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(54) **INFORMATION PROCESSING APPARATUS SETTING PLAY AREA ON VIRTUAL SPACE, INFORMATION PROCESSING METHOD, AND STORAGE MEDIUM**

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(57) **ABSTRACT**

An information processing apparatus capable of avoiding collision with an obstacle in a real space when a user wearing an HMD plays a game in a play area on a virtual space. The information processing apparatus displays a virtual space on a head mounted display worn by a user, detects position information of the user in the virtual space as a first user position, detects posture information of the user in the virtual space as a first user posture, sets a play area on the basis of the first user position and the first user posture, detects an obstacle in a real space in the play area, searches for a new play area on the basis of a position of the detected obstacle, and displays the new play area on the head mounted display.

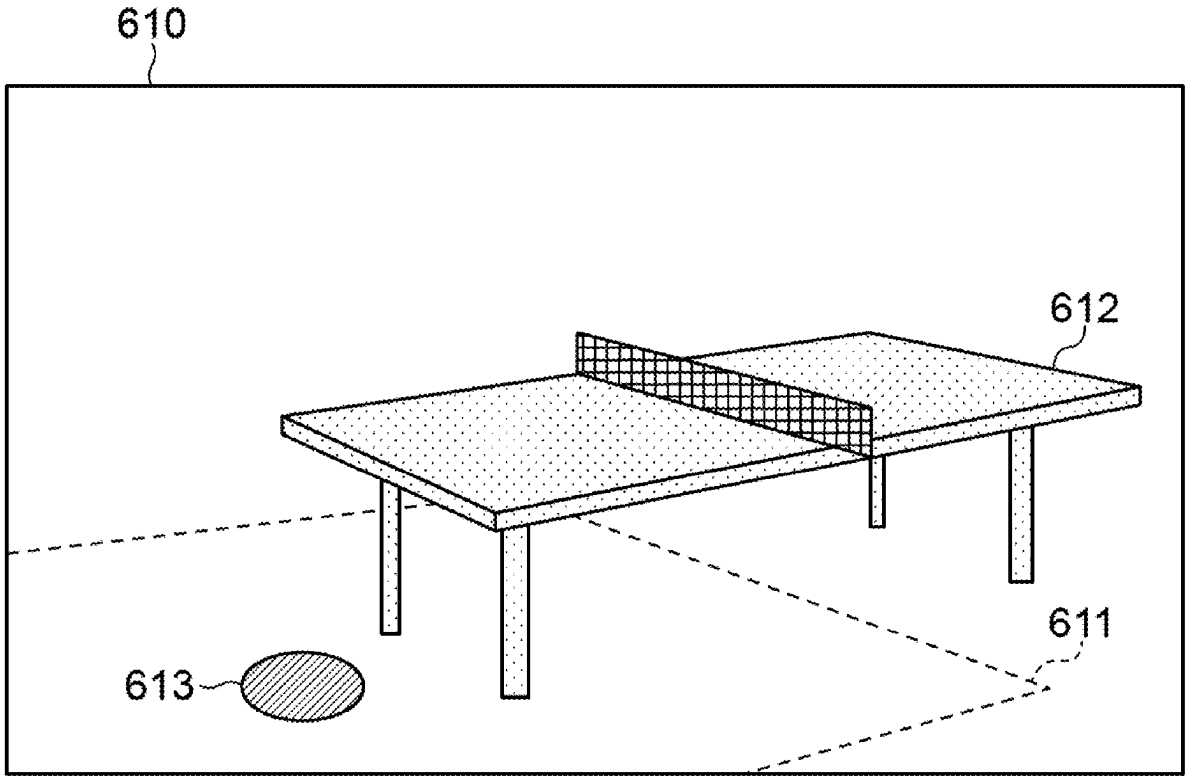


FIG. 1

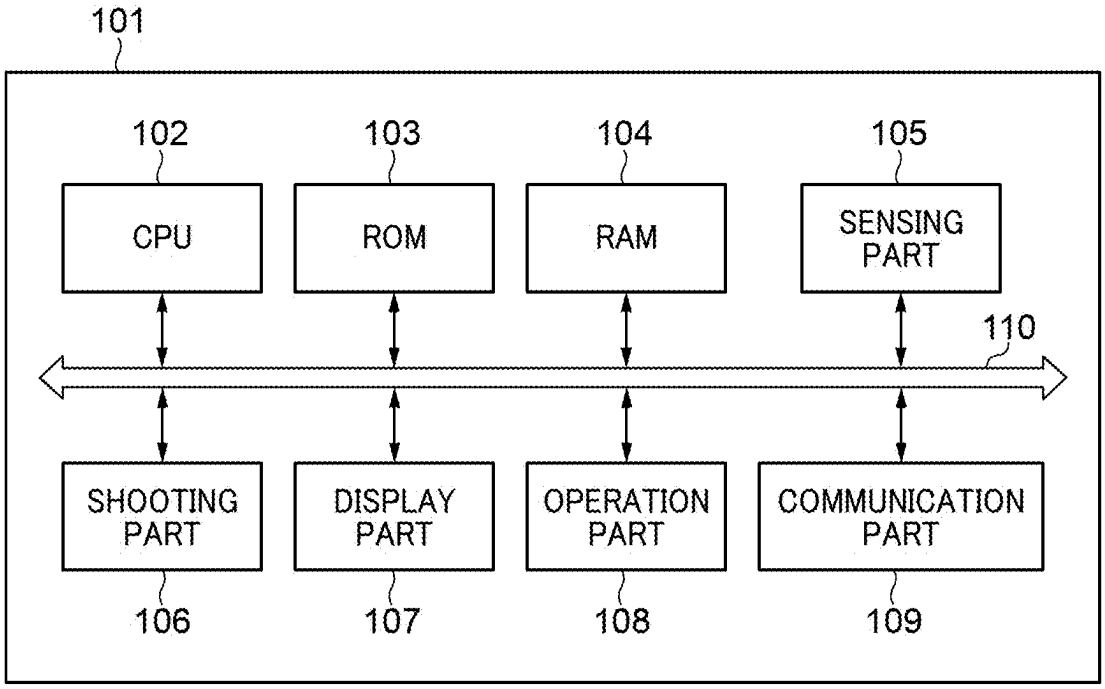

101
102
103
104
105
CPU
ROM
RAM
SENSING PART
110
SHOOTING PART
DISPLAY PART
OPERATION PART
COMMUNICATION PART
106
107
108
109

FIG. 2

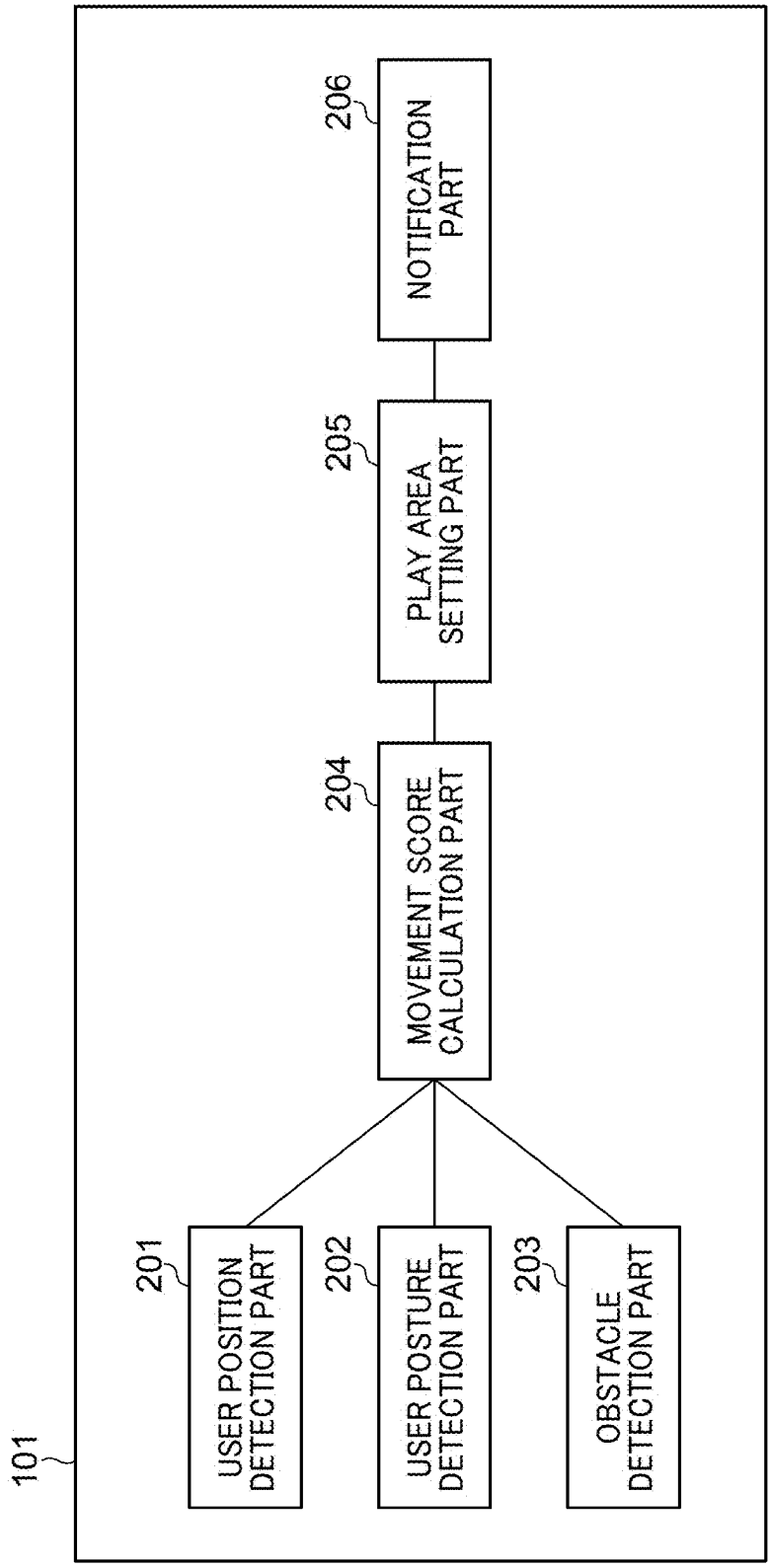

101
201
USER POSITION DETECTION PART
202
USER POSTURE DETECTION PART
203
OBSTACLE DETECTION PART
204
MOVEMENT SCORE CALCULATION PART
205
PLAY AREA SETTING PART
206
NOTIFICATION PART

