content according to the second embodiment of the present invention.

[0017] FIG. **10** is a flowchart of state transition control processing of VR content according to the second embodiment of the present invention.

[0018] FIG. **11** is a diagram showing an example of HMD display according to the second embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0019] The present invention will now be described in detail below with reference to the accompanying drawings showing embodiments thereof.

[0020] Hereinafter, embodiments according to the present invention will be described with reference to the drawings. The following embodiments do not limit the present invention, and not all combinations of features described in the present embodiments are essential to the solution of the present invention. The configuration of the embodiment can be appropriately modified or changed according to specifications of an apparatus to which the present invention is applied and various conditions (usage conditions, usage environment, etc.). Some of the embodiments described later may be appropriately combined. In the following embodiments, the same components are denoted by the same reference numerals.

First Embodiment

[0021] FIG. **1** is a block diagram showing a hardware configuration example of an information processing apparatus **101** according to a first embodiment of the present invention. FIG. **2** is a block diagram showing a functional configuration according to the first embodiment of the present invention of the information processing apparatus **101**. FIG. **3** is a diagram showing an example of state transition control of VR content according to the first embodiment of the present invention. It should be noted that, here, content displayed in a virtual space is referred to as VR content.

[0022] First, an example of state transition control of VR content in the virtual space according to the present embodiment on the basis of the state of the real space and the state of the user will be described with reference to FIG. **3**. Here, as an example, a scene in which the user plays VR table tennis at home will be described. However, the VR content to which the present invention is applied is not limited to VR table tennis as long as it is a scene in which battle type VR content (sports, game, training) is started at home or the like.

[0023] An image **300** in FIG. **3** is an image of the user viewed from above.
[0024] FIG. **3** shows a trash box **301** which is an obstacle in the real space, a user **302** who experiences VR content, a virtual table tennis table **303**, a play area **304**, an avatar **305** of an opponent, and a line-of-sight direction **306** of the user **302**.
[0025] The play area **304** is a play area of the user **302**, and the size thereof is defined in advance according to the type of VR content and the number of players. In FIG. **3**, the play area **304** indicates a movement range of a user of a singles game in VR table tennis.
[0026] It should be noted that, although the user **302** cannot see the trash box **301** in the real space because the user **302** wears a head mounted display (HMD), the HMD worn by the user **302** has a function of acquiring position and orientation information of the trash box **301** and the user **302**. Therefore, the HMD can obtain obstacle information indicating a positional relationship between the trash box **301** and the play area **304**. The HMD can reflect the motion similar to the motion of the user **302** in the real space on an avatar in the virtual space.
[0027] The information processing apparatus **101** (FIG. **1**) determines whether or not to permit a state transition of VR content according to information (position, posture, line of sight, voice) of the user **302** and the obstacle information in the real space existing in the play area **304**, which are acquired by the HMD, and displays the VR content on the HMD. Specifically, state transition control processing of VR content described later will be described with reference to the flowchart of FIG. **4**.
[0028] In order to transition to a state in which the user **302** can start the VR content, it is necessary to confirm in advance whether the safety of the user **302** is secured or whether the preparation of the user **302** for starting the VR content is completed. However, since the user **302** wearing the HMD cannot see the real space, it is difficult for the user himself/herself to recognize the obstacle (trash box **301**) in the real space during the VR content experience and then transition the state of the VR content next.
[0029] When the opponent is an NPC, there is a case where the NPC transitions the state of the VR content regardless of the state of the user **302** or the state of the real space, and in this case, the user **302** cannot comfortably experience the VR content.
[0030] When the user **302** starts the VR content in the state of FIG. **3**, there is a possibility of coming in contact with the trash box **301** during game play since the trash box **301** exists in the play area **304**. In the existing technology, when a text message is received or a person who is talking in the vicinity of the user **302** is detected, the game that is the VR content is interrupted, but the game is not interrupted according to the state of the user **302** or the state of an obstacle in the real space.
[0031] Therefore, in the present embodiment, the information processing apparatus **101** determines whether or not to permit a state transition of VR content from user information such as position information, posture information, and line-of-sight information of the user **302** who experiences the VR content and the obstacle information of the real space, and presents the VR content to the user **302**. This enables the user **302** to safely and comfortably experience the VR content.
[0032] Next, the hardware configuration of the information processing apparatus **101** will be described with reference to FIG. **1**.
[0033] The information processing apparatus **101** is an HMD worn by the user **302** and is connected to an external PC. However, the information processing apparatus **101** may be an electronic device capable of communicating with and controlling the HMD worn by the user **302**, and may be, for example, an electronic device such as a PC to which the HMD is connected. The information processing apparatus **101** includes, as components, a CPU **102**, a ROM **103**, a RAM **104**, a sensing unit **105**, an imaging unit **106**, a display unit **107**, an operation unit **108**, and a communication unit **109**. The components are connected to each other via a bus **110**.
[0034] The CPU **102** is an arithmetic processing apparatus that integrally controls the information processing apparatus **101**. The CPU **102** executes various programs stored in the ROM **103** or the

