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| United States Patent | 12387442              |
| Kind Code            | B2                    |
| Date of Patent       | August 12, 2025       |
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### Mixed reality display device and mixed reality display method

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#### Abstract

The MR display device includes a controller and a display unit. The controller recognizes a reality object from a reality video imaged by a camera and links a predetermined virtual object to the reality object based on an operation of an experiencing person. The display unit displays a video of the linked virtual object. The controller acquires a recognition result of a reality object generated by the other MR display device and data of the linked virtual object, via a communication unit, synthesizes the acquired data and the own data, and displays a video obtained by the synthesis on the display unit. In addition, the controller allows an edit of the virtual object linked to the reality object on the video displayed on the display unit, based on an operation of the experiencing person.

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| <b>Appl. No.:</b> | <b>18/637053</b>  |
| <b>Filed:</b>     | <b>April 16, 2024</b>                                     |

#### Prior Publication Data

|                            |                         |
|----------------------------|-------------------------|
| <b>Document Identifier</b> | <b>Publication Date</b> |
| US 20240265651 A1          | Aug. 08, 2024           |

#### Related U.S. Application Data

continuation parent-doc US 17428646 US 11989838 WO PCT/JP2019/004191 20190206 child-doc US 18637053

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## Publication Classification

**Int. Cl.:** **G06T7/194** (20170101); **G06F3/01** (20060101); **G06F3/14** (20060101); **G06T7/50** (20170101); **G06T15/40** (20110101); **G06T19/00** (20110101); **G06T19/20** (20110101); **G06V20/20** (20220101); **H04L67/131** (20220101); **H04N13/363** (20180101)

**U.S. Cl.:**

**CPC** **G06T19/006** (20130101); **G06F3/011** (20130101); **G06F3/1454** (20130101); **G06T7/194** (20170101); **G06T7/50** (20170101); **G06T15/40** (20130101); **G06T19/20** (20130101); **G06V20/20** (20220101); **H04L67/131** (20220501); **H04N13/363** (20180501); **G06T2219/024** (20130101)

## Field of Classification Search

**CPC:** G06T (19/006); G06T (7/194); G06T (7/50); G06T (15/40); G06T (19/20); G06T (2219/024); G06T (2200/24); G06T (2210/04); G06T (2219/2016); G06T (2219/2021); G06T (2219/2024); G06F (3/011); G06F (3/1454); G06F (3/1423); G06F (3/012); G06F (13/00); G06V (20/20); H04L (67/131); H04N (13/363); G02B (27/017); G09G (2360/144); G09G (2370/16)

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## References Cited

### U.S. PATENT DOCUMENTS

| Patent No.   | Issued Date | Patentee Name   | U.S. Cl.   | CPC             |
|--------------|-------------|-----------------|------------|-----------------|
| 6329986      | 12/2000     | Cheng           | N/A        | N/A             |
| 6421047      | 12/2001     | de Groot        | 345/473    | A63F 13/70      |
| 9503681      | 12/2015     | Popescu         | N/A        | G06F 40/169     |
| 10225656     | 12/2018     | Kratz et al.    | N/A        | N/A             |
| 2004/0189675 | 12/2003     | Pretlove        | 348/E7.087 | G06F 3/1454     |
| 2005/0132288 | 12/2004     | Kirn et al.     | N/A        | N/A             |
| 2012/0249591 | 12/2011     | Maciocci et al. | N/A        | N/A             |
| 2013/0141419 | 12/2012     | Mount           | 345/419    | G09G 3/003      |
| 2013/0234934 | 12/2012     | Champion        | 345/156    | G06F 3/0346     |
| 2014/0132629 | 12/2013     | Pandey          | 345/633    | G06T 11/001     |
| 2014/0184496 | 12/2013     | Gribetz         | 345/156    | G02B 27/017     |
| 2014/0368537 | 12/2013     | Salter et al.   | N/A        | N/A             |
| 2015/0231490 | 12/2014     | Graepel et al.  | N/A        | N/A             |
| 2015/0235398 | 12/2014     | Kim             | 345/633    | G06T 7/194      |
| 2016/0098862 | 12/2015     | Wilson et al.   | N/A        | N/A             |
| 2016/0187969 | 12/2015     | Larsen          | 345/156    | G02B<br>27/0093 |
| 2016/0357491 | 12/2015     | Oya             | N/A        | N/A             |
| 2017/0053446 | 12/2016     | Chen            | N/A        | G06T 19/006     |
| 2017/0124717 | 12/2016     | Baruch et al.   | N/A        | N/A             |
| 2017/0243403 | 12/2016     | Daniels et al.  | N/A        | N/A             |
| 2018/0219975 | 12/2017     | Leppanen et al. | N/A        | N/A             |
| 2019/0035153 | 12/2018     | Dange           | N/A        | G06V 20/20      |
| 2019/0073831 | 12/2018     | Kim             | N/A        | G06F 3/011      |

|              |         |               |     |            |
|--------------|---------|---------------|-----|------------|
| 2019/0082118 | 12/2018 | Wang          | N/A | H04N 5/265 |
| 2019/0279407 | 12/2018 | McHugh et al. | N/A | N/A        |

## FOREIGN PATENT DOCUMENTS

| Patent No.  | Application Date | Country | CPC |
|-------------|------------------|---------|-----|
| 2000-011203 | 12/1999          | JP      | N/A |
| 2002-245294 | 12/2001          | JP      | N/A |
| 2007-514235 | 12/2006          | JP      | N/A |
| 2015-228256 | 12/2014          | JP      | N/A |
| 2016-224810 | 12/2015          | JP      | N/A |
| 2017-538990 | 12/2016          | JP      | N/A |

## OTHER PUBLICATIONS

Zheren Yu, et al., “An Augmented Reality based Cooperative Modeling System and Interface of Interactive Operation”, Proceedings of the Media Computing Conference, Jun. 18, 2016, pp. 1-4. cited by applicant

Fumihisa Shibata, et al., “Design and Implementation of Contents Description Language for Mobile Mixed Reality System”, IEICE Technical Report, vol. 105, No. 533, Jan. 12, 2006, pp. 19-24. cited by applicant

International Search Report of PCT/JP2019/004191 dated Feb. 6, 2019. cited by applicant

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## Background/Summary

### TECHNICAL FIELD

(1) The present invention relates to a mixed reality display device and a mixed reality display method for experiencing a mixed reality (MR) space obtained by synthesizing a real space and a virtual object. In particular, the present invention relates to a technology suitable for causing a plurality of MR experiencing persons to share an MR experience.

### BACKGROUND ART

(2) Adding an augmented reality (AR) object being a virtual object created by computer graphics (CG) or the like, to a real space or a reality video imaged by a camera is used for contents such as games or maintenance works. In order to add an AR object, a video called an AR trigger or marker is imaged simultaneously with the background with a camera, and an AR object to be linked by the AR trigger is synthesized with a reality video. In particular, in an MR experience, an AR object generated in accordance with the position and a posture of a head mounted display (HMD) is superimposed and displayed in the real space as a video of a virtual object, based on a video of the real space imaged by the camera mounted on the HMD. In the HMD, the camera and a display are integrated.

(3) Regarding this, Patent Document 1 discloses an MR system in which a portable information terminal such as a tablet is combined in addition to the HMD in order to cause a plurality of persons to share an MR experience. Patent Document 1 discloses that, in this MR system, an MR video displayed on the HMD is also displayed on the tablet, and thus a user of the tablet can designate a virtual object in the shared MR video and cause the result of the designation to be applied to the MR video.

### CITATION LIST

## SUMMARY OF THE INVENTION

### Problems to be Solved by the Invention

(5) However, in the method in Patent Document 1, the user of the portable information terminal can just designate the virtual object, and it is not possible for the user to perform an operation of disposing the virtual object in the real space or replacing the virtual object. In addition, the real space of the HMD can be shared, but sharing the own real space of the user of the portable information terminal is not possible.

(6) As described above, in Patent Document 1, there are problems as follows. When a plurality of persons experience an MR space, it is not possible that other experiencing persons except for a person wearing the HMD perform an operation of disposing a virtual object in the real space or replacing the virtual object, further it is not possible to share real spaces of the other experiencing persons.

(7) The present invention has been made in view of the above points. An object of the present invention is to provide a mixed reality display device and a mixed reality display method capable of enabling a plurality of experiencing persons to simultaneously perform an operation of disposing a virtual object in a real space, replacing the virtual object, or the like and to share real spaces of the plurality of experiencing persons.

### Solutions to Problems

(8) To solve the above problems, according to the present invention, a mixed reality display device is configured to be connected to other mixed reality display devices worn by other experiencing persons and to cause the experiencing persons to share the reality video and the video of the virtual object with each other. The mixed reality display device includes a camera that images a reality video, a controller that recognizes the reality object from the reality video imaged by the camera and links a predetermined virtual object to the recognized reality object based on an operation of the experiencing person, a display unit that displays a video of the linked virtual object, a memory that stores data of the virtual object linked to the reality object, and a communication unit that is connected to the other mixed reality display devices and transmits and receives data to and from each other. The controller acquires a recognition result of a reality object generated by the other mixed reality display device and data of the linked virtual object, via the communication unit, synthesizes the acquired data and the data stored in the memory, and displays a video obtained by the synthesis on the display unit. In addition, the controller allows an edit of the virtual object linked to the reality object on the video displayed on the display unit, based on an operation of the experiencing person.