FIG. 3

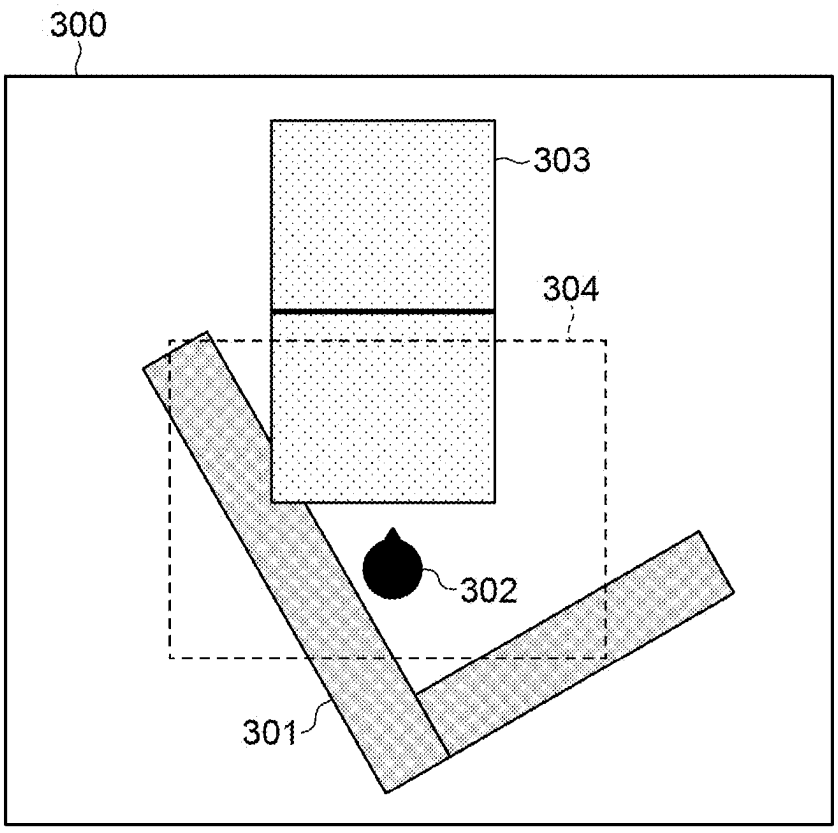


FIG. 4

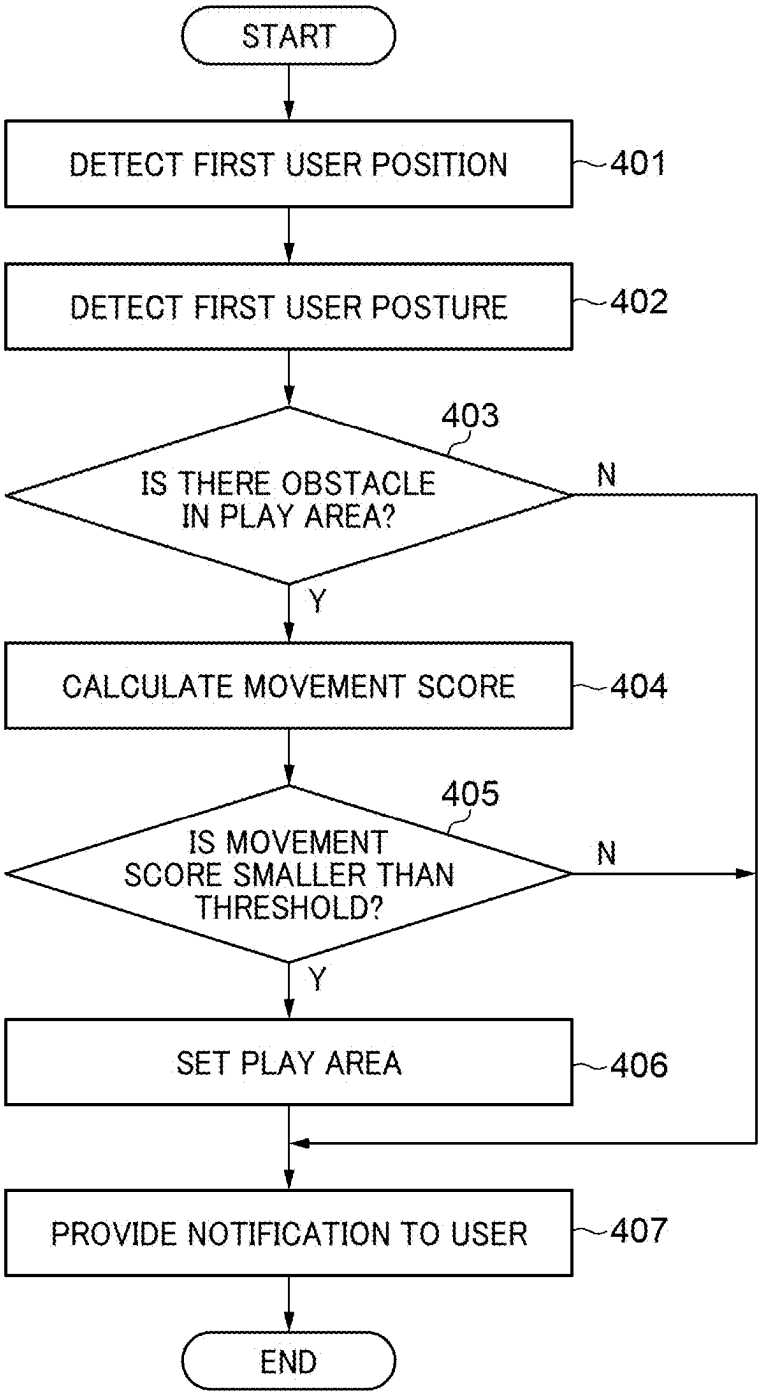

START
DETECT FIRST USER POSITION
401
DETECT FIRST USER POSTURE
402
403
IS THERE OBSTACLE IN PLAY AREA?
N
Y
CALCULATE MOVEMENT SCORE
404
405
IS MOVEMENT SCORE SMALLER THAN THRESHOLD?
N
Y
SET PLAY AREA
406
PROVIDE NOTIFICATION TO USER
407
END

