

- (51) **International Patent Classification:**
H04N 13/363 (2018.01) *H04N 9/31* (2006.01)
- (21) **International Application Number:**
PCT/CN2024/085121
- (22) **International Filing Date:**
31 March 2024 (31.03.2024)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
63/456,363 31 March 2023 (31.03.2023) US
63/456,373 31 March 2023 (31.03.2023) US
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(81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(54) **Title:** IMMERSIVE PROJECTION SYSTEM

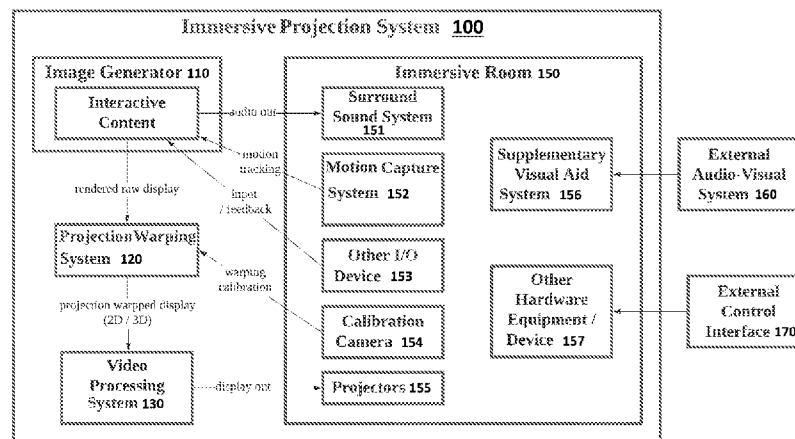


Fig. 1

(57) **Abstract:** An immersive projection system comprises an image generator configured to render images to be displayed; a projection warping system configured to warp and blend rendered images received from the image generator; an immersive room including ceiling having an opening and floor; and a plurality of projectors configured to project images output from the projection warping system into the immersive room; wherein, one of the plurality of projectors is configured to project images onto the floor through the opening.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

Title of Invention: IMMERSIVE PROJECTION SYSTEM

[0001] RELATED APPLICATION

[0002] The present application claims the benefit of U.S. Provisional Patent Applications Serial No. 63/456,373 and No. 63/456,363, both filed on 31 March 2023. The disclosures of the provisional applications are incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0003] The present application relates to an immersive projection system.

BACKGROUND

[0004] HiVE (Hybrid Immersive Virtual Environment) adopts fully immersive Cave Automatic Virtual Environment (CAVE) technology for practical and collaborative learning. The world's first large-scale X-Reality hybrid classroom is a sort of HiVE developed by Hong Kong Polytechnic University for students' education and training. This platform provides a virtual training environment that enables students to experience and practice work-related skills in realistic scenarios like fire outbreaks, medical procedures, and aircraft control rooms that are not easily accessible in the actual world.

SUMMARY

[0005] One objective of the present application is to overcome or substantially ameliorate one or more of the disadvantages of prior art, or at least to provide a useful alternative.

[0006] One or more embodiments combine an existing classroom (which is an example of a preselected room) and a CAVE system into a hybrid teaching facility so as to save installation space. Advantageously, this hybrid classroom allows teachers to conduct and switch between face-to-face and immersive teaching easily in a classroom environment to blend virtual technology with traditional learning. This hybrid teaching facility enables teachers to perform a seamless transition of delivery mode between face-to-face lectures and immersive experiences, achieving the goal of blending virtual technology with conventional learning.

[0007] One or more embodiments provide a new 6-sided CAVE-based technology which creates an extremely real immersive environment to assist students in visualizing abstract concepts and novel points of view that are impossible to display in a real environment. Moreover, this technology allows students to engage in experiences that may not be easy for them to access in the real world, such as fire outbreaks, medical surgery and aircraft control room etc. Theory-based intellectual courses can be very difficult for students to comprehend. With the help of the new 6-sided CAVE

technology, students can visualize abstract concepts that are impossible to portray in the real world. Additionally, this technology enables students to experience and participate in realistic scenarios like fire outbreaks, medical procedures, and aircraft control rooms that are not easily accessible in the actual world.