(9) Furthermore, according to the present invention, a mixed reality display method includes a step of imaging a reality video by each of the mixed reality display devices, a step of connecting the imaged reality videos to recognize a reality object, a step of linking a virtual object selected based on an operation of each of the experiencing persons to the reality object and performing synthesis, a step of displaying a common video based on synthesis data of the connected reality object and the linked virtual object, in each of the mixed reality display devices, and a step of causing the experiencing person of each of the mixed reality display devices to edit the virtual object linked to the reality object on the displayed video.

### Effects of the Invention

(10) According to the present invention, when a plurality of persons experience an MR space, it is possible for a plurality of experiencing persons to perform an operation of disposing a virtual object in a real space, replacing the virtual object, or the like, and to share real spaces of the plurality of experiencing persons.

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# Description

## BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1A is a view illustrating an example of a real space to which a plurality of MR display devices are applied.
- (2) FIG. 1B is a view illustrating a state where background videos are connected.
- (3) FIG. 2 is a view illustrating an appearance configuration of an MR display device according to Example 1.
- (4) FIG. 3 is a block diagram illustrating a functional configuration of an MR display device 1.
- (5) FIG. 4A is a view illustrating an example of an MR space in which AR objects are disposed.
- (6) FIG. 4B is a view for describing a generation method of a cross object.
- (7) FIG. 5 is a flowchart of an overall control process 81.
- (8) FIG. 6 is a flowchart of a reference point/movement history process 82.
- (9) FIG. 7 is a flowchart of a synchronization and priority process 83.
- (10) FIG. 8 is a flowchart of an imaged-object process 84.
- (11) FIG. 9 is a flowchart of a background-object process 85.
- (12) FIG. 10A is a flowchart (case 1) of an AR-object process 86.
- (13) FIG. 10B is a flowchart (case 2) of the AR-object process 86.
- (14) FIG. 11 is a flowchart of a display video generation process 87.
- (15) FIG. 12A illustrates an operation screen for setting a priority to an imaged object.
- (16) FIG. 12B illustrates an operation screen for editing a linked AR object.
- (17) FIG. 13A illustrates a data table of header data.
- (18) FIG. 13B illustrates a data table of reference point and movement history data 91.
- (19) FIG. 13C illustrates a data table of imaged object data 92.
- (20) FIG. 13D illustrates a data table of background object data 93.
- (21) FIG. 13E illustrates a data table of AR object data 94.
- (22) FIG. 14 is a view illustrating an example of an MR space according to Example 2.
- (23) FIG. 15 is a flowchart (additional portion) of the AR-object process 86.
- (24) FIG. 16A illustrates a data table of the imaged object data.
- (25) FIG. 16B illustrates a data table of the AR object data.
- (26) FIG. 17 is a diagram illustrating a configuration of an MR network system according to Example 3.
- (27) FIG. 18A is a sequence chart of the MR network system.
- (28) FIG. 18B is a chart illustrating details of sequences in FIG. 18A.
- (29) FIG. 19 is a view illustrating an appearance configuration of an MR display device 1' according to Example 4.
- (30) FIG. 20 is a block diagram illustrating a functional configuration of the MR display device 1'.

## MODE FOR CARRYING OUT THE INVENTION

(31) Hereinafter, examples of the present invention will be described with reference to the drawings. A mixed reality display device is referred to as an MR display device or an HMD below.

Example 1

(32) In Example 1, a system in which a plurality of MR display devices are connected to each other and data is transmitted and received between the MR display devices will be described.

(33) [MR Display System]

(34) FIG. 1A is a view illustrating an example of a real space to which a plurality of MR display devices are applied. In this system, three MR display devices (HMDs) 1a, 1b, and 1c are provided, and a plurality of experiencing persons 2a, 2b, and 2c in the MR space wear HMDs 1a, 1b, and 1c on the respective heads. As will be described later, each of the HMDs includes a camera, a distance measurement sensor, a display, a communication unit, and a position and direction sensor which are

built therein. The camera images the real space, and the experiencing person visually recognizes an MR video by the MR video displayed on the display. Imaging angle of view of cameras built in the HMDs **1a**, **1b**, and **1c** are indicated by reference signs **3a**, **3b**, and **3c**, respectively. An access point (AP) **5** such as a wireless LAN is provided for communication between the HMDs **1a**, **1b**, and **1c**. Since the positions of the experiencing persons (HMD) and the line-of-sight directions are different, the real spaces visually recognized by the experiencing persons are different. It is possible to experience a common MR video by communicating between the HMDs.

(35) In the real space, walls **4a**, **4b**, and **4c** and a floor **4d** of a room are the background. A window **6**, a sofa **7**, a projector **8**, and a projection screen **8a** of the projector **8** are placed in the real space as reality objects. The MR experiencing persons **2a**, **2b**, and **2c** experience MR in this real space. Specifically, an example in which a plurality of operators (MR experiencing persons) lay out the interior of the room is assumed.

(36) In order to share the MR experience, the experiencing persons **2a**, **2b**, and **2c** perform initial setting (coordinate alignment) of the line-of-sight direction (imaging direction of the camera), the position, and the height. For example, the reference of the imaging direction is determined in a manner that the camera images the window **6**, and the corners **6b** and **6c** of the window **6** are symmetrical with respect to the center **6a** of a display screen of the HMD. In this state, a position obtained by moving at a predetermined distance from the window **6** is set as a reference position. In addition to the imaging direction and the position, the height of the HMD depending on the height of the experiencing person is registered as the reference point. Although the reference point is registered by each of the experiencing persons **2a**, **2b**, and **2c**, a difference in height between the experiencing persons **2b** and **2c** may be corrected based on the height of the experiencing person **2**. The movement of the experiencing persons **2a**, **2b**, and **2c** after the reference point is registered is detected by the position and direction sensor and recorded as movement history data. Thus, it is possible to represent position data of each experiencing person in a common coordinate system.

(37) Incidentally, the initialization method is not limited to the above method, and may be a method using a GPS sensor or a direction center. Any method may be used as long as the reference point can be shared between experiencing persons in the MR space.

(38) The angles **3a**, **3b**, and **3c** of view that can be imaged by the camera of the HMD are just a part of the real space. In the present system, imaged videos having the imaging angles **3a**, **3b**, and **3c** of view acquired by the HMDs **1a**, **1b**, and **1c** are synthesized to generate a connected real space video (background video). At this time, the position, the direction, and the height of each HMD at the time of imaging are viewpoint-transformed into those of a video imaged at the reference point, and then synthesis is performed. The connection of the background video is repeated every time the experiencing persons **2a**, **2b**, and **2c** move. A portion at which regions overlap each other is updated by a new background video.

(39) FIG. 1B is a view illustrating a state where the background videos are connected. A range **3a** (imaging angle of view in FIG. 1A) for imaging by the HMD **1a**, a range **3b** for imaging by the HMD **1b**, and a range **3c** for imaging by the HMD **1c** are background images at different imaging positions. The videos are viewpoint-transformed into videos imaged at the reference point. Then, the videos are mapped to the 360-degree all-around space centered on the reference point to obtain the connected background video.

(40) The 360-degree all-around space does not mean that all spaces are covered by the imaging ranges **3a**, **3b**, and **3c**. Therefore, the HMDs **1a**, **1b**, and **1c** (experiencing persons **2a**, **2b**, and **2c**) move, and perform imaging in new imaging ranges **3aT**, **3bT**, and **3cT** at the next time **T**. Videos in the imaging ranges **3aT**, **3bT**, and **3cT** are viewpoint-transformed, and the resultant is added to the connected background video. In this manner, the space of the background video is expanded. When the space is expanded, it is easy to connect by overlapping the feature points, particularly, such as the boundary of the wall, the tangent line between the floor and the wall, and the frame of the window. A portion at which the background videos overlap each other is replaced with a portion of

a new background video in time, and the background video is updated.

(41) Incidentally, regarding a connection process of the background video, instead of the imaged video of the HMD, background object data described later may be acquired, and then the background object data may be connected. Further, imaged object data and background object data may be acquired from the video imaged by each HMD, and then, the imaged object data acquired by each HMD may be shared, and the background object data may be connected.

(42) As described above, by performing the connection process of the background videos acquired by the plurality of HMDs (plurality of experiencing persons), it is possible to synthesize the background that cannot be recognized by one HMD (one experiencing person). Specifically, in FIGS. 1A and 1B, it is not possible to capture the sofa **7** at the angle **3b** of view of the camera of the experiencing person **2b**, and it is not possible to capture the projector **8** at the angle **3c** of view of the camera of the experiencing person **2c**. However, by connecting camera videos of the experiencing persons and sharing the connected background video with the experiencing persons, the existence of the sofa **7** or the projector **8** is recognized, and the recognized information can be shared by the plurality of experiencing persons **2a**, **2b**, and **2c**, as an imaged object described later.