FIG. 5

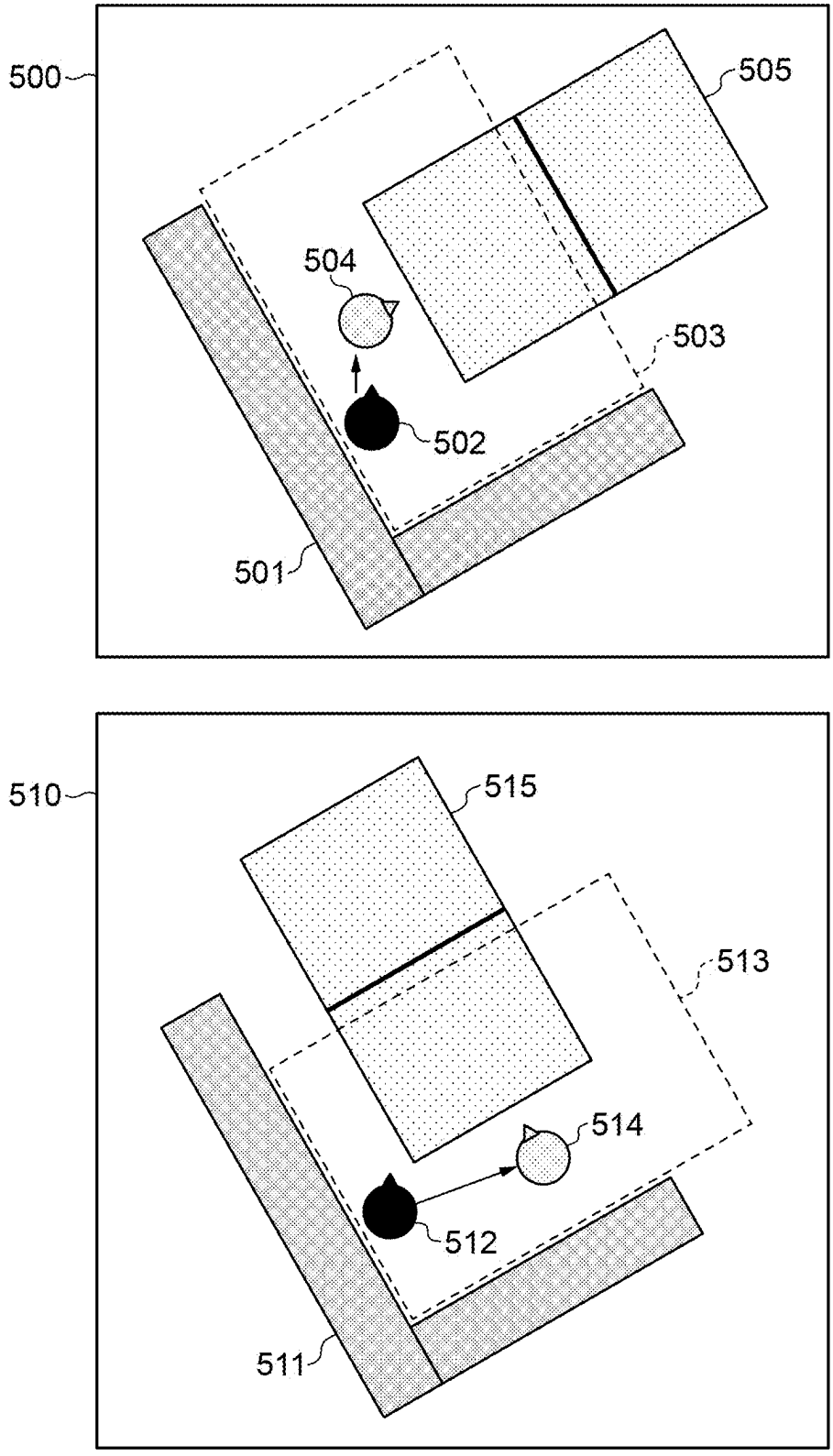


FIG. 6A

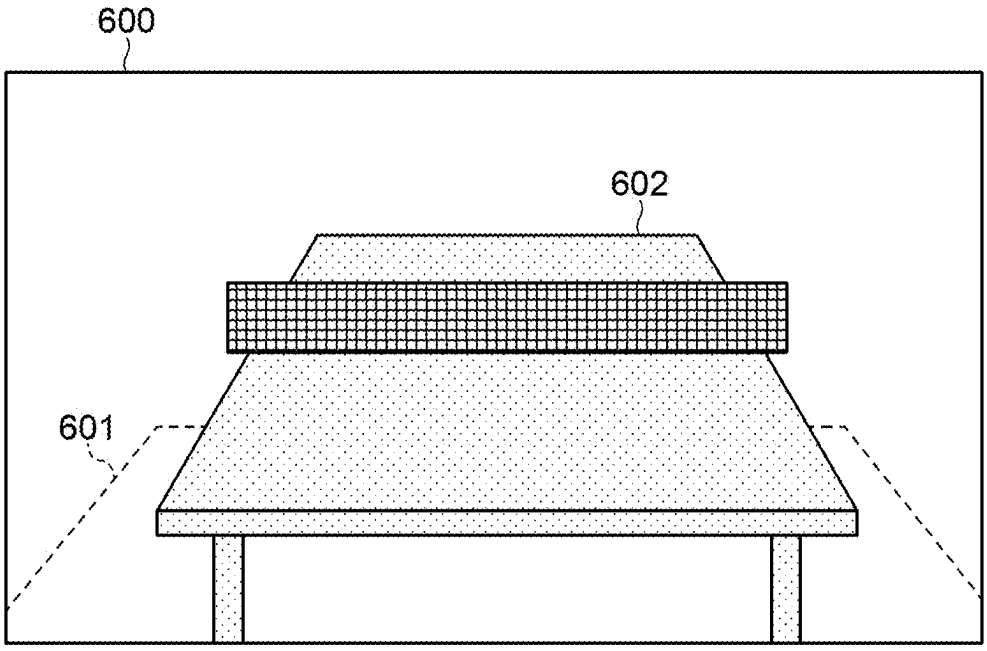


FIG. 6B

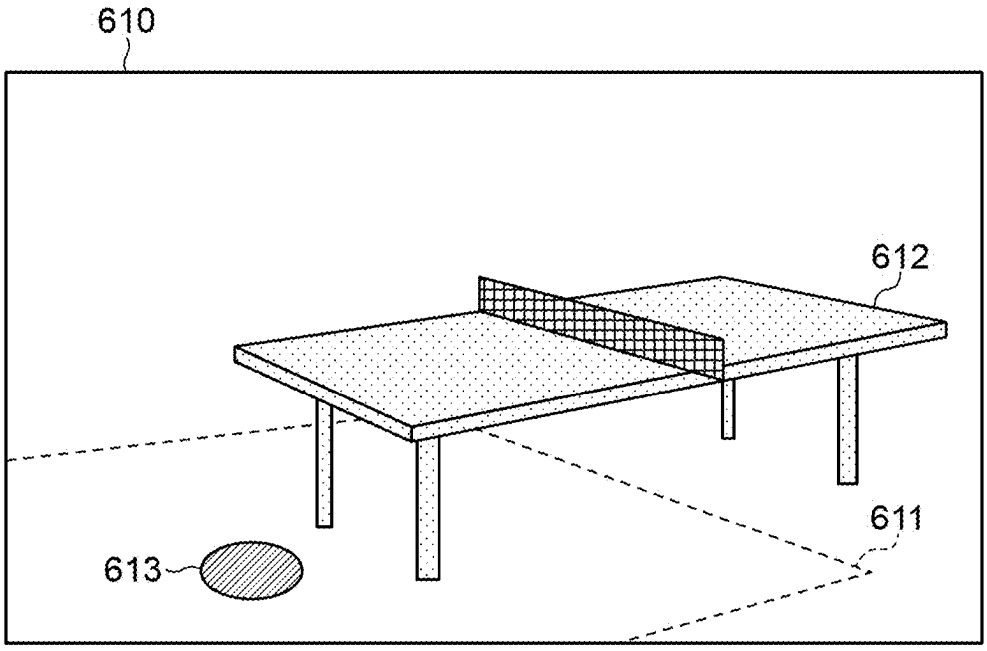


FIG. 6C

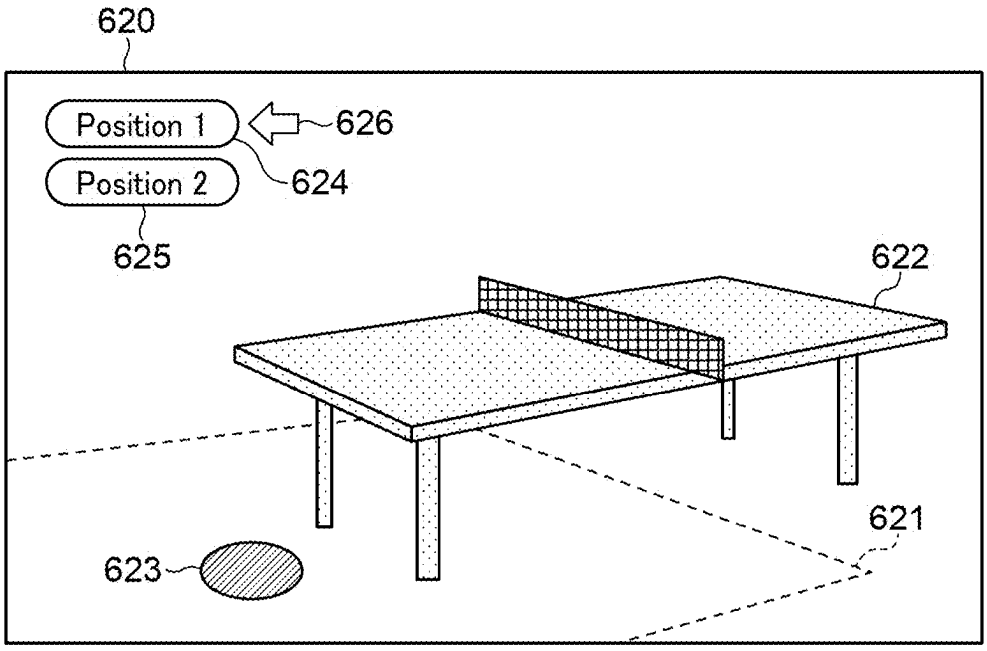


FIG. 7

700
701
PLAY AREA WHERE GAME CAN BE SAFELY PLAYED HAS NOT BEEN FOUND

FIG. 8

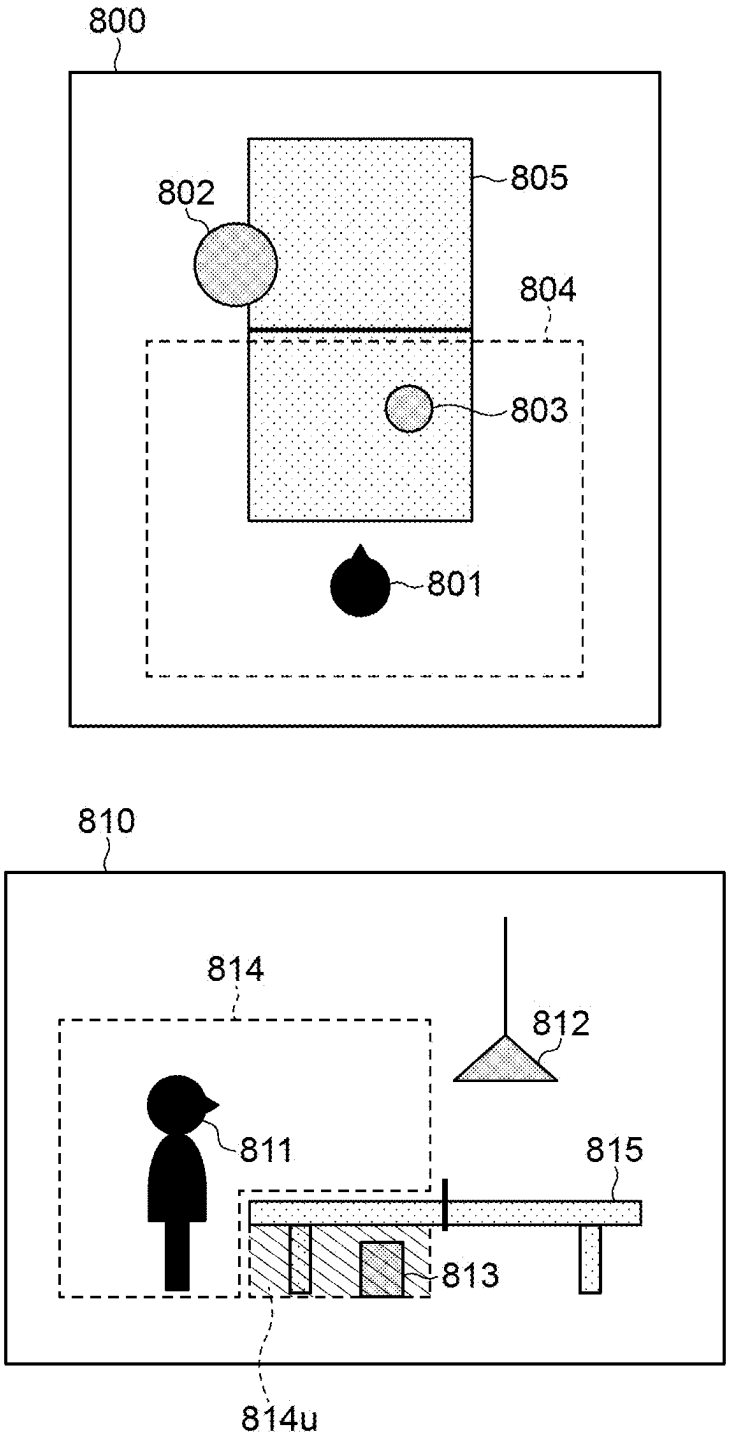


FIG. 9

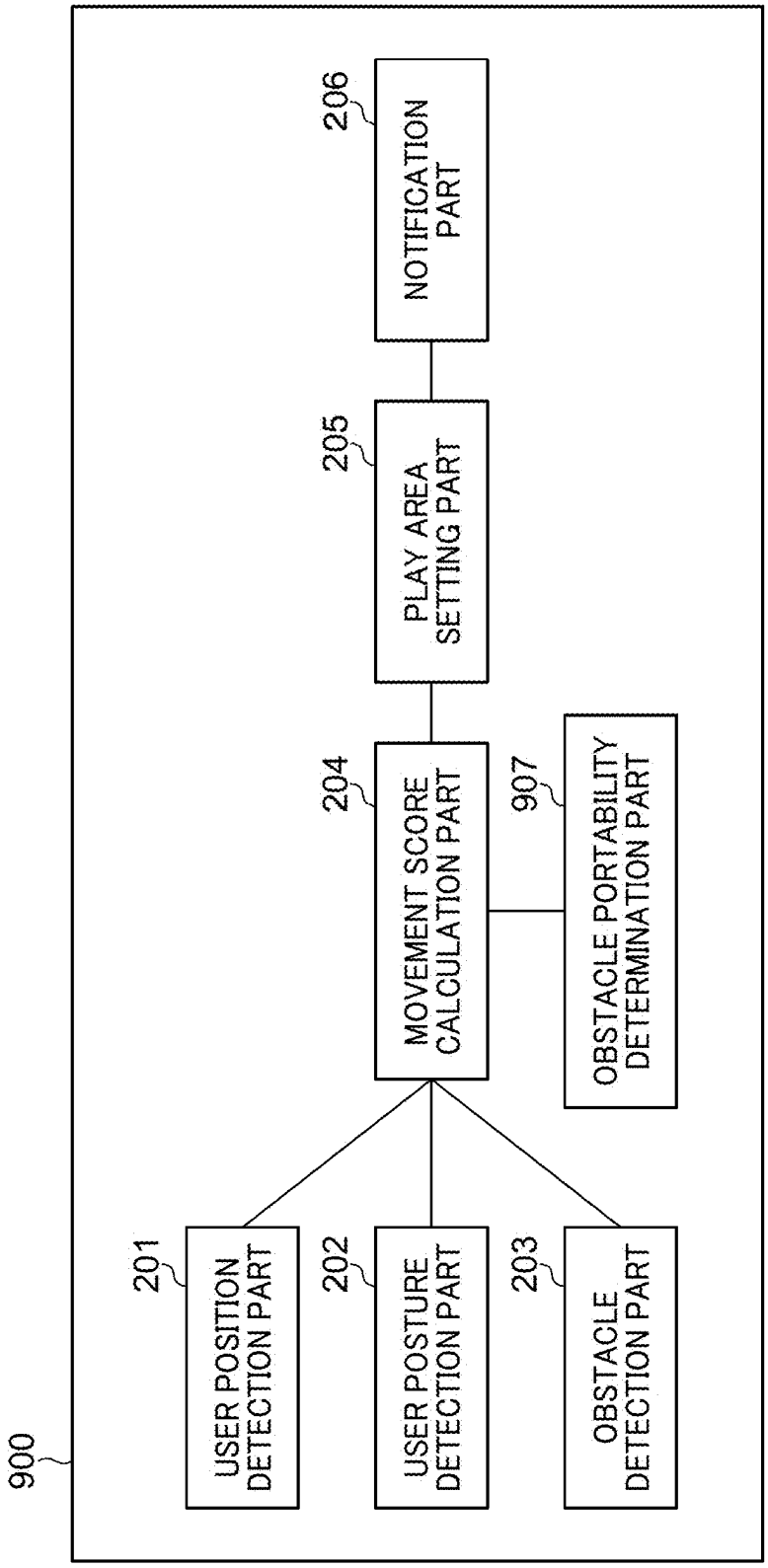

900
USER POSITION DETECTION PART
201
USER POSTURE DETECTION PART
202
OBSTACLE DETECTION PART
203
MOVEMENT SCORE CALCULATION PART
204
OBSTACLE PORTABILITY DETERMINATION PART
907
PLAY AREA SETTING PART