like to perform various processes.
[0035] The ROM **103** is a read-only nonvolatile memory device that stores programs (information processing programs, initial data, and the like) and parameters that do not need to be changed.
[0036] The RAM **104** temporarily stores input information, calculation results in information processing, and the like. The RAM **104** is a memory device that provides the CPU **102** with a work area.
[0037] The sensing unit **105** is a device such as a sensor, and detects the rotation, inclination, or movement amount of the head, and the line of sight of the user **302** wearing the information processing apparatus **101** that is an HMD, thereby acquiring the position and orientation information and the line-of-sight direction information of the user **302**. The sensing unit **105** also includes a sound collecting device such as a microphone that acquires the voice of the user **302**.
[0038] The imaging unit **106** is an imaging device which is a built-in camera of the information processing apparatus **101** that is an HMD, and performs imaging processing. It should be noted that, when the information processing apparatus **101** is a PC connected to the HMD worn by the user, an externally connected web camera or the like functions as the imaging unit **106**.
[0039] The display unit **107** includes a liquid crystal display or the like, and displays a captured image, a virtual object, a character, an icon, or the like to the user wearing the information processing apparatus **101** that is an HMD.
[0040] The operation unit **108** is an operation unit including an operation member such as a power button or a dial.
[0041] The communication unit **109** transmits and receives data to and from an external device by wired communication or wireless communication (wireless LAN, local 5G, etc.). Examples of the external device include an external controller (not shown) held by the user wearing the information processing apparatus **101** that is an HMD, another HMD, and an external operation panel. It should be noted that, when the information processing apparatus **101** is a PC connected to the HMD worn by the user, the communication unit **109** receives position and orientation information and the like detected by the HMD via a network (not shown).
[0042] FIG. **2** is a block diagram showing a functional configuration according to the present embodiment of the information processing apparatus **101** that is an HMD (hereinafter, simply referred to as HMD **101**).
[0043] The HMD **101** includes, as a functional configuration, a play area acquisition unit **201**, an obstacle detection unit **202**, a user position detection unit **203**, a user posture detection unit **204**, a user's line-of-sight detection unit **205**, a state transition determination unit **206**, and a notification unit **207**.
[0044] The play area acquisition unit **201** acquires, from the ROM **103**, information on a play area (first play area) for the user to experience VR content. The size of the play area is defined in advance according to the type of VR content and the number of players.
[0045] The obstacle detection unit **202** detects an obstacle in the real space in the play area and generates obstacle information indicating a positional relationship between the detected obstacle and the play area. There are various kinds of obstacles such as a wall, a chair, a desk, a trash box, a person, and a pet, but a method for specifying an obstacle is not described herein. It should be noted that the detection of the obstacle in the present embodiment may be detected by the imaging unit **106** that is a camera attached to the HMD **101**, or may be detected using an external second camera via the communication unit **109**. Alternatively, the detection may be performed using the sensing unit **105** that is a sensor.
[0046] The user position detection unit **203** acquires position information in the virtual space of the user wearing the HMD **101** by the sensing unit **105**, and holds the position information as the position information of the user.
[0047] The user posture detection unit **204** acquires posture information in the virtual space of the user wearing the HMD **101** by the sensing unit **105**, and holds the posture information as the