(43) [MR Display Device]

(44) FIG. 2 is a view illustrating an appearance configuration of the MR display device according to Example 1. The MR display device (HMD) **1** (**1a** to **1c**) includes a camera **10**, a distance measurement sensor **11**, a position and direction sensor **12**, a 3D projector **13**, a transmissive screen **14**, shutter-attached glasses **15**, a controller **16**, speakers **17a** and **17b**, holders **18a** and **18b**, and a microphone **19**. The experiencing person **2** of MR wears the HMD **1** on the head of the experiencing person **2** with the holders **18a** and **18b**.

(45) The camera **10** is attached to image the front of the head (line-of-sight direction of the experiencing person). The distance measurement sensor **11** measures the distance to a reality object captured by an imaged video of the camera **10**. The position and direction sensor **12** is configured by a gyro sensor, a position sensor, a direction sensor, and the like, and detects the position and the line-of-sight direction of the experiencing person.

(46) The distance measurement sensor **11** may measure a distance by two-dimensional irradiation with light beams as in the time-of-flight (TOF) method. The distance measurement sensor may calculate a distance to a feature point such as a contour by using a method like a stereo camera, or may be capable of measuring a distance between the camera and a reality object corresponding to a camera imaged video.

(47) The 3D projector **13** displays a 3D virtual object (AR object) by alternately projecting a video recognized by the left eye and a video recognized by the right eye on the transmissive screen **14**. The shutter-attached glasses **15** transmit a video alternately on the left and right in synchronization with the display of the 3D projector. The experiencing person **2** can see the scenery or the reality object in front, through the transmissive screen **14**, and can visually recognize the 3D virtual object projected by the 3D projector **13** on the transmissive screen **14** in superimposition on the scenery or the reality object.

(48) The controller **16** takes in the imaged video of the camera **10**, distance data of the distance measurement sensor **11**, and position and direction data of the position and direction sensor **12**, and supplies such types of data to an internal memory and a CPU. The controller creates a video to be projected by the 3D projector **13** or a sound to be output to the speakers **17a** and **17b**. Further, the controller generates a drive signal of the shutter-attached glasses **15**, and synchronizes the drive signal with the video of the AR object projected by the 3D projector **13**. The controller switches transmission between the left and right glasses to provide a 3D video for the experiencing person.

(49) The controller **16** includes a user interface with the MR experiencing person **2**. When the controller **16** is realized by a device such as a smartphone, a panel having a built-in touch sensor can be used as the user interface.

(50) FIG. 3 is a block diagram illustrating a functional configuration of the MR display device **1**.

The same components as those in FIG. 2 are denoted by the same reference signs. A feature extraction processing unit **61**, a distance calculation processing unit **62**, a movement detection processing unit **63**, a communication unit **64**, a CPU **65**, a RAM **66**, an image RAM **67**, a program flash ROM (P-FROM) **68**, a data flash ROM (D-FROM) **69**, and a user operation input unit **60** are provided inside (indicated by a broken line) the controller **16** of the HMD **1**.

(51) The feature extraction processing unit **61** performs a process of extracting a contour (edge) of the reality object from the video imaged by the camera **10**, and setting an inflection point or a vertex of the contour as a feature point. The distance calculation processing unit **62** calculates the distance to the feature point based on measurement data of the distance measurement sensor **11**. The movement detection processing unit **63** obtains the position and movement amount of the HMD **1** and the imaging direction of the camera **10** based on the measurement data from the position and direction sensor **12**. That is, the obtained position and movement amount, and the imaging direction are used as the position and movement amount of the experiencing person **2**, and the line-of-sight direction, respectively.

(52) The communication unit **64** connects the HMD **1** to an access point **5** and transmits and receives data to and from another HMD **1**. Alternatively, the communication unit can be connected to an external network, and handle a portion of processing of the HMD **1** by a server or the like connected to the external network.

(53) Various processing programs are stored in the program flash ROM **68**. The processing programs include an overall control process **81**, a reference point/movement history process **82**, a synchronization and priority process **83**, an imaged-object process **84**, a background-object process **85**, an AR-object process **86**, and a display video generation process **87**. The processing programs are expanded into the RAM **66** and executed by the CPU **65**.

(54) Pieces of data generated in the process of executing the processing program and from a result obtained by the execution are stored in the data flash ROM **69**. Such pieces of data include reference point and movement history data **91**, imaged object data **92**, background object data **93**, and AR object data **94**. Thus, when the experiencing person wants to play and experience the MR space, this can be realized by reading out the pieces of stored data.

(55) Incidentally, the program flash ROM **68** and the data flash ROM **69** may be configured by separate memory media as illustrated in FIG. 3, or may be configured by one memory medium. The program flash ROM and the data flash ROM may two or more memory media, or a non-volatile memory medium other than the flash ROM. The data flash ROM **69** may be disposed in a data server on the network.

(56) The video data generated by the display video generation process **87** is stored in the image RAM **67**, read from the image RAM **67**, and projected by the 3D projector **13**. The user operation input unit **60** receives a user input by the touch sensor. The 3D projector **13** projects a control menu video onto the transmissive screen **14** to control the HMD **1**.

(57) [MR Space]

(58) Next, an operation of each functional block in the MR display device **1**, that is, a process of disposing an AR object in the real space to create the MR space will be specifically described.

(59) Firstly, in the real space illustrated in FIG. 1A, a reality object is recognized and registered as an imaged object or a background object. The room as the real space is surrounded by a front wall **4a**, a left side wall **4b**, a right side wall **4c**, and a floor **4d**, and has a window **6**, a sofa **7**, and a projector **8**.

(60) The cameras **10** of the plurality of HMDs **1** image the reality objects. The feature extraction processing unit **61** performs the process of extracting the contours (edges) of the reality objects and setting the inflection points and vertices of the contours as feature points. The set of feature points constituting the contour is transmitted to the CPU **65** to identify what the object is. At this time, the feature extraction processing unit may identify the object by collating with a video database of the external server via the communication unit **64**.



(61) The distance measurement sensor **11** and the distance calculation processing unit **62** calculate the distance to each of the objects in the room and create a sketch in the real space. The distance data calculated by the distance calculation processing unit **62** is combined with the feature points extracted by the feature extraction processing unit **61**. Further, in the reference point/movement history process **82**, the position and direction sensor **12** and the movement detection processing unit **63** record the position (coordinates) and the direction of the HMD **1** when the HMD performs imaging.

(62) The identified reality object is classified into an “imaged object” or a “background object” and registered by the imaged-object process **84** and the background-object process **85**. The imaged object has a unique object shape, and the distance data indicates that the imaged objects are located relatively close to each other. Thus, in this example, the window **6**, the sofa **7**, and the projector **8** are registered. The background object does not have a unique object shape other than a plane, or the distance data includes the farthest point. Thus, in this example, the front wall **4a**, the left side wall **4b**, the right side wall **4c**, and the floor **4d** are registered as background objects. That is, the background object is an object that constitutes the background of the camera imaged video.

(63) FIG. **4A** is a view illustrating an example of an MR space in which AR objects are disposed in the real space. The same objects as those in the real space illustrated in FIG. **1A** are denoted by the same reference signs, and new AR objects **21** to **26** are disposed as virtual objects. Each of the experiencing persons **2a** to **2c** wearing the HMDs **1a** to **1c** can experience such an MR space.

(64) Each of the AR objects **21** to **26** is disposed to correspond (that is, linked) the position of a specific reality object (imaged object or background object). The disposition of the AR object is determined by the AR-object process **86** based on the operation of each experiencing person **2**. This process is also referred to as a “linking process”. That is, in the linking process, the coordinates for disposing each AR object are determined based on the sketch of the real space created from the camera video in FIG. **1B**. At this time, in order to not only designate an associated object, but also designate a portion of the object, at which the AR object is disposed, in disposition information (linking information) of the AR object, positioning is performed by giving an offset distance to a specific feature point of the object.

(65) In the case of this example, the TV object **21** is disposed to replace the projector **8** being the imaged object. The table object **22** and the vase object **23** are linked to the sofa **7**, and a distance and direction offset is given so that the table object and the vase object are located in front of the sofa **7**. The vase object **23** is designated with an offset in the height direction so that a vase is just disposed on a table. The curtain object **24** is linked to the window **6** and is disposed by giving an offset distance to a specific feature point of the window **6**. The clock object **25** is linked to the wall **4** being the background object. Any point on the front wall **4a** is defined as a pseudo feature point and the clock object is disposed on the pseudo feature point.