- [0008] One or more embodiments provide a system for immersive virtual environment which could be established within a preselected room, which may effectively use the inner space of the preselected room with relevant equipment/devices concealed. The preselected room may be an existing room, such as an existing classroom.
- [0009] The VR hybrid classroom according to one or more embodiments supports real-time multi-CAVE collaboration among CAVE systems. This enables students from different parts of the world to give presentations and even interact with one another.
- [0010] In one embodiment, an immersive interactive projection system comprises an image generator configured to render images to be displayed; a projection warping system configured to warp and blend rendered images received from the image generator; an immersive room including ceiling having an opening and floor; and a plurality of projectors configured to project images output from the projection warping system into the immersive room; wherein, one of the plurality of projectors is configured to project images onto the floor through the opening.
- [0011] In one embodiment, the immersive interactive projection system further comprises a video processing system configured to interface with the image generator through the projection warping system to produce a frame-synchronized image signal to the plurality of projectors.
- [0012] In another embodiment, a projector cover projected downward from the ceiling and concealing a corresponding projector behind the projector cover, wherein the projector cover includes bottom and side walls with one or more openings formed on one of the side walls, thereby to enable the corresponding projector behind the projector cover to project an image through the one or more openings of the projector cover onto a front, back, right or left wall of the immersive room.
- [0013] In another embodiment, the plurality of projectors comprise ceiling projectors installed behind openings defined by walls of the immersive room and oriented to project towards the ceiling.
- [0014] In another embodiment, the immersive room is built inside an existing room (which is an example of a preselected room) .
- [0015] In another embodiment, the immersive interactive projection system further comprises a motion capture system; and a plurality of motion capture devices are installed at locations inside the immersive room, such that a user or object fitted with retroreflective markers forming pre-defined shape or battery-powered trackers with pre-registered hardware identification number, can be identified by the installed

motion capture devices, allowing the motion capture system to resolve the position / movement of the user or the object.

[0016] In another embodiment, the interactive content executed on the image generator may use the motion capture information provided by the motion capture system as user input to update interactive content generated.

[0017] In another embodiment, the projection warping system warps and blends the images to be sent to the plurality of projectors, so as to seamlessly merge the projection images of these projectors in overlap regions where the images are projected to. In further embodiment, the projection warping system will also process the warp and blend image based on the rendering mode: i.e. 1 type of warping output for 2D mode and another type of warping output for 3D mode.

[0018] In another embodiment, the image generator is configured such that an interactive content executed on the image generator uses motion capture information provided by the motion capture system as user input to update interactive content generated.

[0019] In another embodiment, the immersive room is equipped with air ventilation panels that are embedded in the walls of the immersive room and painted the same color as the wall.

[0020] In another embodiment, the immersive room is made of drywall.

[0021] In another embodiment, the plurality of projectors is able to operate in 2D mode or 3D mode depending on command from the image generator.

[0022] In another embodiment, the immersive interactive projection system further comprises a surrounding sound system including speakers, wherein the speakers fit in openings defined by walls of the immersive room onto which a projected image is to be displayed, the system further comprises a perforated panel painted the same color as the wall for covering the openings, such that sound produced by the speakers is projected through the perforated panel to the inside of the room.

[0023] In another embodiment, the plurality of projectors include a combination of Ultra Short Throw (UST) (i.e., projector throw ratio $< 0.5: 1$) and Short Throw (ST) .

[0024] In another embodiment, the immersive interactive projection system further comprises an additional 2D projector fitted on a motorized ceiling projector lift, wherein, while in a non-operating state, the additional 2D projector is concealed behind the ceiling with the bottom of the motorized ceiling projector lift forming part of the ceiling; alternatively, when in an operating state, the additional 2D projector may be lowered down by the lift, so as to project images on the projected area on the front or back wall of the room.

Advantageous effects

[0025] One or more embodiments may achieve one or more of technical effects, including but not limited to the following:

[0026] ·Space problem for the installation of a large-scale CAVE.

[0027] ·Teachers conducted face-to-face teaching and immersive teaching in two physical locations.

[0028] ·There is no similar commercially available technology or products in the market

[0029] ·The Invention combines a teaching classroom and a CAVE system into a hybrid teaching facility that can save installation space.

[0030] ·The Invention enables teachers to easily conduct and switch between face-to-face teaching and immersive teaching in a classroom environment to blend virtual technology with traditional learning.

[0031] ·Relatively low-cost projection system may apply.