posture information of the user.
[0048] The user's line-of-sight detection unit **205** acquires information of the line-of-sight direction in the virtual space of the user wearing the HMD **101** by the sensing unit **105**, and holds the information.
[0049] The state transition determination unit **206** determines whether or not to transition the VR content state to the next state (state transition determination) according to the obstacle information generated by the obstacle detection unit **202** and the user information such as the position, posture, and line-of-sight direction of the user.
[0050] The notification unit **207** (notifying unit) displays, on the display unit **107**, a notification screen corresponding to the result of the state transition determination in the state transition determination unit **206**.
[0051] FIG. **4** is a flowchart of state transition control processing of VR content according to the present embodiment. The processing shown in this flowchart is realized by the CPU **102** reading a program stored in the ROM **103** into the RAM **104** and executing the program. The execution timing of this processing is not limited. For example, it may be a timing at which a user wearing the HMD **101** (hereinafter, simply referred to as a user) activates VR content, or may be executed when the operation unit **108** detects a predetermined user operation. Hereinafter, the VR table tennis will be described as an example in which the VR content is in an interrupted state and the user is in the play area at the start of the VR content.
[0052] First, in step S**401**, the play area acquisition unit **201** acquires information on the play area of the VR content currently interrupted from the ROM **103**.
[0053] Next, in step S**402**, the obstacle detection unit **202** detects an obstacle in the real space in the play area on the basis of the information on the play area acquired in step S**401**. At this time, the notification unit **207** may notify the user to look around so that a wide area around the user can be searched. Thereafter, the obstacle detection unit **202** generates obstacle information indicating a positional relationship between the detected obstacle and the play area.
[0054] Next, in step S**403**, the user position detection unit **203** acquires position information of the user.
[0055] Next, in step S**404**, the user posture detection unit **204** acquires posture information of the user.
[0056] Next, in step S**405**, the user's line-of-sight detection unit **205** acquires information of the line-of-sight direction of the user (line-of-sight information).
[0057] It should be noted that the generation of the obstacle information and the acquisition of the position, posture, and line-of-sight information of the user in steps S**402** to S**405** may be performed after step S**401** and before step S**406** described later, and the execution order thereof is not limited to the order shown in FIG. **4**.
[0058] Next, in step S**406**, the state transition determination unit **206** determines whether or not to permit a state transition of VR content on the basis of the obstacle information generated in step S**402** and the position, posture, and line-of-sight information of the user acquired in steps S**403** to S**405**. Specifically, when table tennis is played in the real space, the referee confirms whether the receiver is ready before resuming the interrupted game and starting a serve by hitting the ball held in the hand by the opponent on the server side, so a similar operation is performed in the VR environment. When it is determined that the state transition of the VR content cannot be performed (NO in step S**406**), the processing proceeds to step S**408**, and when it is determined that the state transition of the VR content can be performed (YES in step S**406**), the processing proceeds to step S**407**.
[0059] Here, a method for determining whether or not to permit a state transition of VR content according to the present embodiment will be described with reference to FIG. **3** and FIGS. **5**A and **5**B. Each of the image **300** of FIG. **3**, an image **500** of FIG. **5**A, and an image **510** of FIG. **5**B is an image of the user viewed from above.

[0060] Here, as shown in FIG. **3**, when the trash box **301** exists in the play area **304**, the user **302** may collide with the trash box **301** during the game. In such a case, in order to avoid a collision between the user **302** and the trash box **301**, the state transition determination unit **206** determines that the state transition of the VR content cannot be performed, that is, maintains the current suspension state and does not transition to the play state.
[0061] FIGS. **5**A and **5**B are diagrams for explaining a method for determining whether or not to permit a state transition of VR content on the basis of the obstacle information generated in step S**402** and the line-of-sight direction information of the user **302** acquired in step S**405**.
[0062] In the image **500** in FIG. **5**A, there is no obstacle in the real space in the play area **304**, but a line-of-sight direction **501** of the user **302** does not face the direction of the avatar **305** of the opponent. Therefore, the state transition determination unit **206** determines that the state transition of the VR content cannot be performed, that is, maintains the current suspension state and does not transition to the play state.
[0063] On the other hand, in the image **510** in FIG. **5**B, there is no obstacle in the real space in the play area **304**, and a line-of-sight direction **511** of the user **302** faces the direction of the avatar **305** of the opponent. Therefore, the state transition determination unit **206** determines that the state of the VR content can transition, that is, the state transitions from the current suspension state to the play state.
[0064] It should be noted that, in the present embodiment, when an angle formed by the line-of-sight direction of the user acquired in step S**405** and the direction of the avatar of the opponent viewed from the user in the virtual space is a predetermined angle or less, it is determined that the line of sight of the user is directed to the avatar of the opponent. On the other hand, when the angle formed by the line-of-sight direction of the user and the direction of the avatar of the opponent viewed from the user in the virtual space is larger than the predetermined angle, it is determined that the line of sight of the user is not directed to the avatar of the opponent.
[0065] In the present embodiment, the line-of-sight direction of the user to the opponent is used to determine whether or not to permit a state transition, but the present invention is not limited thereto. The line-of-sight direction of the user used to determine whether or not to permit the state transition may be able to be designated for each VR content, or may be able to be set according to the type and the number of opponents. A gaze time may be used in addition to the line-of-sight direction of the user. The target to which the line of sight of the user is directed may be a target designated in advance. For example, the target may be a predetermined area in the virtual space instead of the avatar of the opponent.
[0066] Even when the user does not exist in the play area or when either the position or the posture of the user is not stationary in the play area, it may be determined that the user is not ready and the state of the VR content cannot transition.
[0067] Further, when the user does not conform to a posture specified in advance, for example, a form of a reception in table tennis, or the like, it may be determined that the user is not ready and the state of the VR content cannot transition.
[0068] The information processing apparatus **101** may include a user voice detection unit (FIG. **8**) described later. In this case, when there is utterance of a word specified in advance by the user, for example, “WAIT!”, it may be determined that the state of the VR content cannot transition since the user is not ready.
[0069] That is, when it is determined that there is no obstacle in the play area **304** and the preparation of the user is ready on basis of at least one of the position, line of sight, posture, and voice of the user, the state transition determination unit **206** determines that the state of the VR content can transition.
[0070] Next, in step S**407**, the state transition determination unit **206** transitions the state of the VR content according to the determination result in step S**406**. For example, the state transitions from the suspension state to the play state.