(66) The cross object **26** is a 3D object that obtains the effect of covering the background object with a cloth. In this example, the cross object can be applied to a region of the floor **4d** portion being the background object, and processing as if a carpet is spread on the floor **4d** can be simulated. At this time, the projector **8** replaced by the TV object **21** is also covered with the cross object **26**, but, due to the existence of the projector **8**, the cross object **26** is raised and wrinkles **26a** are formed.

(67) FIG. **4B** is a view for describing a generation method of the cross object **26**. By using distance information to the projector **8** covered with the cross object **26**, a polygon group **26b** is disposed at a position in contact with the projector **8** to cover the projector **8**. A texture is pasted on the planar region of the floor portion **4d** and the polygon group **26b** by a rendering technique of 3D computer graphics to generate the cross object **26**.

(68) [Process Flow of MR Display Device]

(69) Next, various process flows performed by the MR display device (HMD) **1** will be described. That is, the CPU **65** performs the process in accordance with the following program stored in the

program flash ROM **68**.

(70) FIG. 5 is a flowchart of the overall control process **81**. That is, FIG. 5 illustrates the entire process from camera imaging to displaying an AR object in each HMD.

(71) In **S101**, log-in is performed to participate in an MR experience. A login server may be a personal computer directly connected to the AP **5**, or may be a network server connected to the AP **5** via a network.

(72) In **S102**, the camera **10** starts imaging in the real space. The camera imaging may be performed at a timing at which the entire MR display is performed. For example, an imaged video may be captured at a timing at which the entire MR display is performed by continuing moving imaging of 30 frame per second (fps).

(73) **S103** corresponds to the reference point/movement history process **82**. In **S103**, the position, the imaging direction, and the height of the HMD are detected and registered in the reference point and movement history data **91**.

(74) **S104** corresponds to the synchronization and priority process **83**. In this process **83**, synchronization of imaged objects, background objects, and AR objects are performed between a plurality of HMDs participating in the MR experience, and a process of a priority set in each of the imaged objects and the background objects is performed, and thus the data is updated to the latest state. The priority means assignment of an operation authority for a specific object to a specific HMD (experiencing person). When the priority is set, it is not possible for other experiencing persons to edit the object.

(75) **S105** corresponds to a process **87** of display video generation. The MR experiencing person wearing the HMD performs the imaged-object process **84** of **S106**, the background-video process **85** of **S107**, and the AR-object process **86** of **S108** as follows, while confirming a display video in a state where each of the imaged object and the background object, and the priority are updated latest.

(76) In the imaged-object process **84** of **S106**, feature extraction of the captured camera imaged video is performed. A feature point is selected, what is the reality object is identified from the set of the feature points, and the identified object is registered as the imaged object in the imaged object data **92**.

(77) In the background-object process **85** of **S107**, a feature point at the farthest point in the distance data given to the feature point is included. A region other than the imaged object is registered as the background object in the background object data **93**.

(78) In the AR-object process **86** of **S108**, an AR object disposed on the imaged object or the background object is selected (added), and parameters (display parameters) when the AR object is disposed are edited. This process includes an operation of downloading AR object data from the network and causing the experiencing person to select the AR object. The data of the selected AR object is registered in the AR object data **94**. The display parameters are registered as liking data in the imaged object data **92** and the background object data **93**.

(79) **S109** corresponds to the display video generation process **87**. In **S109**, a display video of the AR object added or edited in **S108** is generated, and the MR experiencing person visually recognizes the display video with the HMD.

(80) It is determined in **S110** whether to continue. In the case of continuing (Yes), the process returns to **S102**. In the case of not continuing (No), the process is ended.

(81) As described above, in this example, the plurality of HMDs **1** worn by the plurality of experiencing persons **2** can be connected to each other, and pieces of data of the imaged object and the background object acquired by each HMD and the virtual object (AR object) linked to the imaged object or the background object can be synchronized with each other and shared. As a result, it is possible to share the same real space between a plurality of experiencing persons, and each of the experiencing persons can individually perform an operation of, for example, displaying the virtual object in the real space or replacing the virtual object.

(82) Each of the processes will be described below in detail.

(83) FIG. 6 is a flowchart of the reference point/movement history process 82. This process is performed by the position and direction sensor 12 and the movement detection processing unit 63.

(84) In S111, the MR experiencing person 2 wears the HMD 1 and starts camera imaging.

(85) In S112, the position and direction sensor 12 detects the position of the HMD 1 and the imaging direction of the camera 10, and acquires the data representing the position, the height, and the line-of-sight direction of the experiencing person.

(86) In S113, it is confirmed whether reference point data is already registered in the reference point and movement history data 91 in the data flash ROM 69, that is, whether or not the MR experience is started.

(87) When the reference point data is registered (Yes), the reference point data is registered as movement history data in S114. When the reference point data is not registered (No), the reference point data is registered as the reference point data in S115. The movement history data is represented by a difference from the reference point data.

(88) After that, each time a user performs camera imaging while moving in the real space, the pair of the current position and the camera imaging direction is registered as movement history in the reference point and movement history data 91.

(89) FIG. 7 is a flowchart of the synchronization and priority process 83.

(90) Firstly, the synchronization process is a process of sharing and latest updating the data of the imaged object, the background object, and the AR object possessed by the plurality of HMDs 1, between the plurality of HMDs 1.

(91) In S121, each of the HMDs transmits and receives data to and from another HMD via the communication unit 64, and stores the acquired data in the data flash ROM 69.

(92) In S122, synchronization for the imaged object data is performed.

(93) In S123, synchronization for the background object data is performed.

(94) In S124, synchronization for the AR object data is performed.

(95) Next, the priority process is a process of reading the priority assigned to the imaged object or the background object. It is not possible for a person other than the set MR experiencing person to edit the object for which the priority has been set (link the AR object).

(96) In S125, priority setting for the imaged object is read.

(97) In S126, the priority setting for the background object is read.

(98) Priority setting information is used as a reference in the linking process of the AR object (S108).

(99) FIG. 8 is a flowchart of the imaged-object process 84. This process is performed by the feature extraction processing unit 61.

(100) In S131, the imaged video is read out from the camera 10.

(101) In S132, the feature analysis of the video is performed. For example, an edge is extracted, and the vertex and the inflection point of the edge are extracted as feature points.

(102) In S133, the distance data acquired by the distance measurement sensor 11 and the distance calculation processing unit 62 is added to the feature points.

(103) In S134, a difference from the previous feature point is evaluated.

(104) In S135, the type of the object and the like are identified from the set of feature points between which a difference is evaluated to be significant. At this time, the object can be identified by collating with the video database of the external server via the communication unit 64.

(105) In S136, the result of the identification is registered as the imaged object in the imaged object data 92.

(106) In S137, when the identified imaged objects include a person, the result of the identification is transmitted to the display video generation process 87. This is because there is a high possibility that the camera is imaging another MR experiencing person. When the other MR experiencing person determines that the MR video is not necessary, identification information of the person

object is transmitted to the display video generation process **87**, and exclusion of the person object from the display video is requested. Alternatively, the experiencing person himself/herself may determine, from the camera imaged video in **S131**, that the identified imaged object indicates the other MR experiencing person, exclude the person object from the display video.

(107) FIG. **9** is a flowchart of the background-object process **85**.

(108) In **S141**, among the feature points extracted by the feature extraction processing unit **61**, the feature point having the farthest distance is selected. In the example of FIG. **1A**, the corner of the front wall **4a** and the like correspond to the feature point having the farthest distance. A region that includes the feature point having the farthest distance and is not recognized as the imaged object is selected and set as a region A.

(109) In **S142**, among the feature points extracted by the feature extraction processing unit **61**, a region in which distance detection is not possible (exceeding the detection limit) is selected and set as designated as a region B.

(110) In **S143**, the region A and the region B selected in the above processes are used as background objects in the real space.

(111) In **S144**, difference data from the registered background object data is calculated.

(112) In **S145**, the background object data acquired from another HMD is synchronized.

(113) In **S146**, pieces of the background object data synchronized with the above difference data is integrated.

(114) In **S147**, the background object is divided into some regions as necessary.

(115) In **S148**, AR objects are disposed in the divided regions. For example, as illustrated in FIGS. **4A** and **4B**, the cross object **26** can be pasted to the floor **4d**.

(116) In **S149**, background data obtained by the integration and the region data obtained by the division are registered as background objects in the background object data **93**.

(117) FIGS. **10A** and **10B** are flowcharts of the AR-object process **86**. A portion of the process procedure is changed in FIGS. **10A** and **10B**. Either flow may be used. This process is performed interactively while the experiencing person looks at an operation screen.

(118) A case (case **1**) of FIG. **10A** will be described.

(119) In **S151**, one object on which the AR object is disposed is selected from the imaged object or the background object (which may be the divided region).

(120) In **S152**, it is confirmed whether a priority is set for the selected object by another HMD. For the confirmation, the result of reading the priority in the synchronization and priority process **83** (FIGS. **7**, **S125**, and **S126**) is used as the reference. When the priority is set (Yes), the process proceeds to **S156**. When the priority is not set (No), the process proceeds to **S153**.