[0032] BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0033] The scope of the present disclosure is best understood from the following detailed description of exemplary embodiments when read in conjunction with the accompanying drawings. Included in the drawings are the following figures:

[0034] FIG. 1 is a block diagram illustrating main components of the fully immersive projection system according to one embodiment of the application;

[0035] FIG. 2A and 2B are photos taken inside an immersive environment established according to one embodiment of the application;

[0036] FIG. 3 is a model drawing illustrating a perspective view of an immersive room including projectors and projection frustum inside the immersive room according to one embodiment of the application;

[0037] FIG. 4 is a photo taken inside a hybrid class established according to one embodiment of the application;

[0038] FIG. 5 illustrates motion capture cameras installed near the ceiling area according to one embodiment of the application according to one embodiment of the application;

[0039] FIG. 6 illustrates an immersive room installed in with surround sound system and showing a city night view according to one embodiment of the application;

[0040] FIG. 7A illustrates an upper perspective view of a projector cover structure according to one embodiment of the application;

[0041] FIG. 7B is a cross-sectional view of an immersive room with two projector covers installed on the ceiling according to one embodiment of the application;

[0042] FIG. 8 is a picture of an inside of an immersive room with two projector covers installed on the ceiling according to one embodiment of the application;

[0043] FIG. 9 is an image of an inside of an immersive room equipped with tilted wall upper segment and openings for projection light on a vertical lower segment of a side wall according to one embodiment of the application;

[0044] FIG. 10 is an image of an inside of an immersive room equipped with ventilation panel according to one embodiment of the application;

[0045] FIG. 11A is a cross-sectional view of an immersive room with an additional 2D projector fitted on a motorized ceiling projector lift according to one embodiment of the application;

[0046] FIG. 11B is a cross-sectional view of an immersive room showing supplementary visual aid system with hidden control panel and projected area.

DETAILED DESCRIPTION

[0047] It should be appreciated that the following description uses a plurality of various examples for various elements of the illustrative embodiments to further illustrate example implementations of the illustrative embodiments and to aid in the understanding of the mechanisms of the illustrative embodiments. These examples intended to be non-limiting and are not exhaustive of the various possibilities for implementing the mechanisms of the illustrative embodiments. It will be apparent to those of ordinary skill in the art in view of the present description that there are many other alternative implementations for these various elements that may be utilized in addition to, or in replacement of, the examples provided herein without departing from the scope of the present invention.

[0048] As used herein, the term “immersive room” refers to a room that may create immersiveness or virtual reality for users inside the room . A common approach to provide immersiveness or virtual reality is to mimic a special environment by projecting images on 4 or 5 sides of an immersive room.

[0049] Fully immersive projection system

[0050] FIG. 1 is a block diagram illustrating main components of the fully immersive projection system according to one embodiment of the application. Referring to Fig. 1, the fully immersive projection system 100 includes, image generator 110 which may generate interactive content and render images to be displayed, projection warping system 120, video processing system 130, immersive room 150, external audio-visual system 160, and external control interface 170.

[0051] The immersive room 150 is installed with one or more projectors 155 that project images to the ceiling, walls or floor or any combination thereof of the immersive room; a motion capture system 152.

[0052] In one embodiment, the immersive room 150 is also equipped with a surrounding sound system, at least one calibration cameras 154, supplementary visual aid system receiving input from the external audio-visual system 160, and other hardware equipment or device receiving input form the external control interface 170 for additional functions.