[0071] Next, in step S**408**, the notification unit **207** performs HMD display of displaying a notification screen according to the state of the VR content on the HMD **101** (display unit **107**) of the user. Thereafter, this processing ends.
[0072] FIGS. **6**A to **6**C are examples of the HMD display according to the state of the VR content.
[0073] In FIGS. **6**A to **6**C, a user on the receiver side when playing in VR table tennis is referred to as a first user, and a user on the server side is referred to as a second user.
[0074] In FIG. **6**A, an HMD display **600** is an HMD display example when the state of the VR content used by the user wearing the HMD **101** as the first user is in the play state.
[0075] On the HMD display **600** displayed on the display unit **107** of the first user, a play area **601**, a virtual table tennis table **602**, an avatar **603** of the second user who is an opponent, and a text **604** are displayed.
[0076] The text **604** is a user interface that presents a message to the first user according to the current state, and displays "PLAY" indicating that the state of the VR content is the play state. In this state, a ball is displayed on the hand of the avatar **603** of the second user, so that the second user can hit the ball to start serving.
[0077] An HMD display **610** of FIG. **6**B is an HMD display example when the state of the VR content used by the user wearing the HMD **101** as the first user is in the suspension state. An HMD display **620** of FIG. **6**C is an HMD display example when the stat of the VR content used by the user wearing the HMD **101** as the second user is in the suspension state.
[0078] On the HMD display **610** (FIG. **6**B) displayed on the display unit **107** of the first user, a play area **611**, a virtual table tennis table **612**, an avatar **613** of the second user who is an opponent, and a text **614** are displayed.
[0079] The text **614** is a user interface that presents a message to the first user according to the current state, and displays "TIME!! " indicating that the state of the VR content is the suspension state.
[0080] On the HMD display **620** (FIG. **6**C) displayed on the display unit **107** of the second user, a play area **621**, a virtual table tennis table **622**, an avatar **623** of the first user who is an opponent, and a text **624** are displayed.
[0081] The text **624** is a user interface that presents a message to the second user according to the current state, and displays "TIME!! " indicating that the state of the VR content is the suspension state. In this state, a ball is not displayed on the hand of the avatar **613** of the second user, so that the second user cannot start serving.
[0082] It should be noted that, in the present embodiment, the method for determining whether or not to permit a state transition in the two-dimensional space in the horizontal direction has been described with reference to FIGS. **3**, **5**A, and **5**B, but a three-dimensional space including the vertical direction may be used. The shape of the play area may be changed according to the type of VR content.
[0083] FIGS. **7**A and **7**B are diagrams for explaining a method for determining whether or not to permit a state transition using obstacle detection and posture information in the three-dimensional space including the vertical direction.
[0084] An image **700** of FIG. **7**A is an image of the user viewed from above, and an image **710** of FIG. **7**B is an image of the user viewed from right beside.
[0085] In FIGS. **7**A and **7**B, a user **701** and a user **711** are the same person. A lighting **702** and a lighting **712** are the same obstacle existing in the real space, and similarly, a trash box **703** and a trash box **713** are the same obstacle existing in the real space. A play area **704** and a play area **714** indicate the same area, and a table tennis table **705** and a table tennis table **715** are the same virtual object. The height of the play area **714** is preferably set such that the tip of a racket or the like gripped by the user **711** is within the play area **714** even when the user holds the racket or the external controller and raises his/her hand directly upward. Since the user **711** usually does not enter a space **714***u* under the virtual table tennis table **715** during the game play, the space **714***u* is