(121) In **S153**, priority setting registration is performed for the selected object. Thus, editing (linking the AR object) the object selected in preference to other HMDs can be performed. In the case of the background object, there are a priority assigned to the AR object linked to the entirety of the background object and a priority assigned to each region obtained by dividing the background object.

(122) The registered priority can be canceled. The priority is canceled in a manner that a cancellation request (for example, voice call by the microphone **19**) of another experiencing person is received, and the experiencing person holding the priority changes the setting. Alternatively, the set experiencing person may cancel the priority. The priority may be automatically lost when linking of the AR object is canceled (deleted). FIG. **12A** illustrates a specific setting screen.

(123) In **S154**, an AR object linked to the selected object is selected. The AR object selection candidate may be prepared in advance in the HMD **1**, or may refer to data accumulated in the external server via the communication unit **64**. The selected AR object is registered in the AR object data **94**.

(124) In **S155**, the display parameters when the AR object is displayed are set. Thus, the display position, the size, and the direction of the AR object with respect to the object are given. That is,

positioning with respect to the object can be performed by giving an offset to the position of a certain feature point of the selected object. In a background object having a feature point which is not clear, such as the region B, any point in the region may be selected and the selected point may be used as a pseudo feature point. The set display parameter is registered as linking data of the AR object in the imaged object data **92** or the background object data **93**. FIG. **12B** illustrates a specific AR object edit screen.

(125) In **S156**, it is determined whether or not the imaged object or the background object on which the AR object is disposed remains. When the imaged object or the background object remains (Yes), the process returns to **S151**. When the imaged object or the background object does not remain (No), the process ends.

(126) Next, a case (case **2**) of FIG. **10B** will be described. In this case, a procedure of first selecting an AR object, and assigning the imaged object or the background object to the selected AR object is performed.

(127) In **S161**, all AR objects to be used are selected. For the selection, the component built in the HMD **1** or the external server is used for the reference. The selected AR object is registered in the AR object data **94**.

(128) In **S162**, one of the selected AR objects is selected.

(129) In **S163**, the imaged object or the background object to which the selected AR object is linked is selected.

(130) In **S164**, it is confirmed whether a priority is set for the selected object by another HMD. For the confirmation, the result of reading the priority in the synchronization and priority process **83** (FIGS. **7**, **S125**, and **S126**) is used as the reference. When the priority is set (Yes), the process proceeds to **S167**. When the priority is not set (No), the process proceeds to **S165**.

(131) In **S165**, priority setting registration is performed for the selected object. Thus, the object selected in preference to other HMDs can be edited.

(132) In **S166**, display parameters (position, size, direction on the display) when the AR object is displayed are set. The set display parameter is registered as linking data of the AR object in the imaged object data **92** or the background object data **93**.

(133) In **S167**, it is determined whether or not the AR object selected in **S161** remains. When the AR object selected in **S161** remains (Yes), the process returns to **S162**. When the AR object selected in **S161** does not remain (No), the process ends.

(134) FIG. **11** is a flowchart of the display video generation process **87**. Here, various types of data registered in the data flash ROM **69** are read out to generate a display video of the AR object, and the display video is projected and displayed by the 3D projector **13**.

(135) In **S171**, the AR object to be displayed is selected with reference to the imaged object data **92**, the background object data **93**, and the AR object data **94**.

(136) In **S172**, the AR object is rotated in accordance with the direction (line of sight of the user) of the HMD **1**. The AR object is enlarged or reduced in accordance with the distance to the imaged object (or background object) to be linked.

(137) In **S173**, a distance relation (far and close) between the AR object and the reality object (imaged object) that overlaps the AR object in the line-of-sight direction is evaluated. The distance to the reality object is measured by the distance measurement sensor **11**.

(138) In **S174**, it is determined whether or not the AR object is hidden by the reality object, that is, whether or not the reality object is in front of the AR object. When the AR object is hidden (Yes), the process proceeds to **S175**. When the AR object is not hidden (No), the process proceeds to **S176**.

(139) In **S175**, the hidden portion or the entire video of the AR object is set not to be displayed (for example, the image data is rewritten to 0).

(140) In **S176**, the 3D projector **13** projects and displays the AR object.

(141) In **S177**, when there is an unprocessed AR object (Yes), the process returns to **S171** and the

next AR object is processed. When there is no unprocessed AR object (No), the process proceeds to **S178**.

(142) In **S178**, the information of the person object in the imaged object is read out. The information of the person object is the information transmitted in the imaged-object process **84** (**S137**) and is temporarily stored.

(143) In **S179**, a person is covered (masking) in a manner that a background video is cut out from the region of the background object that matches a person display region, based on the person object information, and the cut-out background video is displayed in front of the person (position closer to the HMD). Thus, an occurrence of a situation in which another MR experiencing person appears in the display video is prevented.

(144) [Setting of Priority and AR Object]

(145) Next, an example of a user operation screen in the AR-object process **86** described with reference to FIG. **10A** (FIG. **10B**) will be described.

(146) FIG. **12A** illustrates an operation screen for setting (**S153** and **S165**) the priority for the imaged object. Here, the sofa **7** as the reality object is recognized as the imaged object, and the priority is set for the imaged object. In this setting operation, a cursor **30** is first placed on the sofa **7** and clicked. With this operation, a small menu screen **31** pops up. “Set priority” is clicked from a list presented on the small menu screen **31**. The clicked item is converted to outline characters on a black background. This state is illustrated in FIG. **12A**. In response to this, a priority setting screen **31a** appears. The experiencing person selects “set” or “cancel” of the priority with the cursor **30**, and makes a desired setting for the sofa **7**.

(147) FIG. **12B** illustrates an operation screen for editing (**S155** and **S166**) the linked AR object. Here, a case where the setting of various display parameters is changed for the table object **22** linked to the sofa **7** is illustrated. The cursor **30** is placed on the table object **22** and clicked. With this operation, a menu small screen **32** is popped up. When “edit AR object” is clicked, an edit screen **32a** appears. Here, edit operations such as switching “display/non-display”, changing “display size”, changing “display rotation”, and changing “display disposition” are performed. Further, when “delete” of the AR object is selected, the linked table object **22** is deleted. At this time, when the table object **22** is linked to the sofa **7**, the priority set on the sofa **7** may also be canceled.

(148) [Data Table]

(149) FIGS. **13A** to **13E** are views illustrating examples of various data tables stored in the data flash ROM **69**.

(150) FIG. **13A** illustrates header data. “Content ID” at the top of the table is an ID common to tables of an imaged object, a background object, and an AR object, which will be described later, and the like. “Content type” indicates that the data is header data. “Content name” indicates that the data is related to the MR experience. A list of data handled by the HMD **1** is described in “accompanying content”. In addition, information such as “content holder” and “copyright” is contained.

(151) FIG. **13B** illustrates the reference point and movement history data **91**. The common “content ID” is provided, and “content type” indicates that the data is reference point and movement history data. As the data, time (**T0**, **T1**, **T2**) and the position and direction of “reference point (PBase)” and “movement history (MP1, MP2)” are described. The time is the camera imaging time in MR processing, and is described in coordinated universal time (UTC). Regarding the position and direction, the position (including the height) of the MR display device **1** and the imaging direction at each time are indicated by difference data starting from the reference point (PBase). For example, the movement history (MP1) at time **T1** is represented by the difference position ( $r1, \theta1, \phi$ )=(distance, horizontal angle, vertical angle) and the difference direction ( $\theta\theta1, \phi\phi1$ )=(horizontal angle, vertical angle).

(152) In this example, the reference point values are given as the position=(0, 0, 0) and the

direction=(0, 0). The value of GPS data value may be given at the position other than the height, and the value of the azimuth angle may be given at the direction.

(153) FIG. 13C illustrates the imaged object data **92**. The imaged object data is described separately for each imaging position as the reference position (PBase) and the movement position (MP1, . . . ). The imaged object data is synchronized, and the result obtained by integrating pieces of data of a plurality of HMDs is described.

(154) A serial number, for example, “imaged object **1**”, “imaged object **2**”, or the like is given to the imaged object recognized at each imaging position, and the name being the name of the recognized object, such as “window”, “projector”, and “sofa” is described. Extracted “feature point **1**”, “feature point **2**”, and the like, and data of “linked AR object”, and a priority flag indicating a priority setting status are described in each imaged object.

(155) The data of each feature point includes a relative position (distance and direction) with respect to the imaging position of the HMD **1**. The data of “linked AR object” is linked to the AR object data **94** described later, and the AR object (title) designated by the data ID is linked. Further, “linking position” indicates the feature point and the offset distance at which the AR object is disposed. “Size” and “rotation” are parameters when the AR object is displayed.

(156) In this example, when the imaging position is the reference position (PBase), the imaged objects **1** to **3** are described. The AR object **1** is linked to the imaged object **1** (window). The AR object **2** is linked to the imaged object **2** (projector). The AR object **3** is linked to the imaged object **3** (sofa).