- [0053] A scenario where the fully immersive projection system is applied is shown in Fig. 3, which is a model drawing illustrating a perspective view of an immersive room 150 including projectors 155 and projection frustum inside the immersive room 150 according to one embodiment of the application. Figs. 2A and 2B are photos taken inside immersive environments established according to one embodiment of the application, which mimic a bird's view (Figs. 2A) and a scenario inside a museum (Figs. 2B) , respectively.
- [0054] Image Generator
- [0055] In one embodiment of the application, the Image Generator 110 is a computing workstation with at least a Central Processing Unit (CPU) , a memory, a storage system, a set of Graphics Processing Unit (GPU) , a power supply unit (PSU) , and a set of I/O interfaces. The Image Generator runs on a compatible operating system (OS) to process input signals, execute commands written in applications saved to the storage system, and render display and sound output for the Fully immersive projection system.
- [0056] A configurable launcher application with graphical user interface is available on the Image Generator 110 to interface with connected hardware devices and to launch commands in raw or executable format. The Image Generator 110 can be configured to render content in either 2D or 3D mode.
- [0057] When set to render content in 2D mode, the launcher application of the Image Generator 110 sends a command to set the projectors to operate in 2D mode and another command to the projection warping and blending system to engage the 2D mode mapping profile; when set to render content in 3D mode, the launcher application sends a command to set the projectors to operate in 3D mode and another command to the projection warping and blending system to engage the 3D mode mapping profile.
- [0058] During the process of projection warping and blending, a two-step process is engaged to produce the desirable immersive visual effect. Firstly, the interactive content on the Image Generator 110 is rendered and arranged based on the physical layout of the projection surface. Here, the projection surface is defined as a continuous surface facing the same direction in the Immersive Room. Warping is then done based on the rendered display layout then further processed, rearranged, and distributed to each projector. When running 2D mode with projection warping and blending, the entirety of pixel assigned to each projector will be displayed by the projector directly. When running in 3D mode, the Image Generator 110 will render images for both the left and the right eye, and arranged in side-by-side manner as final output to send to the video processor.

- [0059] The interactive content executed on the Image Generator 110 may use the motion capture information provided by the Motion Capture System as user input to update the interactive content. When the viewer fitted with motion tracker moves around in the Immersive Room, the interactive content can be rendered from the perspective of the viewer to offer a first person perspective rendering tailored to the viewer. Optionally, other input devices such as controllers and haptic devices can also be connected to the Image Generator to use as extra I/O devices to add additional interactivity elements into the system.
- [0060] Immersive Projection System
- [0061] The immersive projection system includes a plurality of projectors 155. In one embodiment, the plurality of projectors 155 include a combination of Ultra Short Throw (UST) (i.e., projector throw ratio $< 0.5: 1$) and Short Throw (ST) (i.e., projector throw ratio between $0.5-1: 1$) projectors which are arranged strategically outside the visible space of the system operating in a front projection manner. For the projectors supplying image projections for the front, back, left, right, and ceiling of the system, preferably, UST projectors or projectors equipped with UST lens are used to minimize the throw distance needed between the projectors and the projection surface, and to maximize the effective space the viewer can move inside the system without encountering the projector's projection frustum and cast a shadow. For the projectors supplying image projections for the floor, preferably, ST projectors or projectors equipped with ST lens are used.
- [0062] In one embodiment of the application, at least 1 projector 155 is used to project image on the floor. Projectors 155 for the floor are installed on top of the ceiling wall and projected onto the floor through opening on the ceiling carved out in the same manner as the ceiling projectors, as shown in Fig. 5. In another embodiment, there is at least 1 projector 155 for each projection side (front, back, left, right, ceiling, floor) .
- [0063] In one embodiment, when more than 1 projector is used for any given side of the system, the projection image output from each of the projector 155 should have some overlap region so that an effective projection warping and blending can be achieved to seamlessly merge the projection image of these projectors 155.
- [0064] In one embodiment, the projectors 155 are plugged in to a video processing system 130 that is interfacing with the image generator 110 through a layer of projection warping system 120 to produce frame-synchronized image signal to the projectors 155. The projectors 155 are capable of operating in either normal 2D mode or 3D stereoscopic mode. When operating under 2D mode, users are able to see clear image with their naked eyes. When operating under 3D mode, the projectors 155 will display images intended for the either the left or the right eye in an alternating manner, users need to wear a pair of active stereo 3D glasses that is synchronized with the

projectors 155' display frequency to separate the alternating images in order to see a clear stereoscopic image. During 3D mode, a 3D synchronization signal is needed to synchronize the active stereo 3D glasses with the display image from the projectors 155. Such 3D synchronization signal can either be generated by the video processing system when the 3D image is processed and created by the video processing system, or from any one of the projectors 155 connected to the video processing system, when the 3D image is processed and created by the projectors 155 themselves.

[0065] In another embodiment, a plurality of calibration cameras with fisheye lens are placed strategically inside the system and connected to the Image Generator 110 for projection warping and blending. To facilitate projection warping and blending, a camera-based calibration process conducted by the projection warping and blending system is needed, which computes a uv mapping transformation of the real-world image captured by the calibration cameras with a pre-defined 3D model of the room. Projection warping and blending can then be achieved by applying the computed uv mapping onto the rendering buffer of the Image Generator 110's GPU. The uv mapping for both 2D mode and 3D mode are computed and user can switch between 2D and 3D projection warping and blending by sending the corresponding command on the Image Generator 110.