excluded from the space of the play area **714**. Therefore, the trash box **703** looks like being in the play area **704** when viewed from above as in the image **700**, but the trash box **713** is not in the play area **714** when viewed from right beside as in the image **710**. Thus, in the cases of FIGS. **7**A and **7**B, there is no obstacle in the play area, and the safety of the user can be secured even when the game is resumed. Therefore, the state transition determination unit **206** determines that the state of the VR content can transition, that is, the state transitions from the current suspension state to the play state. The user posture detection unit **204** may acquire posture information of the user **711** in three dimensions, and determine whether or not the user **711** squats below the table tennis table **715** from the posture information. At this time, when it is determined that the user **711** is squatting, the state transition determination unit **206** may determine that the user **711** is not ready for a serve from the opponent on the server side and cannot transition the state of the VR content.

[0086] As described above, according to the present embodiment, the user can safely and comfortably experience the VR content by using the obstacle information in the real space and the user information.

Second Embodiment

[0087] The HMD **101** according to a second embodiment will be described with reference to FIGS. **8** to **11**.

[0088] Since the HMD **101** according to the second embodiment has a hardware configuration similar to that of the HMD **101** according to the first embodiment, redundant description will be omitted.

[0089] The HMD **101** according to the first embodiment determines whether or not to permit the state of the VR content on the basis of the obstacle information in the real space and the position and orientation information and line-of-sight information of the user, and presents the determination result to the user. On the other hand, the HMD **101** according to the second embodiment uses one VR content by a plurality of persons at the same time, determines whether or not to permit the state of the VR content on the basis of the obstacle information in the real space of each user and the position and orientation information, line-of-sight information, and voice information of each user, and presents the determination result to the each user. Here, as an example, the operation of the HMD **101** according to the present embodiment will be described with a scene where a plurality of persons handle a work device in cooperation.

[0090] FIG. **8** is a block diagram showing a functional configuration according to the present embodiment of the HMD **101**.

[0091] The HMD **101** includes, as a functional configuration, a play area acquisition unit **201**, an obstacle detection unit **202**, a user position detection unit **203**, a user posture detection unit **204**, a user's line-of-sight detection unit **205**, a user voice detection unit **806**, a state transition determination unit **206**, and a notification unit **207**. That is, in the HMD **101** in the present embodiment, the user voice detection unit **806** is added to the function (FIG. **2**) of the HMD **101** according to the first embodiment.

[0092] The user voice detection unit **806** acquires a voice with a sound collection device such as a microphone attached to the HMD **101** worn by the user. It should be noted that, the user voice detection unit **806** may acquire a voice with an external sound collection device of the HMD **101** such as an intercom.

[0093] The operation of the HMD **101** at the time of work by a plurality of persons in the present embodiment will be described with reference to FIG. **9**. An image **900** in FIG. **9** is an image of a device installation work viewed from above.

[0094] In FIG. **9**, users **903**, **905**, and **908** and a work device **901** exist in the real space.

[0095] The work device **901** is a real space device in which an operation panel **902** is provided and work is simultaneously performed by the users **903**, **905**, and **908**.

[0096] The user **903**, the user **905**, and the user **908** are users who operate the work device **901**, and although not shown in FIG. **9**, the users **905** and **908** wear the HMDs **101** and **101***a*, respectively,

and perform work while receiving work support by the VR content. The user **903** does not wear the HMD. It should be noted that, since an HMD **101***a* is an information processing apparatus having the same hardware configuration and functional configuration as those of the HMD **101**, thus "a" is added at the end of the numbering for the corresponding configuration, and redundant description will be omitted.