205
NOTIFICATION PART
206

FIG. 10

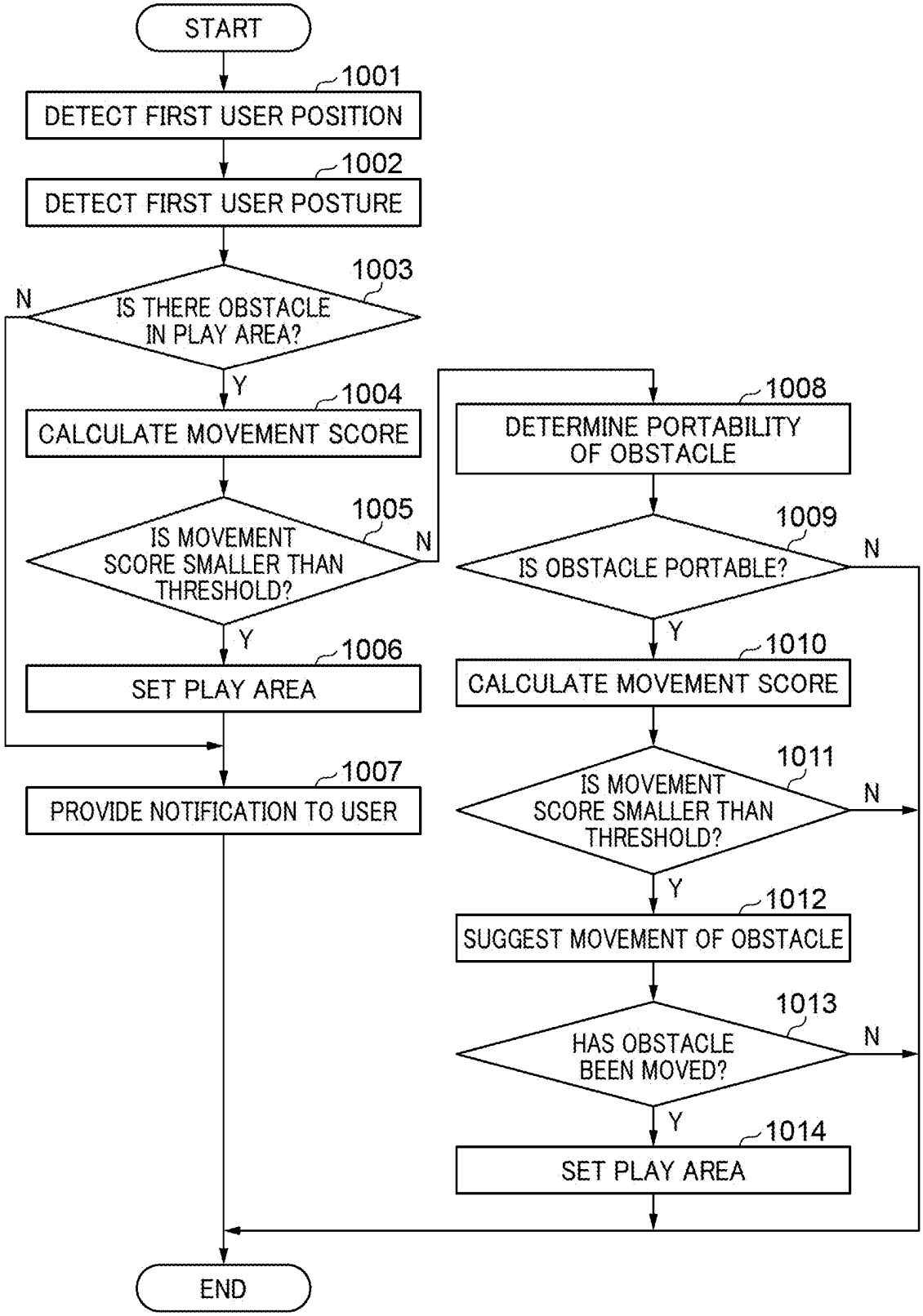

START
1001
DETECT FIRST USER POSITION
1002
DETECT FIRST USER POSTURE
1003
IS THERE OBSTACLE IN PLAY AREA?
N
Y
1004
CALCULATE MOVEMENT SCORE
1005
IS MOVEMENT SCORE SMALLER THAN THRESHOLD?
N
Y
1006
SET PLAY AREA
1007
PROVIDE NOTIFICATION TO USER
1008
DETERMINE PORTABILITY OF OBSTACLE
1009
IS OBSTACLE PORTABLE?
N
Y
1010
CALCULATE MOVEMENT SCORE
1011
IS MOVEMENT SCORE SMALLER THAN THRESHOLD?
N
Y
1012
SUGGEST MOVEMENT OF OBSTACLE
1013
HAS OBSTACLE BEEN MOVED?
N
Y
1014
SET PLAY AREA
END