[0066] Motion Capture System

[0067] In one embodiment, to add interactivity to the system, a plurality of motion capture/sensing devices using optical or infrared light mechanism are installed at strategic locations inside the system near the ceiling, as illustrated in Fig. 5. User/object fitted with retroreflective markers forming pre-defined shape, or battery-powered trackers with pre-registered hardware identification number, can be identified by the installed motion capture /sensing devices, allowing the motion capture system to resolve the position/movement of the tracked body (motion capture information) . The motion capture information is streamed out using network or relevant common protocol for use by the fully immersive projection system as input data to render interactive contents on the display system.

[0068] Surround Sound System

[0069] In one embodiment, there is provided a surround sound system installed outside of the display area to provide immersive spatial sound inside the system. The surround sound system, consisting a minimum of one subwoofer and a set of speakers for the front, left, right, and back of the system, are placed in strategic locations around the system to enhance the produced surround sound effect.

[0070] Fig. 6 illustrates an immersive room installed in with surround sound system and showing a city night view according to one embodiment of the application. Referring to Fig. 6, the walls which the projected image is to be displayed on are

carved rectangular openings just large enough to fit the speakers of the surround sound system, such that the sound produced by the speakers can be projected to the inside of the room. The openings on the wall are covered with perforated panel painted the same color as the wall to minimize its impact to the system's immersion while allowing adequate sound to pass through.

[0071] Immersive Room

[0072] Fig. 3 schematically shows a model drawing illustrating a perspective view of an immersive room 150.

[0073] The immersive room 150 depicted in Fig. 3 is to be established inside the original existing structural room using partition plate, i.e., drywall (or any other suitable materials in the art) . The drywalls partitions the original structural room into an immersive room for the fully immersive projection system of the application and additional room (s) /space (s) for storage (e.g. hosting the image generator 110) , concealment of relevant hardware equipment /device, or for any other purposes.

[0074] In addition to creating an immersive environment, the immersive room of the application may also serve as a normal classroom, as shown in Fig. 4, where a lecturer is delivering a face-to-face lecture to the audience as commonly seen in a normal classroom. The hybrid teaching facility enables teachers to perform a seamless transition of delivery mode between face-to-face lectures and immersive experiences, achieving the goal of blending virtual technology with conventional learning.

[0075] The projection system in the embodiment shown in Fig. 5, are installed behind the drywall (ceiling and floor projectors) or installed inside the immersive room 150 around the ceiling area. Fig. 5 illustrates an opening carved out on the ceiling, and a projector 155 installed above the ceiling may project light through the opening onto the floor.

[0076] In one embodiment, the projection system, especially the projectors 155, are concealed behind custom-made covers (for front, back, left, and right wall projectors) . FIG. 7A illustrates an upper perspective view of a projector cover according to one embodiment of the application. The custom-made projector cover 700 is made of rigid material (such as fiber glass) and has curvy edges to minimize blocking the projection light from ceiling projectors. Openings are made on the projector cover to allow projection light to pass through.

[0077] FIG. 7B is a cross-sectional view of an immersive room with two projector covers 700 installed on the ceiling according to one embodiment of the application. The projector covers 700 protrude from the ceiling and including bottom and side walls.

[0078] FIG. 8 is a picture of an inside of an immersive room built according to one embodiment of the application, on the ceiling of the immersive room 150 are installed two projector covers 700 with openings formed on the side walls of the cover to allow

projection light to pass through and projected on front, back, left, or right wall of the immersive room. It can also be seen that an image is projected on the ceiling including the bottom and side walls of the projector covers 700. By cutting openings on the side walls of the projector covers 700, it minimizes the effect of the openings of the cover on the images, and therefore enhances experience of users inside the immersive room.

[0079] Although in the above embodiment, the immersive room 150 is created using drywall, however, the present application is not limited thereto. Any suitable materials known to those of skilled in the art can be used in place of the dry wall, including wooden plates, PVC plates, metal plates, and plastic plates.