[0097] A play area **906** (first play area) is a play area of the user **905** wearing the HMD **101**, and is acquired by the play area acquisition unit **201**. A play area **909** (second play area) is a play area of the user **908** wearing the HMD **101***a*, and is acquired by a play area acquisition unit **201***a*. A work area **904** (first work area) is an area where the user **905** performs work, and a work area **911** (second work area) is an area where the user **908** performs work. The HMD **101** superimposes and displays a video of the real space viewed from the user **905** on the virtual space. Similarly, the HMD **101***a* superimposes and displays a video of the real space viewed from the user **908** on the virtual space. The user **903** operates the entire work device **901** using the operation panel **902**.

[0098] It should be noted that, in the present embodiment, the work device **901**, the work area **904**, the work area **911**, and the operation panel **902** are described as objects/areas existing in the real space, but may be objects/areas on the virtual space.

[0099] A line-of-sight direction **907** is a line-of-sight direction of the user **905** and is detected by the user's line-of-sight detection unit **205**. Similarly, a line-of-sight direction **910** is a line-of-sight direction of the user **908** and is detected by a user's line-of-sight detection unit **205***a*.

[0100] The work in the work device **901** needs to be performed by the users **903**, **905**, and **908** in cooperation, and the user **903** (third user) operates the operation panel **902** in a state where the preparation of the users **905** and **908** are ready. The HMD **101** worn by the user **905**, the HMD **101***a* worn by the user **908**, and the operation panel **902** are communicably connected to each other. Accordingly, when the state transition determination unit **206** determines that the preparation of the users **905** and **908** are ready, the determination result is reflected in the interface of the operation panel **902**.

[0101] Here, the state in which the preparation of the user **905** is ready means that conditions under which the user **905** can safely start work are satisfied. Specifically, it indicates that there is no obstacle detected by the obstacle detection unit **202** in the play area **906**, that the user **905** is in the play area **906**, and that the line-of-sight direction **907** is directed to the work area **904**. In addition, presence or absence of a word specified in advance by the user **905**, for example, utterance of "READY" may be included in the condition.

[0102] Similarly, the state in which the preparation of the user **908** is ready means that conditions under which the user **908** can safely start work are satisfied. Specifically, it indicates that there is no obstacle detected by an obstacle detection unit **202***a* in the play area **909**, that the user **908** is in the play area **909**, and that the line-of-sight direction **910** is directed to the work area **911**. In addition, presence or absence of a word specified in advance by the user **908**, for example, utterance of "READY" may be included in the condition. It should be noted that, the obstacle information (second obstacle information) generated by the obstacle detection unit **202***a* of the HMD **101***a* and the user information (second user information) such as the position, posture, and line-of-sight direction of the user **908** are acquired by the state transition determination unit **206** via the communication unit **109**.

[0103] FIG. **10** is a flowchart of state transition control processing of VR content according to the second embodiment of the present invention. The processing shown in this flowchart is realized by the CPU **102** executing the information processing program according to the present embodiment. The execution timing of this processing is not limited. For example, it may be a timing at which any one of the users **905** and **908** activates VR content, or may be executed when the operation unit **108** detects a predetermined user operation. Hereinafter, the installation work of the work device **901** will be described as an example on the assumption that work support by VR content cannot be performed (hereinafter, referred to as a work impossible state).