FIG. 11

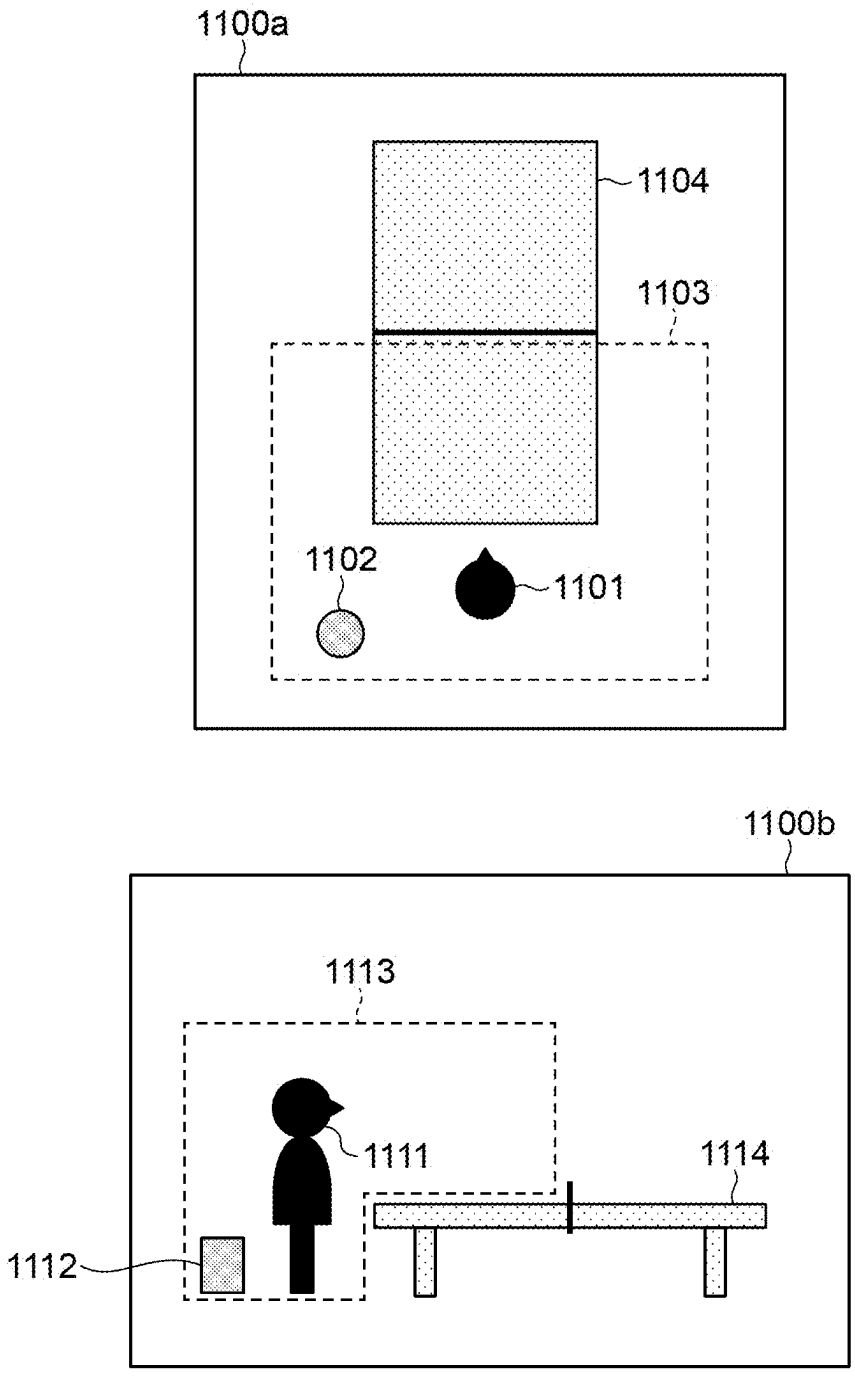
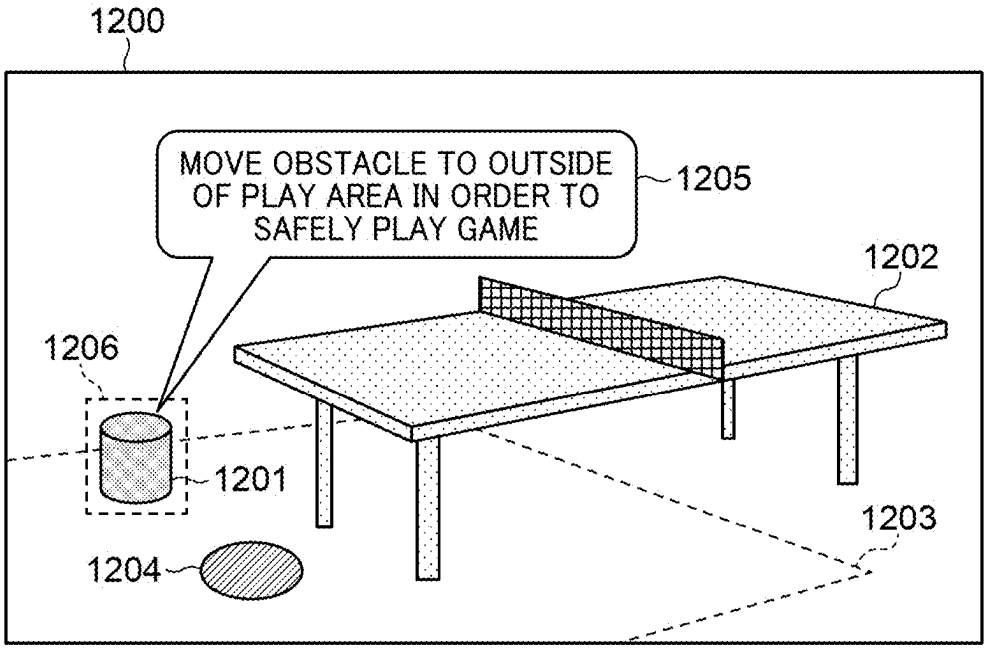


FIG. 12


1200
MOVE OBSTACLE TO OUTSIDE OF PLAY AREA IN ORDER TO SAFELY PLAY GAME
1205
1202
1206
1201
1203
1204

INFORMATION PROCESSING APPARATUS SETTING PLAY AREA ON VIRTUAL SPACE, INFORMATION PROCESSING METHOD, AND STORAGE MEDIUM

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.

Description of the Related Art

[0002] Recently, a technology called virtual reality (VR) in which immersion in a virtual space created by a computer different from reality is experienced has been widely used, and there are many contents to which the VR technology is applied. For example, a user wears a head mounted display (HMD) on his/her head, views a screen displayed on the HMD, and operates a controller or the like to play a game. When the HMD is worn in this way, the real world becomes invisible, and thus a user's sense of immersion in a virtual space increases. Furthermore, a content of playing a sport battle by displaying a remote user or a non player character (NPC) in the HMD is also provided, and a user wearing an HMD can also play a game in a play area set on the virtual space.

[0003] Thus, for example, Japanese Laid-Open Patent Publication (kokai) No. 2013-257716 discloses a technique for avoiding a situation in which a user collides with an obstacle in the real space when the user wears an HMD and enjoys a virtual space. For example, when a user is wearing an HMD and playing a shooting game, there may be an obstacle immediately in front of the user's body in the real space. In such a case, a fence is displayed immediately in front of the user as a virtual object with which the obstacle is replaced so that the user does not push the controller forward or move the body forward.

[0004] However, in the technique in Japanese Laid-Open Patent Publication (kokai) No. 2013-257716, when there is an obstacle immediately in front of a user in the real space, a virtual object with which the obstacle is replaced is displayed in a play area, and the user cannot freely move around in the play area.

SUMMARY OF THE INVENTION

[0005] The present invention provides an information processing apparatus, an information processing method, and a storage medium capable of avoiding collision with an obstacle in a real space when a user wearing an HMD plays a game in a play area on a virtual space.

[0006] According to an aspect of the invention, the present invention provides an information processing apparatus that displays a virtual space on a head mounted display worn by a user, the information processing apparatus comprising one or more processors and/or circuitry configured to execute a first detection process of detecting position information of the user in the virtual space as a first user position, execute a second detection process of detecting posture information of the user in the virtual space as a first user posture, execute a play area setting process of setting a play area on the basis of the first user position and the first user posture, execute an obstacle detection process of detecting an obstacle in a real space in the play area, execute a search process of searching for a new play area on the basis of a position of the detected obstacle, and execute a notification process of displaying the new play area on the head mounted display.

[0007] According to the present invention, it is possible to avoid collision with an obstacle in a real space when a user wearing an HMD plays a game in a play area on a virtual space.

[0008] Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a block diagram showing a hardware configuration example of an information processing apparatus according to a first embodiment of the present invention.