(157) Further, even when the imaging position is the movement position (MP1, . . . ), similar description will be made. The numerical values of the positions and directions of the imaged objects **1** and **2** with respect to each feature point are slightly different depending on whether the imaging position is the reference position (PBase) or the movement position (MP1). This is because, even though the imaged objects **1** and **2** do not move in the real space, the values differ depending on the movement of the HMD **1**. In addition, when a new imaged object is recognized at the movement position, this is added to the table.

(158) Further, the priority flag indicating the priority setting status is assigned to each imaged object. The priority flag is configured by a plurality of digits. The first digit is “1” when the priority is set by the person who images the object (data provider). The remaining digits represent the MR experiencing persons who hold the priority. A relation between the digit value and the MR experiencing person is given at the time of log-in. The priority is set when a certain MR experiencing person links an AR object with the imaged object and does not want another MR experiencing person to change the linked AR object.

(159) FIG. 13D illustrates the background object data **93**. The background object data is classified for each imaging position, and is described separately as a reference position (PBase) and a movement position (MP1, . . . ). The background object data is also synchronized, and this is the result obtained by integrating pieces of the background object data of a plurality of HMDs.

(160) In the case of the feature point, “feature point **1**”, “feature point **2**”, and the like are described in the background object data. The feature points may include pseudo feature points instructed by the experiencing person. Subsequently, as in the case of the imaged object, “linked AR object” is described, and the data ID of the linked AR object and the priority flag are included in “linked AR object”. The background object data has bitmap data corresponding to the coordinates of a virtual video of the 360° camera centered on the reference point so that the position and the shape can be grasped.

(161) Further, when the background object is divided into regions, the background object data includes divided region data. The divided region data includes region division information such as feature points, priority information, and 3D image data of a cross object covering the divided region.

(162) FIG. 13E illustrates the AR object data **94**. The AR object data is, for example, data

downloaded from a server on the network, and a serial number is assigned to each AR object. A data ID for identification is assigned to each AR object data. With the data ID, the AR object data is linked to the imaged object data or the background object data described above. The title and the description of copyright are provided as items, and 3D image data is stored. A display video is generated by using the 3D image data.

(163) As described above, according to Example 1, the plurality of MR display devices worn by the plurality of experiencing persons can be connected to each other, and pieces of data of the imaged object and the background object acquired by each device and the virtual object (AR object) linked to the imaged object or the background object can be transmitted and received to and from each other and shared. As a result, it is possible to share the same real space between a plurality of experiencing persons, and each of the experiencing persons can individually perform an operation of, for example, displaying the virtual object in the real space or replacing the virtual object.

(164) In addition, in the process of linking a virtual object to an imaged object or a background object, a priority for assigning an operation authority for a specific object to a specific HMD (experiencing person) is set. Thus, for example, it is possible to smoothly and efficiently perform the collaborative operation in the same space by a plurality of operators, by sharing the space.

#### Example 2

(165) In Example 2, a case where an AR object is configured by a plurality of components, and a priority is set for each component will be described.

(166) [MR Space]

(167) FIG. **14** is a view illustrating an example of an MR space according to Example 2. The same elements as those in the MR space illustrated in FIG. **4A** in Example 1 are denoted by the same reference signs, and repetitive description will be omitted. The difference from the MR space in FIG. **4A** is that the projector **8** is removed, there is no cross object **26**, and the TV object **21** being the AR object is configured by three components **21a**, **21b**, and **21c**. Here, **21a** indicates a flat panel, **21b** indicates a support, and **21c** indicates a pedestal. The colors and forms of the three components can be individually selected, and the different MR experiencing person can set the color and form for each component.

(168) FIG. **15** illustrates a flowchart of AR-object process **86** (additional portion) in Example 2. Here, it is assumed that AN AR object is already linked by the flow of FIG. **10A** or FIG. **10B** in Example 1. This is a process when the linked AR object is configured by a plurality of components and some components are edited (changed).

(169) In **S201**, one AR object is selected.

(170) In **S202**, it is confirmed whether the priority is set on an imaged object or a background object to which the selected AR object is linked, from another HMD. When the priority is set (Yes), the priority extends to the entirety of the AR object, and the process proceeds to **S206**. When the priority is not set (No), the process proceeds to **S203**.

(171) In **S203**, the component of the AR object, which is to be changed, is selected.

(172) In **S204**, it is confirmed whether the priority is set on the selected component of the AR object, from another HMD. When the priority is set (Yes), the process proceeds to **S206**. When the priority is not set (No), the process proceeds to **S205**.

(173) In **S205**, the component of the AR object is edited (changed). The priority is set, and the registration in a data table is performed.

(174) In **S206**, it is determined whether or not there is an AR object having a component which is intended to be changed. When there is such an AR object (Yes), the process returns to **S201**. When there is no AR object (No), the process ends.

(175) FIGS. **16A** and **16B** are examples of data tables according to Example 2. FIG. **16A** illustrates a data table of imaged object data, and FIG. **16B** illustrates a data table of AR object data.

(176) Describing the difference from Example 1, an AR object **2** linked to the projector being the imaged object **2** in FIG. **16A** is configured by a plurality of components **1** to **3**. For each



component, a subdivision of data ID is described. The priority flag indicating an edit authority is assigned to each component by the different MR experiencing person.

(177) In the AR object data in FIG. 16B, in the corresponding column of the AR object 2, pieces of 3D image data of the three components being the panel, the support, and the pedestal, which correspond to the components 1 to 3 are stored.

(178) As described above, according to Example 2, it is possible to obtain the similar effects to those in Example 1, and to configure the AR object with a plurality of components and set a different priority for each component. As a result, it is possible to edit one AR object by a plurality of MR experiencing persons and to express various combinations of MR spaces.

### Example 3

(179) In Example 3, a configuration (MR network system below) in which a plurality of MR display devices (HMDs) are connected to a network and MR processing performed by each of the HMDs is performed by a server connected to the network will be described.

### (180) [MR Network System]

(181) FIG. 17 is a diagram illustrating a configuration of an MR network system according to Example 3. A plurality of MR display devices (HMDs) 1a, 1b, and 1c can be worn by MR experiencing persons 2a, 2b, and 2c, respectively. Each of the HMDs 1a, 1b, and 1c can be connected to a network 51 via an access point (AP) 5 such as a wireless LAN and a gateway 50, and thus transmission and reception of data can be performed between the experiencing persons.

(182) An application server 52 and a data storage server 53 are connected to the network 51. The application server 52 includes an MR processing application for synthesizing imaged videos of a plurality of experiencing persons and disposing AR objects. The data storage server 53 can store data of an AR object and an imaged object, synthesized indoor video data, position information when the AR object is disposed, and the like. Each of the experiencing person can read out the pieces of data.

(183) Therefore, the internal configuration of each of the HMDs 1a, 1b, and 1c can be obtained by omitting or simplifying the processing programs 81 to 87 stored in the program flash ROM 68 or the data tables 91 to 94 stored in the data flash ROM 69 in the functional block illustrated in FIG. 3 in Example 1.

### (184) [Sequence of MR Network System]

(185) FIGS. 18A and 18B are sequence charts of the MR network system, illustrating data transmission and reception between each of the HMDs 1a, 1b, and 1c (each of the MR experiencing persons 2a, 2b, and 2c) and the application server 52.

(186) FIG. 18A is a view illustrating an overall sequence. The similar processes to those in FIG. 5 in Example 1 are denoted by the same reference signs. This is configured by the log-in process of S101 to the display video generation process of S109. Also in this sequence, a pair of basic communication sequences of a request and a response is used, but this pair are omitted here to avoid complication of description. The outline will be described below in the order of processes.

(187) S101: The MR experiencing persons 2a to 2c log in to the application server 52 and participate in an MR experience.

(188) S102: The MR experiencing persons 2a to 2c perform camera imaging of a portion of a real space and transmit imaged video data to the application server 52.

(189) S103: Further, the MR experiencing persons 2a to 2c transmit data of the position and direction to the application server 52, as reference point and movement history data.

(190) S104: The application server 52 integrates pieces of the data of all MR experiencing persons, and synthesizes and synchronizes the videos.

(191) S105: The application server 52 generates and transmits a display image of each of the MR experiencing persons (S105).

(192) S106: The application server 52 processes the imaged object.

(193) S107: The application server 52 processes the background object. At this time, an instruction

of the divided region and a cross object is received from the MR experiencing person.

(194) **S108**: The application server **52** processes an AR object. At this time, the data of the AR object selected for the designation and linking of the imaged object or the background object selected by the MR experiencing person is received.

(195) **S109**: The application server **52** generates a display video reflecting the results of the performing and transmits the display video to the MR experiencing person. In addition, the data generated when the application is executed is stored in the data storage server **53**.

(196) In the above sequence, by repeating a series of sequences excluding the log-in of **S101** as the basic sequence, the MR experiencing persons **2a** to **2c** realize the MR experience via the application server **52**.