[0104] Since the processing from step S**1001** to step S**1005** is similar to the processing from step S**401** to step S**405** shown in FIG. **4**, the description thereof will be omitted.
[0105] In step S**1006**, the user voice detection unit **806** acquires the voice of the user.
[0106] It should be noted that the generation of the obstacle information and the acquisition of the position information, posture information, and line-of-sight information of the user **905**, and the voice of the user **905** in steps S**1002** to S**1006** may be performed after step S**1001** and before step S**1007** described later. That is, the execution order thereof is not limited to the order shown in FIG. **10**. Although not shown in the flowchart of FIG. **10**, processing similar to steps S**1002** to S**1006** is executed by a CPU **102***a* of the HMD **101***a*, and obstacle information and various types of user information of the actual environment on the user **908** side are acquired.
[0107] Next, in step S**1007**, the state transition determination unit **206** determines whether or not to permit a state transition of VR content on basis of the obstacle information of the actual environment acquired in step S**1002** and various types of user information acquired in steps S**1003** to S**1006**. When it is determined that the state transition of the VR content cannot be performed (NO in step S**1007**), the processing proceeds to step S**1009**, and when it is determined that the state transition of the VR content can be performed (YES in step S**1007**), the processing proceeds to step S**1008**.
[0108] Here, a method for determining whether or not to permit a state transition of VR content according to the present embodiment will be described with reference to FIG. **9**. As described above, when the preparation of the user **905** and the user **908** are ready, the state transition determination unit **206** determines that the state transition of the VR content can be performed. Specifically, when there is no obstacle in the play area **906**, the user **905** is in the play area **906**, the line-of-sight direction **907** is directed to the work area **904**, and the user **905** has uttered the specified word, it is determined that the preparation of the user **905** is ready. Here, the specified word is not particularly limited, but “READY” or the like is exemplified.
[0109] In addition to the determination condition for determining that the preparation of the user **905** is ready, the user may perform a posture designated in advance, for example, a posture according to a pointing posture for safety confirmation. The determination condition may be stored in the ROM **103** in advance, or may be added or deleted by the user. The determination condition may be stored in the ROM **103** with a priority or may be selected by the user. That is, when it is determined that there is no obstacle in the play area **906** and at least one of the position, line of sight, posture, and voice of the user satisfies the determination condition for determining that the preparation of the user **905** is ready, the state transition determination unit **206** determines that the preparation of the user **905** is ready.
[0110] In the present embodiment, when the preparation of both users of the users **905** and **908** is ready, the state transition determination unit **206** determines that the state of the VR content can transition, and the processing proceeds to step S**1008**. On the other hand, when the preparation of any one of the users **905** and **908** is not ready, the state transition determination unit **206** determines that the state of the VR content cannot transition, and the processing proceeds to step S**1009**. That is, the state transition determination unit **206** acquires information indicating whether or not the preparation of the user **908** is ready from the HMD **101***a*, and determines whether or not to permit a state transition of VR content.
[0111] Next, in step S**1008**, the state transition determination unit **206** transitions the state of the VR content according to the determination result in step S**1007**. For example, the state transitions from the work impossible state to a state in which work support by the VR content can be performed (hereinafter, referred to as a workable state).
[0112] Next, in step S**1009**, the notification unit **207** transmits information indicating the state of the VR content to the operation panel **902**, and causes the operation panel **902** to display a notification screen for the user **903** according to the received information. Hereinafter, the operation of the notification unit **207** and the operation panel **902** in step S**1009** will be described

with reference to FIGS. **9** and **11**.
[0113] FIG. **11** is an example of a notification screen displayed on the operation panel **902** visually recognized by the user **903**.
[0114] As shown in FIG. **11**, a notification screen including a start button **1103** and a stop button **1104** is displayed on the operation panel **902** of the work device **901**.
[0115] The start button **1103** is a user interface for activating the work device **901**, and the stop button **1104** is a user interface for stopping the work device **901**.
[0116] When the state transition determination unit **206** causes the state of the VR content to transition to the workable state in step S**1008**, the notification unit **207** transmits information indicating that the state of the VR content is in the workable state to the operation panel **902** in step S**1009**. When receiving this information, the operation panel **902** sets the start button **1103** to the active state (user-selectable state).
[0117] On the other hand, when the state transition determination unit **206** causes the state of the VR content to be maintained in the work impossible state in step S**1008**, the notification unit **207** transmits information indicating that the state of the VR content is maintained in the work impossible state to the operation panel **902** in step S**1009**. When receiving this information, the operation panel **902** sets the start button **1103** to the inactive state (user-non-selectable state).
[0118] At this time, the operation panel **902** may change the display method of the start button **1103** between the active state and the inactive state. When the start button **1103** is in the active state, the user **903** can start the work device **901** by pressing the start button **1103**.
Other Embodiments
[0119] Embodiment(s) of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.
[0120] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.
[0121] This application claims the benefit of Japanese Patent Application No. 2024-022785, filed Feb. 19, 2024 which is hereby incorporated by reference herein in its entirety.

Claims

1. An information processing apparatus displaying a virtual space on a head mounted display worn by a user, comprising: one or more processors and/or circuitry configured to: acquire a play area of

the user as a first play area; detect an obstacle in a real space in the first play area and generate obstacle information indicating a positional relationship between the detected obstacle and the first play area; acquire user information from the user; execute state transition determination of determining whether content to be displayed in the virtual space can transition to a next state on basis of the obstacle information and the user information; and make a notification according to a result of the state transition determination.

2. The information processing apparatus according to claim 1, wherein the user information includes at least one of a position, line-of-sight direction, posture, or voice of the user.

3. The information processing apparatus according to claim 2, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not a position of the obstacle exists in the first play area.