[0010] FIG. **2** is a block diagram showing a functional configuration according to the first embodiment of the present invention included in the information processing apparatus.

[0011] FIG. **3** is a diagram showing an example of an obstacle and a play area in a two-dimensional space.

[0012] FIG. **4** is a flowchart showing a play area search process according to the first embodiment of the present invention.

[0013] FIG. **5** is a diagram for describing a specific example of the play area search process in FIG. **4**.

[0014] FIG. **6**A is a diagram showing an example of HMD display in a case where there is no obstacle at an initial position of a user in the play area search process in FIG. **4**.

[0015] FIG. **6**B is a diagram showing an example of HMD display in a case where a new play area is found in the play area search process in FIG. **4**.

[0016] FIG. **6**C is a diagram showing an example of HMD display in a case where a new play area is found in the play area search process in FIG. **4**.

[0017] FIG. **7** is a diagram showing an example of HMD display in a case where a new play area is not found in the play area search process in FIG. **4**.

[0018] FIG. **8** is a diagram showing an example of an obstacle and a play area in a three-dimensional space.

[0019] FIG. **9** is a block diagram showing a functional configuration according to a second embodiment of the present invention included in the information processing apparatus.

[0020] FIG. **10** is a flowchart showing a play area search process according to the second embodiment of the present invention.

[0021] FIG. **11** is a diagram showing an example of a portable obstacle and a play area in a three-dimensional space.

[0022] FIG. **12** is a diagram showing an example of HMD display in a case where a portable obstacle is found in a play area in the play area search process in FIG. **10**.

DESCRIPTION OF THE EMBODIMENTS

[0023] Hereinafter, embodiments according to the present invention will be described with reference to the drawings. A configuration of each of the following embodiments can be modified or changed as appropriate according to specifications of a device to which the present invention is applied

and various conditions (usage conditions, usage environment, and the like). In addition, some of the embodiments described later may be combined as appropriate. In the following embodiments, the same constituents are indicated by the same reference numerals.

[0024] 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 of the information processing apparatus **101** according to the first embodiment of the present invention. FIG. **3** is a diagram showing an example of an obstacle and a play area in a two-dimensional space.

[0025] First, an example of resetting a play area in a virtual space will be described with reference to FIG. **3**. Here, as an example, a scene in which a user plays VR table tennis at home will be described. However, it is sufficient that a VR content (sports, a game, or training) is started at home or the like, and a VR content to which the present invention is applied is not limited to VR table tennis.

[0026] FIG. **3** is a diagram showing an example of an obstacle and a play area in a two-dimensional space.

[0027] FIG. **3** shows a disposition example of a wall **301** in a real space, a user **302** who experiences a VR content, a virtual table tennis table **303**, and a play area **304** before the play area is reset.

[0028] The play area **304** is defined in advance according to a size depending on the type of VR content or the number of players. In FIG. **3**, the play area **304** indicates a movement range of the user of a singles game in VR table tennis.

[0029] It should be noted that although the user **302** cannot see the wall **301** in the real space since the user **302** wears a head mounted display (HMD), the HMD worn by the user **302** has a function of acquiring position/posture information of the wall **301** and the user **302**. Therefore, the HMD can obtain obstacle information indicating a positional relationship between the wall **301** and the play area **304**. Furthermore, the HMD can reflect movement similar to the movement of the user **302** in the real space on an avatar of the user in the virtual space.

[0030] In a case where there is an obstacle in the play area **304** in the real space, first, the information processing apparatus **101** resets a new play area according to the position/posture information of the user **302** and the obstacle information of the obstacle (wall **301**) in the real space present in the play area **304**. Thereafter, the new play area is displayed on the HMD. Specifically, the HMD display will be described in a play area search process that will be described later with reference to a flowchart of FIG. **4**.

[0031] Since the user **302** performs VR table tennis at home, a space that can be set as the play area **304** in the real space is limited. 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 (wall **301**) in the real space. Therefore, when the user **302** starts the VR content in the play area **304** set according to a position of the user **302** (hereinafter, referred to as a first user position) in the real space, the wall **301** is present in the play area **304**. Thus, the user **302** may contact the wall **301** during gameplay.

[0032] Therefore, in the present embodiment, the information processing apparatus **101** performs a play area search process that will be described later so that the user can play the game safely without coming into contact with an obstacle. Specifically, in the present embodiment, the information processing apparatus **101** sets a new play area on the basis of the position/posture information of the user who experiences the VR content and the obstacle information in the real space, and presents (HMD display) the play area to the user. As a result, the user can safely play the game without coming into contact with the obstacle in the set new play area simply by the user moving to a position of the user (hereinafter, referred to as a second user position) in the new play area.

[0033] Next, a hardware configuration of the information processing apparatus **101** will be described with reference to FIG. **1**.

[0034] Hereinafter, the user before resetting the play area will be referred to as a first user, and the user after resetting the play area will be referred to as a second user.

[0035] The information processing apparatus **101** is an HMD worn by the first user and is connected to an external PC. However, the information processing apparatus **101** may be any electronic apparatus that can communicate with and control the HMD worn by the first user, and may be, for example, a PC to which the HMD worn by the first user is connected. The information processing apparatus **101** includes, as constituents, a CPU **102**, a ROM **103**, a RAM **104**, a sensing part **105**, a shooting part **106**, a display part **107**, an operation part **108**, and a communication part **109**. The respective constituents are connected to each other via a bus **110**.

[0036] The CPU **102** is an arithmetic processing unit 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.

[0037] The ROM **103** is a read-only nonvolatile memory device that stores programs (image processing programs, initial data, and the like) and parameters that do not need to be changed.

[0038] The RAM **104** temporarily stores input information, calculation results in image processing, and the like. The RAM **104** is a memory device that provides the CPU **102** with a work area.

[0039] The sensing part **105** is a device such as a sensor, and acquires position/posture information of the user by detecting rotation, inclination, and a movement amount of the head of the user wearing the information processing apparatus **101** that is an HMD.

[0040] The shooting part **106** is a shooting device including a built-in camera of the information processing apparatus **101** that is an HMD, and performs a shooting process. For example, the shooting part **106** detects a position of the hand of the user wearing the information processing apparatus **101** (hand tracking). Note that, in a case where 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 shooting part **106**.

[0041] The display part **107** includes a liquid crystal display or the like, and displays a picked-up image, a virtual object, text, and/or an item (icon; content) to the user wearing the information processing apparatus **101** that is an HMD.

[0042] The operation part **108** is an operation unit including an operation member such as a power button or a dial.

[0043] The communication part **109** transmits and receives data to and from an external device through wired communication or wireless communication (wireless LAN,

local 5G, or the like). Examples of the external device include an external controller (not shown) held by the user wearing the information processing apparatus **101**. Note that, in a case where the information processing apparatus **101** is a PC connected to the HMD worn by the user, the communication part **109** receives position/posture information and the like detected by the information processing apparatus **101** that is an HMD via a network (not shown).

[0044] FIG. **2** is a block diagram showing a functional configuration according to the present embodiment included in the information processing apparatus **101** (hereinafter, simply referred to as the HMD **101**) that is an HMD.

[0045] The HMD **101** includes a user position detection part **201**, a user posture detection part **202**, an obstacle detection part **203**, a movement score calculation part **204**, a play area setting part **205**, and a notification part **206** as functional constituents.

[0046] The user position detection part **201** (first detection unit) acquires position information in the virtual space of the user wearing the HMD **101** from the sensing part **105**, and stores the position information as a first user position.

[0047] The user posture detection part **202** (second detection unit) acquires posture information in the virtual space of the user wearing the HMD **101** from the sensing part **105**, and stores the posture information as a first user posture.

[0048] The obstacle detection part **203** (obstacle detection unit) detects an obstacle around the user wearing the HMD **101**. There are various types of obstacles such as a wall, a chair, a desk, and a trash box, but a method for specifying an obstacle is not described here. Note that an obstacle in the present embodiment may be detected by the shooting part **106** that is a camera attached to the HMD **101**, or may be detected by using an external second camera via the communication part **109**. Alternatively, an obstacle may be detected by using the sensing part **105** that is a sensor.

[0049] On the basis of information regarding the obstacle detected by the obstacle detection part **203**, the movement score calculation part **204** (search unit) searches for a position and an orientation of a new play area that is not covered by the obstacle and the position of the user wearing the HMD **101**. A method for searching for a new play area will be described later. In this case, the movement score calculation part **204** (first determination unit/second determination unit) also determines a position (second user position) and a posture (second user posture) of the user wearing the HMD **101** in the new play area. Here, in a case where there is no obstacle, there is no change in the position and orientation of the play area, the first user position and the second user position coincide with each other, and the first user posture and the second user posture coincide with each other. The movement score calculation part **204** (movement score calculation unit) calculates a movement score from the first user position and the second user position. For example, the movement score may be obtained as a distance between the first user position and the second user position. However, the movement score is not limited thereto as long as the movement score has a positive correlation with a distance between the first user position and the second user position. That is, since the shorter the distance between the first user position and the second user position becomes, the smaller the load associated with the movement of the user becomes, the movement score calculation part **204** calculates a smaller value of the movement score as the distance between the first user position and the second user position becomes shorter. Furthermore, since a load on the user decreases as a change difference between the first user posture and the second user posture decreases, the movement score calculation part **204** may calculate a smaller value of the movement score as the change difference between the first user posture and the second user posture decreases. That is, the movement score may also have a positive correlation with a change difference between the first user posture and the second user posture.

[0050] The play area setting part **205** (play area setting unit) sets the play area according to the movement score calculated by the movement score calculation part **204**.