(197) FIG. **18B** is a chart illustrating details of sequences in FIG. **18A**. Here, in order to avoid the complication of the description, only the repetition of the synchronization and priority process (**S104**) and the AR-object process (**S108**) in the processes of the basic sequence is illustrated. Other display video generation process (**S105**), imaged-object process (**S106**), and background-object process (**S107**) are omitted, but are executed as appropriate. In addition, the data, the display video, and the like are also appropriately stored in the data storage server **53**. The contents of communication between the HMDs **1a** to **1c** (MR experiencing persons **2a** to **2c**) and the application server **52** will be sequentially described.

(198) **T11**: Each imaged video, the position of the HMD, and the imaging direction are transmitted from the HMDs **1a** to **1c** to the application server **52**. A transmission timing may be set in accordance with a transmission request from the application server **52**, or the application server **52** may capture the continuously transmitted imaged videos at a convenient timing.

(199) **T12**: The application server **52** performs a synchronization and priority process **S104a**, and transmits, for example, a display image such as an AR object having a display position which has been updated in response to the movement of the HMD, to each of the HMDs **1a** to **1c**.

(200) **T13**: At this time, when the HMD **1a** (MR experiencing person **2a**) who has the priority of the imaged object **A** wants to link the AR object  $\alpha$  to the imaged object **A**, the selection information of the imaged object **A** and the selection information of the AR object  $\alpha$  to be linked are transmitted to the application server **52**.

(201) **T14**: The application server **52** performs an AR-object process **S108a**, and transmits the display video of the AR object  $\alpha$  based on the setting information of the AR object  $\alpha$ , to the HMD **1a** and other HMDs **1b** and **1c**.

(202) **T15**: A new imaged image, a new position of the HMD, and a new imaging direction are transmitted from the HMDs **1a** to **1c** to the application server **52**.

(203) **T16**: The application server **52** performs a synchronization and priority process **S104b**, and transmits a display video including the disposition of the AR object  $\alpha$  to each of the HMDs **1a** to **1c**.

(204) **T17**: After that, when the HMD **1b** (MR experiencing person **2b**) who does not have the priority of the imaged object **A** wants to link a different AR object  $\beta$  to the imaged object **A**, a request to cancel the priority assigned to the imaged object **A** is transmitted to the HMDs **1a** and **1c**, and the application server **52**. When the HMD **1a** (MR experiencing person **2a**) holding the priority receives the request to cancel the priority from the HMD **1b**, the priority is canceled, and the priority is assigned to the HMD **1b**.

(205) **T18**: The HMD **1b** transmits the selection information of the AR object  $\beta$  linked to the imaged object **A** to the application server **52**.

(206) **T19**: The application server **52** performs an AR-object process **S108b**, and transmits the display video of the AR object  $\beta$  based on the setting information of the AR object  $\beta$ , to the HMDs **1a** to **1c**.

(207) **T20**: A new imaged image, a new position of the HMD, and a new imaging direction are transmitted from the HMDs **1a** to **1c** to the application server **52**.

(208) T21: The application server **52** performs a synchronization and priority process **S104c**, and transmits a display video including the disposition of the AR object  $\beta$  to each of the HMDs **1a** to **1c**.

(209) T22: At this time, it is assumed that the HMD **1c** (MR experiencing person **2c**) selects a different imaged object **C** and transmits a request to select the AR object  $\gamma$ , and this request is permitted. The HMD **1c** transmits the selection information of the AR object  $\gamma$  to be added.

(210) T23: The application server **52** performs an AR-object process **S108c**, and transmits the display video of the AR object  $\gamma$  based on the setting information of the AR object  $\gamma$ , to the HMDs **1a** to **1c**.

(211) As a result, the HMD **1a** to **1c** (MR experiencing persons **2a** to **2c**) can share an imaged object in the same real space, add an AR object being a virtual object to the real space, and visually recognize a video of the added AR object as a display video generated corresponding to each position.

(212) As described above, the MR network system in Example 3 has characteristics that it is possible to obtain the similar effects to those in Example 1, and to utilize resources such as the application server and the data server on the network. Thus, the effects of reducing the load on the MR display device, contributing to the size reduction and cost reduction of the MR display device, and facilitating the response even when the number of MR experiencing persons increases are obtained.

#### Example 4

(213) In Example 4, an MR display device equipped with a 3D camera to perform imaging and distance measurement will be described.

(214) [MR Display Device]

(215) FIG. **19** is a view illustrating an appearance configuration of an MR display device **1'** according to Example 4. The components having the equivalent functions to those of the MR display device **1** described in Example 1 (FIG. **2**) are denoted by the same reference signs, and repetitive description will be omitted.

(216) The MR display device **1'** includes three-dimensional (3D) cameras **40a** and **40b** and a flat display **41**. The 3D cameras **40a** and **40b** replace the camera **10** and the distance measurement sensor **11** in Example 1. Thus, the 3D cameras **40a** and **40b** can not only obtain a camera imaged video, but also measure a distance of a reality object in a camera video by a difference between a video of the left visual line obtained by the **40a** and a video of the right visual line obtained by the **40b**.

(217) The flat display **41** replaces the 3D projector **13** and the transmissive screen **14** in Example 1. The controller **16** synthesizes and displays the imaged videos of the 3D cameras **40a** and **40b** and a video of the AR object. At this time, the video of the left visual line and the video of the right visual line are displayed alternately, and a 3D image is displayed in synchronization with the shutter-attached glasses **15**. Incidentally, a general-purpose device such as a smartphone may be used for the flat display **41**. At this time, the function of the controller **16** can be performed by a control device built in the smartphone.

(218) FIG. **20** is a block diagram illustrating a functional configuration of the MR display device **1'**. Blocks having the equivalent functions to the blocks described in Example 1 (FIG. **3**) are denoted by the same numbers, and repetitive descriptions are omitted. The blocks different from those in Example 1 are the 3D cameras **40a** and **40b**, the flat display **41**, a video synthesis processing unit **42**, and a feature extraction processing unit **61'** and a distance calculation processing unit **62'** in the controller **16**.

(219) The feature extraction processing unit **61'** extracts feature points from videos of the 3D cameras **40a** and **40b**, and identifies the reality object in the camera imaged video from the feature points. The distance calculation unit **62'** measures the distance of the reality object in the camera video by the difference between the videos of the left eye and right visual lines, which are obtained

by the 3D cameras **40a** and **40b**. The synthesis processing unit **42** synthesizes the imaged videos of the 3D cameras **40a** and **40b** and the video of the AR object, and the flat display **41** displays the synthesized video.

(220) According to Example 4, there are characteristics that the similar effects to those in Example 1 are obtained, and a general-purpose device such as a smartphone including a flat display can be utilized.

(221) Although the examples of the present invention have been described above, the present invention is not limited to the above examples, and a part of the configuration of a certain example may be replaced with the configuration of another example, or the configuration of another example may be added.

#### REFERENCE SIGNS LIST

(222) **1**(**1a** to **1c**), **1'** Mixed reality display device (MR display device, HMD) **2a** to **2c** MR experiencing person **3a** to **3c** Camera imaging angle of view **4** Reality object (background object) **5** Access point (AP) **6** to **8** Reality object (imaged object) **10** Camera **11** Distance measurement sensor **12** Position and direction sensor **13** 3D projector **14** Transmissive screen **15** Shutter-attached glasses **16** Controller **17a**, **17b** Speaker **18a**, **18b** Holder **19** Microphone **21** to **26** AR object (virtual object) **40a**, **40b** 3D camera **41** Flat display **50** Gateway **51** Network **52** Application server **53** Data storage server **60** User operation input unit **61**, **61'** Feature detection processing unit **62**, **62'** Distance calculation processing unit **63** Movement detection processing unit **64** Communication unit **65** CPU **66** RAM **67** Image RAM **68** Program flash ROM **69** Data flash ROM **81** Overall control process **82** Reference point/movement history process **83** Synchronization and priority process **84** Imaged-object process **85** Background-object process **86** AR-object process **87** Display video generation process

#### Claims

1. A mixed reality display method of providing a video of a virtual object with being superimposed on a reality video, to a mixed reality display device worn by an experiencing person, wherein the mixed reality display device comprises a camera, a display, a memory and a communicator, and wherein the mixed reality display method comprises: a step of imaging a reality video by the camera, a step of recognizing a reality object from the reality video imaged by the camera, a step of linking a predetermined virtual object to the recognized reality object based on an operation of the experiencing person, a step of storing data of the virtual object linked to the reality object in the memory, a step of acquiring data of a reality object recognized by another mixed reality display device and a virtual object linked to the recognized reality object, via the communicator, a step of synthesizing the data acquired via the communicator and the data stored in the memory, a step of displaying a video obtained by the synthesis on the display, and a step of editing of the virtual object linked to the reality object on the video displayed on the display, based on an operation of the experiencing person, wherein the mixed reality display device further comprises a distance measurement sensor configured to measure a distance to a reality object in the reality video, wherein, in the step of recognizing the reality object from the reality video imaged by the camera, recognizing the reality object to be classified into an imaged object and a background object, based on the distance measured by the distance measurement sensor, and wherein, in the step of linking the predetermined virtual object to the recognized reality object, dividing a region of the background object into a plurality of regions and linking the virtual object to the one of the plurality of regions.