4. The information processing apparatus according to claim 2, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not the position of the user is included in the first play area.

5. The information processing apparatus according to claim 2, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not at least one of the position and posture of the user is stationary in the first play area.

6. The information processing apparatus according to claim 2, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not the line of sight of the user is directed to a target designated in advance in the virtual space.

7. The information processing apparatus according to claim 6, wherein the state transition determination is a determination of a target to which the line of sight of the user is directed based on the line-of-sight direction of the user.

8. The information processing apparatus according to claim 6, wherein the state transition determination is a determination of a target to which the line of sight of the user is directed based on the line-of-sight direction of the user and a gaze time thereof.

9. The information processing apparatus according to claim 2, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not the posture of the user conforms to a posture designated in advance.

10. The information processing apparatus according to claim 2, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not a word designated in advance is included in the voice of the user.

11. The information processing apparatus according to claim 1, wherein the notification is display of a message to the user in the virtual space according to the result of the state transition determination.

12. The information processing apparatus according to claim 2, further comprising a communication unit configured to communicate with another information processing apparatus that displays the virtual space on another head mounted display worn by another user, wherein the another information processing apparatus comprises one or more processors and/or circuitry configured to: acquire a play area of the another user as a second play area; and detect an obstacle in a real space in the second play area and generate second obstacle information indicating a positional relationship between the detected obstacle and the play area; and acquire second user information from the another user, the state transition determination is a determination of determining whether the content can transition to a next state according to the second obstacle information and the second user information acquired from the another information processing apparatus by the communication unit, the obstacle information, and the user information.

13. The information processing apparatus according to claim 12, wherein the second user information includes at least one of a position, line-of-sight direction, posture, and voice of the

another user.

14. The information processing apparatus according to claim 13, wherein the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not a word designated in advance is included in the voice of the user and the voice of the another user.

15. The information processing apparatus according to claim 12, wherein the communication unit is configured to further communicable with an operation panel of a work device in a real space operated by a third user, and the notification sets a start button, which is displayed on the operation panel for the third user to activate the work device, to one of an active state and an inactive state according to the result of the state transition determination.

16. The information processing apparatus according to claim 15, wherein the head mounted display superimposes and displays a video of a real space viewed from the user on the virtual space, the another head mounted display superimposes and displays a video of a real space viewed from the another user on the virtual space, and the state transition determination is a determination as to whether or not to permit a state transition of the content according to whether or not the line of sight of the user is directed to a first work area in the work device and the line of sight of the another user is directed to a second work area in the work device.

17. The information processing apparatus according to claim 16, wherein the state transition determination is a determination of a target to which the lines of sight of the user and the another user are directed based on the line-of-sight directions of the user and the another user.

18. The information processing apparatus according to claim 16, wherein the state transition determination is a determination of a target to which the lines of sight of the user and the another user are directed based on the line-of-sight directions of the user and the another user and gaze times thereof.

19. The information processing apparatus according to claim 1, wherein the obstacle is detected in a two-dimensional space in a horizontal direction.

20. The information processing apparatus according to claim 1, wherein the obstacle is detected in a three-dimensional space in a horizontal direction and a vertical direction.

21. The information processing apparatus according to claim 20, wherein the obstacle is searched for in a space excluding a space that the user does not enter from the play area.

22. An information processing method of an information processing apparatus that displays a virtual space on a head mounted display worn by a user, wherein the method comprises: a play area acquisition step of acquiring a play area of the user as a first play area; an obstacle detection step of detecting an obstacle in a real space in the first play area and generating obstacle information indicating a positional relationship between the detected obstacle and the first play area; a user information acquisition step of acquiring user information from the user; a state transition determination step of determining whether content to be displayed in the virtual space can transition to a next state on basis of the obstacle information and the user information; and a notification step of making a notification according to a result of the state transition determination step.

23. A non-transitory computer readable storage medium storing a program that causes a computer to execute an information processing method of an information processing apparatus that displays a virtual space on a head mounted display worn by a user, wherein the method comprises: a play area acquisition step of acquiring a play area of the user as a first play area; an obstacle detection step of detecting an obstacle in a real space in the first play area and generating obstacle information indicating a positional relationship between the detected obstacle and the first play area; a user information acquisition step of acquiring user information from the user; a state transition determination step of determining whether content to be displayed in the virtual space can transition to a next state on basis of the obstacle information and the user information; and a

notification step of making a notification according to a result of the state transition determination step.