[0051] The notification part **206** (notification unit) displays various messages on the display part **107** and displays the play area set by the play area setting part **205** on the display part **107**. Note that the movement score calculation part **204** may only search for a new play area without calculating the movement score. In this case, when the movement score calculation part **204** searches for a plurality of new play area candidates, the notification part **206** may display the candidates on the display part **107** in a user-switchable manner and cause the user to select one of the candidates as a new play area.

[0052] FIG. **4** is a flowchart showing a play area search process according to the present embodiment. The process 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. An execution timing of this process is not limited. The execution timing may be, for example, a timing at which the user wearing the HMD **101** (hereinafter, simply referred to as a user) starts the content, or may be a timing at which the operation part **108** detects a predetermined user operation. First, in step S**401**, the user position detection part **201** acquires a first user position.

[0053] Next, in step S**402**, the user posture detection part **202** acquires a first user posture.

[0054] Next, in step S**403**, the play area setting part **205** sets a play area on the basis of the first user position and the first user posture, and the obstacle detection part **203** determines whether or not an obstacle in the real space has been detected from the set play area. In this case, the notification part **206** may notify the user to look around so that a wide region around the user can be searched. In a case where an obstacle is detected from the play area (YES in step S**403**), the process proceeds to step S**404**, and in a case where an obstacle is not detected from the play area (NO in step S**403**), the process proceeds to step S**407**. In this case, in step S**407**, the notification part **206** displays on the display part **107** the play area set by the play area setting part **205** in step S**406**.

[0055] Next, in step S**404**, the movement score calculation part **204** calculates a movement score by using the method described above. Here, a method of searching for a new play area will be described with reference to FIGS. **3** and **5**. Each of an image **300** in FIG. **3** and images **500** and **510** in FIG. **5** is an image in which the user is viewed from above. The user **302** in FIG. **3**, and a user **502** and a user **512** in FIG. **5** are the same person, and a position of any user corresponds to the first user position. In addition, the wall **301** in FIG. **3**, and a wall **501** and a wall **511** in FIG. **5** correspond to the same wall in the real space. Here, as shown in FIG. **3**, in a case where the play area is set on the basis of the first user position and the first user posture, since the wall **301** is present as an obstacle in the play area **304**, the user may collide with the wall **301** during the game. In order to avoid

this, the movement score calculation part **204** searches for a position and an orientation of a new play area.

[0056] The image **500** in FIG. **5** is an example in which the play area **304** in FIG. **3** is rotated and moved clockwise horizontally in parallel. In this case, the play area **304** (FIG. **3**) is rotated and moved so that the wall **501** does not enter the new play area **503**. Furthermore, a position and an orientation of a virtual table tennis table **505**, a position of a second user **504** (second user position), and a posture of the second user **504** (second user posture) are determined, and a movement score **1** is calculated.

[0057] On the other hand, the image **510** in FIG. **5** is an example in which the play area **304** in FIG. **3** is rotated and moved counterclockwise horizontally in parallel. In this case, the play area **304** (FIG. **3**) is rotated and moved so that the wall **511** does not enter the new play area **513**. Furthermore, a position and an orientation of a virtual table tennis table **515**, a position of a second user **514** (second user position), and a posture of the second user **514** (second user posture) are determined, and a movement score 2 is calculated.

[0058] Note that the movement score calculated by the movement score calculation part **204** in step S**404** is stored in the RAM **104** together with the corresponding new play area.

[0059] Returning to FIG. **4**, next, in step S**405**, the play area setting part **205** determines whether or not the movement score calculated in step S**404** is smaller than a threshold stored in advance in the ROM **103**. Note that a movement score that is a determination target here may be all movement scores calculated by the movement score calculation part **204**, may be some extracted from the movement scores, or may be only a movement score having the minimum value.

[0060] In a case where the movement score that is a determination target is smaller than the threshold (YES in step S**405**), it is determined that a new play area has been found, and the process proceeds to step S**406**. On the other hand, in a case where the movement score that is a determination target is the threshold or more (NO in step S**405**), it is determined that no new play area has been found, and the process proceeds to step S**407**. In this case, in step S**407**, the notification part **206** displays, on the display part **107**, a message (for example, a message **701** in FIG. **7**) for presenting to the user that no play area where the game play can be safely performed has been found.

[0061] Next, in step S**406**, the play area setting part **205** sets a new play area stored in the RAM **104** in association with a movement score smaller than the threshold as a play area used in the VR content, and proceeds to step S**407**. In this case, in step S**407**, the notification part **206** displays the play area set in step S**406** on the display part **107** in order to present the play area to the user.

[0062] Processing in the case of transition from step S**406** to step S**407** will be described with reference to FIGS. **6**A to **6**C. Hereinafter, display on the HMD **101** by the display part **107** will be referred to as HMD display.

[0063] Each of HMD displays **600**, **610**, and **620** in FIGS. **6**A to **6**C is an example of HMD display of the play area set in step S**406**.

[0064] The HMD display **600** in FIG. **6**A is an example of HMD display in a case where the first user position and the second user position are the same, that is, in a case where there is no obstacle at the initial position of the user (NO in step S**403**). A play area **601** and a virtual table tennis table **602** are displayed in the HMD display **600**, and the user can immediately start game play without moving. Therefore, the display part **107** may display a message (not shown) for inquiring whether or not to start the game play to be superimposed on the HMD display **600**.

[0065] The HMD display **610** in FIG. **6**B is an example of HMD display in a case where it is determined in step S**405** that a single candidate for a new play area has been found. In the HMD display **610**, the single new play area found in step S**405** is displayed as a play area **611**, and a virtual table tennis table **612** and a second user position **613** are displayed. The user may start the game play by moving to the second user position **613**. Thus, the display part **107** may highlight the second user position **613** through blinking display or the like, and display a message (not shown) for notifying the user to move to the blinking display position to be superimposed on the HMD display **610**.

[0066] The HMD display **620** in FIG. **6**C is an example of HMD display in a case where it is determined in step S**405** that a plurality of candidates for a new play area have been found. In the HMD display **620**, there are UI buttons **624** and **625** that are user interfaces for displaying respective candidates on the display part **107**, and an arrow **626** indicating a candidate currently displayed on the display part **107**. The arrow **626** indicates the candidate "Position**1**" associated with the UI button **624**, and the play area **621**, a virtual table tennis table **622**, and a second user position **623** of the candidate "Position**1**" are displayed on the display part **107**. The user can switch and select one of the UI buttons **624** and **625** by using, for example, an operation part **108**, an external controller, or through a tap operation based on hand tracking. The display part **107** displays information associated with each candidate according to the selected UI button.

[0067] Returning to FIG. **4**, after the user notification in step S**407**, the HMD **101** ends the process in the flowchart of FIG. **4**.

[0068] It should be noted that, in the present embodiment, the methods for detecting an obstacle and setting a play area in the two-dimensional space in the horizontal direction have been described. However, obstacle detection and play area setting may be performed in a three-dimensional space including a vertical direction. Furthermore, a shape of a play area may be changed according to a situation and the type of VR content.

[0069] FIG. **8** is a diagram showing an example of an obstacle and a play area in a three-dimensional space including the vertical direction. In FIG. **8**, an image **800** is an image in which a user is viewed from above, and an image **810** is an image in which the user is viewed from the right side.

[0070] A user **801** and a user **811** are the same person. A light **802** and a light **812** are the same obstacle present in the real space, and a trash box **803** and a trash box **813** are the same obstacle present in the real space. In addition, a play area **804** and a play area **814** indicate the same area, and a table tennis table **805** and a table tennis table **815** are the same virtual object. A height of the play area **814** is preferably set such that the tip of a racket or the like gripped by the user **811** is within the play area **814** even when the user **811** holds the racket or an external controller and raises his/her hand directly upward. Furthermore, since the normal user **811** does not enter a space **814***u* under the virtual table tennis table **815** during the game play, the space **814***u* is

excluded from the space of the play area **814**. Accordingly, the trash box **803** looks like being in the play area **804** when viewed from above as in the image **800**, but the trash box **813** is not in the play area **814** when viewed from right beside as in the image **810**. Therefore, in the case of FIG. **8**, there is no obstacle in the play area, and the user can comfortably play the game.

[0071] As described above, according to the present embodiment, a play area can be efficiently set without an operation of a user by using an obstacle in the real space and position/posture information of the user.

[0072] An HMD **101** according to a second embodiment will be described with reference to FIGS. **9** to **12**.

[0073] 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.

[0074] The HMD **101** according to the first embodiment compares a movement score with a threshold set in advance, and in a case where it is determined that no new play area has been found on the basis of a comparison result, a user is notified of that effect. In contrast, even in a case where a new play area has not been found, when it is determined that an obstacle is movable, the HMD **101** according to the second embodiment suggests movement of the obstacle to a user, and sets a new play area on the basis of a state of the real space after the movement of the obstacle by the user.

[0075] FIG. **9** is a block diagram showing a functional configuration of the HMD **101** according to the present embodiment.

[0076] The HMD **101** includes, as functional constituents, a user position detection part **201**, a user posture detection part **202**, an obstacle detection part **203**, a movement score calculation part **204**, a play area setting part **205**, a notification part **206**, and an obstacle portability determination part **907**. That is, in the HMD **101** according to the present embodiment, the obstacle portability determination part **907** is added to the function (FIG. **2**) of the HMD **101** according to the first embodiment.

[0077] The obstacle portability determination part **907** (obstacle portability determination unit) determines whether an obstacle detected by the obstacle detection part **203** has portability or not, and stores a determination result. In the case of the present embodiment, the portability may be determined on the basis of object information (size and type) registered in advance, or may be determined by using a trained model (not shown) registered in advance in the HMD **101**.