2. The mixed reality display method according to claim 1, wherein the mixed reality display device further comprises a position and direction sensor configured to detect a position of the camera and an imaging direction, a reference point for the position of the camera and the imaging direction detected by the position and direction sensor is set to coincide with a reference point of a position

of a camera and an imaging direction in the another mixed reality display device, wherein, in the step of synthesizing the data acquired via the communicator and the data stored in the memory, viewpoint-transforming the video in accordance with the positions of the cameras and the imaging directions of the mixed reality display device and the another mixed reality display device and then performing synthesis, and wherein, in the step of displaying the video obtained by the synthesis on the display, updating the video to a new video based on new positions of the cameras and new imaging directions every time the experiencing person moves.

3. The mixed reality display method according to claim 1, further comprising: a step of assigning a priority flag indicating whether another experiencing person is allowed to change the linking for the virtual object, and a step of storing a resultant of the assignment in the memory.

4. The mixed reality display method according to claim 1, wherein the display is configured by a 3D projector that projects the video of the virtual object onto a transmissive screen, and wherein the experiencing person is allowed to visually recognize the reality video seen through the transmissive screen and, at the same time, visually recognize the video of the virtual object on the transmissive screen.

5. The mixed reality display method according to claim 1, wherein the virtual object linked to the reality object is configured by a plurality of components, and wherein the mixed reality display method further comprises: a step of assigning a priority flag indicating an edit authority of the virtual object to each of the components, and a step of storing a resultant of the assignment in the memory.

6. A mixed reality display method of providing a video of a virtual object with being superimposed on a reality video, to a mixed reality display device worn by an experiencing person, wherein the mixed reality display device comprises a camera, a display, a memory and a communicator, and wherein the mixed reality display method comprises: a step of imaging a reality video by the camera, a step of recognizing a reality object from the reality video imaged by the camera, a step of linking a predetermined virtual object to the recognized reality object based on an operation of the experiencing person, a step of storing data of the virtual object linked to the reality object in the memory, a step of acquiring data of a reality object recognized by another mixed reality display device and a virtual object linked to the recognized reality object, via the communicator, a step of synthesizing the data acquired via the communicator and the data stored in the memory, a step of displaying a video obtained by the synthesis on the display, and a step of editing of the virtual object linked to the reality object on the video displayed on the display, based on an operation of the experiencing person, wherein the virtual object linked to the reality object is configured by a plurality of components, and wherein the mixed reality display method further comprises: a step of assigning a priority flag indicating an edit authority of the virtual object to each of the components, and a step of storing a resultant of the assignment in the memory.

7. The mixed reality display method according to claim 6, wherein the mixed reality display device further comprises a distance measurement sensor configured to measure a distance to a reality object in the reality video, and wherein the mixed reality display method further comprises: a step of evaluating a distance between the reality object and the virtual object by the distance measurement sensor, a step of setting a portion or an entirety of the virtual object not to be displayed when the reality object is in front of the virtual object, and a step of performing masking on the reality object by displaying the background object when the reality object indicates another experiencing person.

8. The mixed reality display method according to claim 7, wherein a 3D camera capable of imaging a reality video and measuring a distance to a reality object in the reality video is provided as the camera and the distance measurement sensor, and wherein the display is a flat display that displays a result obtained by synthesizing a video of a virtual object with the reality video imaged by the 3D camera.

9. The mixed reality display method according to claim 6, wherein the mixed reality display device

further comprises a position and direction sensor configured to detect a position of the camera and an imaging direction, a reference point for the position of the camera and the imaging direction detected by the position and direction sensor is set to coincide with a reference point of a position of a camera and an imaging direction in the another mixed reality display device, wherein, in the step of synthesizing the data acquired via the communicator and the data stored in the memory, viewpoint-transforming the video in accordance with the positions of the cameras and the imaging directions of the mixed reality display device and the another mixed reality display device and then performing synthesis, and wherein, in the step of displaying the video obtained by the synthesis on the display, updating the video to a new video based on new positions of the cameras and new imaging directions every time the experiencing person moves.

10. The mixed reality display method according to claim 6, wherein the display is configured by a 3D projector that projects the video of the virtual object onto a transmissive screen, and wherein the experiencing person is allowed to visually recognize the reality video seen through the transmissive screen and, at the same time, visually recognize the video of the virtual object on the transmissive screen.

11. A mixed reality display method of providing a video of a virtual object with being superimposed on a reality video, to a display device, wherein the display device comprises a camera, a display, a memory and a communicator, and wherein the mixed reality display method comprises the steps of: imaging a reality video by the camera, recognizing a reality object from the reality video imaged by the camera, linking a predetermined virtual object to the recognized reality object based on an operation of a user of the display device, storing data of the virtual object linked to the reality object in the memory, acquiring data of a virtual object linked to a reality object recognized by another display device, via the communicator, synthesizing the data acquired via the communicator and the data stored in the memory, displaying a video obtained by the synthesis on the display, and editing of the virtual object linked to the reality object on the video displayed on the display, based on an operation of the user, wherein the display device further comprises a distance measurement sensor, wherein the mixed reality display method further comprises the steps of: measuring a distance to a reality object in the reality video by the distance measurement sensor, recognizing the reality object to be classified into an imaged object and a background object, based on the distance measured by the distance measurement sensor, and dividing a region of the background object into a plurality of regions and linking the virtual object to the one of the plurality of regions.

12. The mixed reality display method according to claim 11, wherein the display device further comprises a position and direction sensor configured to detect a position of the camera and an imaging direction, a reference point for the position of the camera and the imaging direction detected by the position and direction sensor is set to coincide with a reference point of a position of a camera and an imaging direction in the another display device, wherein the mixed reality display method further comprises the steps of: viewpoint-transforming the video in accordance with the positions of the cameras and the imaging directions of the display device and the another display device and then performing synthesis, and updating the video to a new video based on new positions of the cameras and new imaging directions every time the user moves.

13. The mixed reality display method according to claim 11, wherein the virtual object linked to the reality object is configured by a plurality of components, and wherein the mixed reality display method further comprises the steps of: assigning a priority flag indicating an edit authority of the virtual object to each of the components, and storing a resultant of the assignment in the memory.

14. The mixed reality display method according to claim 11, further comprising the steps of: assigning a priority flag indicating whether another user is allowed to change the linking for the virtual object, and storing a resultant of the assignment in the memory.

15. The mixed reality display method according to claim 11, wherein the display is configured by a 3D projector that projects the video of the virtual object onto a transmissive screen, and wherein

the user is allowed to visually recognize the reality video seen through the transmissive screen and, at the same time, visually recognize the video of the virtual object on the transmissive screen.

16. A mixed reality display method of providing a video of a virtual object with being superimposed on a reality video, to a display device, wherein the display device comprises a camera, a display, a memory and a communicator, and wherein the mixed reality display method comprises the steps of: imaging a reality video by the camera, recognizing a reality object from the reality video imaged by the camera, linking a predetermined virtual object to the recognized reality object based on an operation of a user of the display device, storing data of the virtual object linked to the reality object in the memory, acquiring data of a virtual object linked to a reality object recognized by another display device, via the communicator, synthesizing the data acquired via the communicator and the data stored in the memory, displaying a video obtained by the synthesis on the display, and editing of the virtual object linked to the reality object on the video displayed on the display, based on an operation of the user, wherein the virtual object linked to the reality object is configured by a plurality of components, and wherein the mixed reality display method further comprises the steps of: assigning a priority flag indicating an edit authority of the virtual object to each of the components, and storing a resultant of the assignment in the memory.

17. The mixed reality display method according to claim 16, wherein the display device further comprises a position and direction sensor configured to detect a position of the camera and an imaging direction, a reference point for the position of the camera and the imaging direction detected by the position and direction sensor is set to coincide with a reference point of a position of a camera and an imaging direction in the another display device, wherein the mixed reality display method further comprises the steps of: viewpoint-transforming the video in accordance with the positions of the cameras and the imaging directions of the display device and the another display device and then performing synthesis, and updating the video to a new video based on new positions of the cameras and new imaging directions every time the user moves.

18. The mixed reality display method according to claim 16, wherein the display device further comprises a distance measurement sensor configured to measure a distance to a reality object in the reality video, and wherein the mixed reality display method further comprises the steps of: evaluating a distance between the reality object and the virtual object by the distance measurement sensor, setting a portion or an entirety of the virtual object not to be displayed when the reality object is in front of the virtual object, and performing masking on the reality object by displaying the background object when the reality object indicates another user.

19. The mixed reality display method according to claim 18, wherein a 3D camera capable of imaging a reality video and measuring a distance to a reality object in the reality video is provided as the camera and the distance measurement sensor, and wherein the display is a flat display that displays a result obtained by synthesizing a video of a virtual object with the reality video imaged by the 3D camera.

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