[0078] FIG. **10** is a flowchart showing a play area search process according to the second embodiment of the present invention. The process 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. An execution timing of this process is not limited. For example, the execution timing may be, for example, a timing at which a user starts the content or may be a timing at which the operation part **108** detects a predetermined user operation.

[0079] Since the processes in steps S**1001** to S**1007** are similar to the processes in steps S**401** to S**407** shown in FIG. **4**, the description thereof will be omitted. However, in FIG. **4**, in a case where the movement score that is a determination target is the threshold or more (NO in step S**405**), the process proceeds to step S**407**, but in FIG. **10**, in a case where the movement score that is a determination target is the threshold or more (NO in step S**1005**), the process proceeds to step S**1008**.

[0080] In step S**1008**, the obstacle portability determination part **907** determines whether the obstacle detected in step S**1003** has portability or not.

[0081] Next, in step S**1009**, as a result of the determination in step S**1008**, in a case where the detected obstacle has portability, the movement score calculation part **204** proceeds to step S**1010**. On the other hand, as a result of the determination in step S**1008**, in a case where all the detected obstacles have no portability, it is determined that a play area where the obstacles can be avoided cannot be secured, and the process in the flowchart of FIG. **10** is ended.

[0082] Next, in step S**1010**, the movement score calculation part **204** calculates a movement score in a case where it is assumed that there is no obstacle having portability among the detected obstacles by using the method described in step S**404** in FIG. **4**.

[0083] With reference to FIG. **11**, a play area in a case where there is a portable obstacle as a result of the determination in step S**1008** will be described.

[0084] FIG. **11** is a diagram showing an example of an obstacle and a play area in a three-dimensional space including a vertical direction. In FIG. **11**, an image **1100***a* is an image in which a user is viewed from above, and an image **1110***b* is an image in which the user is viewed from right beside.

[0085] A user **1101** and a user **1111** are the same person. A trash box **1102** and a trash box **1112** are the same obstacle present in the real space. In addition, a play area **1103** and a play area **1113** indicate the same region, and a table tennis table **1104** and a table tennis table **1114** are the same virtual object.

[0086] In the case of FIG. **11**, an obstacle in the play area detected in step S**1003** is only the trash box **1112**, and it is determined in step S**1008** that trash box **1112** has portability. In this case, in step S**1010**, assuming that the user moves the trash box **1112** to the outside of the play area **1113** and assuming that the trash box **1112** is not present, the movement score is calculated by using the method described in step S**404** in FIG. **4**. In step S**1003**, not only a portable obstacle (for example, a trash box) but also a non-portable obstacle (for example, a wall) may be detected in the play area. In this case, in step S**1010**, it is assumed that there is no portable obstacle among the detected obstacles and only a non-portable obstacle is an obstacle in the play area, and a movement score is calculated by using the method described in step S**404** in FIG. **4**.

[0087] Returning to FIG. **10**, next, in step S**1011**, the play area setting part **205** determines whether or not the movement scores calculated in step S**1010** are smaller than a threshold stored in advance in the ROM **103**. Note that a movement score that is a determination target here may be all movement scores, may be some extracted from all the movement scores, or may be only a movement score having the minimum value.

[0088] When the movement score that is a determination target is smaller than the threshold (YES in step S**1011**), it is determined that a new candidate for the play area has been found, and the process proceeds to step S**1012**. On the other hand, in a case where the movement score that is a determination target is the threshold or more (NO in step S**1011**),

it is determined that no new candidate for the play area has been found, and the process in the flowchart of FIG. **10** is ended.

[0089] Next, in step S**1012**, the notification part **206** suggests movement of the obstacle determined to be portable to the user.

[0090] Hereinafter, HMD display **1200** in FIG. **12**, which is an example of the user suggestion method in step S**1012**, will be described. In the HMD display **1200** in FIG. **12**, the display part **107** includes a trash box **1201** in the real space, a table tennis table **1202** in the virtual space, a play area **1203**, a second user position **1204**, a message **1205**, and a display frame **1206**. The trash box **1201** is an obstacle in the real space determined to be portable by the obstacle portability determination part **907**, and a video of the trash box **1201** in the real space is superimposed and displayed on the virtual space. The display frame **1206** is display of decoration for attracting attention of the user to the trash box **1201**, and the attention degree may be increased through blinking or animation. The message **1205** is a message box for presenting, to the user, a notification for requesting the user to move the trash box **1201** to the outside of the play area **1203**.

[0091] Returning to FIG. **10**, next, in step S**1013**, the play area setting part **205** determines whether or not the user has moved all the portable obstacles to the outside of the candidate play area. In a case where the user has moved all the portable obstacles to the outside of the candidate play area (YES in step S**1013**), it is determined that the candidate play area is a play area where the collision between the user and the obstacle can be avoided, and the process proceeds to step S**1014**. On the other hand, in a case where the user has not moved all the portable obstacles to the outside of the candidate play area (NO in step S**1013**), it is determined that a play area where the collision between the user and the obstacle can be avoided cannot be confirmed, and the process in the flowchart of FIG. **10** is ended. In this case, before the process is ended, the process may return to step S**1012**, and the notification part **206** may suggest the movement of the obstacle determined to be portable to the user.

[0092] Next, in step S**1014**, the play area setting part **205** sets the candidate play area as a play area used in the VR content, and ends the process in the flowchart of FIG. **10**.

Other Embodiments

[0093] 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.

[0094] 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.

[0095] This application claims the benefit of Japanese Patent Application No. 2024-017795, filed Feb. 8, 2024 which is hereby incorporated by reference wherein in its entirety.

What is claimed is:

1. An information processing apparatus that displays a virtual space on a head mounted display worn by a user, the information processing apparatus comprising one or more processors and/or circuitry configured to:

execute a first detection process of detecting position information of the user in the virtual space as a first user position;

execute a second detection process of detecting posture information of the user in the virtual space as a first user posture;

execute a play area setting process of setting a play area on the basis of the first user position and the first user posture;

execute an obstacle detection process of detecting an obstacle in a real space in the play area;

execute a search process of searching for a new play area on the basis of a position of the detected obstacle; and

execute a notification process of displaying the new play area on the head mounted display.

2. The information processing apparatus according to claim **1**, wherein, in the search process, the new play area is determined so that the obstacle does not enter the new play area.

3. The information processing apparatus according to claim **1**, wherein the one or more processors and/or circuitry is/are configured to

execute a first determination process of determining a second user position that is a position of the user in the new play area.

4. The information processing apparatus according to claim **3**, wherein,

in the notification process, the second user position is displayed on the head mounted display together with the new play area.

5. The information processing apparatus according to claim **3**, wherein the one or more processors and/or circuitry is/are configured to execute a movement score calculation process of calculating a movement score having a positive correlation with a distance between the first user position and the second user position, and

in a case where the movement score is a threshold or more, in the notification process, a notification that

there is no play area where game play can be safely performed is provided without displaying the new play area on the head mounted display.

6. The information processing apparatus according to claim **5**, wherein

in a case where a plurality of play areas having the movement score smaller than the threshold, which are candidates for the new play area, are searched for in the search process, a play area having the smallest movement score among the play areas that have been searched for is set as the new play area.

7. The information processing apparatus according to claim **5**, wherein

in a case where a plurality of play areas having the movement score smaller than the threshold, which are candidates for the new play area, are searched for in the search process, in the notification process, the play areas that have been searched for are displayed on the head mounted display in a switchable manner as the candidates for the new play area.

8. The information processing apparatus according to claim **5**, wherein the one or more processors and/or circuitry is/are configured to execute a second determination process of determining a second user posture that is a posture of the user in the new play area, and

the movement score further has a positive correlation with a change difference between the first user posture and the second user posture.

9. The information processing apparatus according to claim **1**, wherein the one or more processors and/or circuitry is/are configured to execute an obstacle portability determination process of determining portability of the detected obstacle, and

in the search process, the new play area is searched for assuming that there is no obstacle determined to be portable by the obstacle portability determination process among the detected obstacles.

10. The information processing apparatus according to claim **9**, wherein,

in the notification process,

a video of an obstacle determined to be portable in the obstacle portability determination process is displayed in a real space to be superimposed on the virtual space, and

a message for requesting movement of the obstacle determined to be portable in the obstacle portability determination process is displayed on the head mounted display.

11. The information processing apparatus according to claim **10**, wherein, in the notification process, display for decorating the video displayed to be superimposed on the virtual space is displayed on the head mounted display.

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

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

14. The information processing apparatus according to claim **13**, wherein, in the obstacle detection process, a space that the user does not enter during game play is excluded from the play area.

15. An information processing method for an information processing apparatus that displays a virtual space on a head mounted display worn by a user, the information processing method comprising:

a first detection step of detecting position information of the user in the virtual space as a first user position;

a second detection step of detecting posture information of the user in the virtual space as a first user posture;

a setting step of setting a play area on the basis of the first user position and the first user posture;

an obstacle detection step of detecting an obstacle in a real space in the play area;

a search step of searching for a new play area on the basis of a position of the detected obstacle; and

a notification step of displaying the new play area on the head mounted display.

16. A non-transitory storage medium storing a program for causing a computer to execute information processing method for an information processing apparatus that displays a virtual space on a head mounted display worn by a user,

the information processing method for the information processing apparatus, comprising:

a first detection step of detecting position information of the user in the virtual space as a first user position;

a second detection step of detecting posture information of the user in the virtual space as a first user posture;

a setting step of setting a play area on the basis of the first user position and the first user posture;

an obstacle detection step of detecting an obstacle in a real space in the play area;

a search step of searching for a new play area on the basis of a position of the detected obstacle; and

a notification step of displaying the new play area on the head mounted display.

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