[0080] In one embodiment, projectors 155 for the ceiling, which are configured to project lights onto the ceiling, are installed behind the left and right walls outside of the inner space of the immersive room, an opening matching the shape of the projection light frustum is carved out on the wall for each projector to allow light to pass through while minimizing the impact to immersion.

[0081] In one embodiment, each of the side walls (i.e., the walls on the left and right side of the immersive room 150) consist of two segments –the vertical lower segment, which extends vertically upward from floor of the immersive room, and tilted upper segment, which extends from the upper edge of the vertical lower segment tilting towards the inner space of the immersive room. In the embodiment of Fig. 3, the vertical lower segment has a height of 2, 100 mm, which is higher than a normal height of a person, while the internally tilted upper segment has a height of 1, 600 mm.

[0082] In one embodiment, the ceiling projectors 155, which are configured to project lights onto the ceiling, are installed behind the wall at a height above normal height of a person and oriented to project towards the ceiling or towards the ceiling and the tilted upper segment on the opposite side. In the prior art, where a vertically extending wall intersects with the horizontally extending ceiling, images projected on to an area around the intersection distort severely. To address this deficiency, conventionally, an advanced and usually more expensive projection system is adopted. By implementing the present application, that is, by adopting a tilted upper segment, a relatively low-cost projection system may be used and the distortion is effectively overcome.

[0083] For each projector 155, an opening with the shape of the projector light frustum is cut on the lower segment of the drywall to allow the projection light to pass through. In one embodiment, the opening is arranged at a height above normal height of a person. The height of the opening on the vertical lower segment may be above 180, 190, or 200 cm. With a fair distance above the cut opening (e.g., 0 to 100 cm, preferably 1 to 80 cm, more preferably 5 to 60 cm, more preferably 10 to 50 cm, more preferably 20 to 40 cm), the upper segment of the drywall is tilted inward at an angle that closely

matches the light path of the bottom of the projection frustum. One such example is shown in Fig. 9.

- [0084] By the arrangement of the internally tilted upper segment, the equipment of the immersive projection system or any other equipment may be installed in the space between the tilted upper segment and the walls/ceiling of the existing room (e.g., a classroom), so as to enhance the effectiveness of usage of the inner space of the existing room.
- [0085] In one embodiment, entrances to the immersive room 150 are equipped with concealed doors where the surface material of the concealed door facing the interior of the system matches the material used at the inside of the room and painted with the same surface paint.
- [0086] The interior of the room is painted with a grey-tinted surface paint specially chosen to minimize the internal reflection of the projector lights while preserving the vividness of the projected color.
- [0087] In one embodiment, the immersive room 150 is equipped with air ventilation panel as illustrated in Figs. 5 and 10. Other equipment or devices that are necessary to support the normal usage of the system or relevant regulatory requirements are installed behind the drywall, embedded into the drywall in similar manner as the surround sound system speakers, or placed inside the Immersive room 150 at positions least distracting to the viewers. Examples of such equipment /device include but not limited to: air ventilation system, light panel, carbon dioxide detect, sprinkler, etc. Without sacrificing the functionality of the equipment /device, the appearance of the devices can be set to match the painted color of the Immersive room 150.
- [0088] Supplementary Visual Aid System
- [0089] FIG. 11A is a cross-sectional view of an immersive room with an additional 2D projector fitted on a motorized ceiling projector lift 400 according to one embodiment of the application. The additional 2D projector fitted on a motorized ceiling projector lift 400 is concealed behind the drywall ceiling. In a non-working state, the motorized ceiling projector lift 400 is elevated with the bottom of the motorized ceiling projector lift forming part of the ceiling drywall structure; while in a working state, the projector situated on the motorized ceiling projector lift 400 is lowered down with the lift, and may project images on the projected area of the front side. Activated by pressing the button on the control panel 1110 behind a hidden cabinet door inside the system. External audio-visual devices can be connected to this supplementary visual aid system to provide additional audio-visual content rendered in 2D for viewers.
- [0090] FIG. 11B is a cross-sectional view of an immersive room showing supplementary visual aid system with hidden control panel and projected area.

[0091] Techniques consistent with the present disclosure provide, among other features, systems and methods for automatic configuration of a communication network and configuration of a partition-resistant communication network. While various exemplary embodiments of the disclosed system and method have been described above it should be understood that they have been presented for purposes of example only, not limitations. It is not exhaustive and does not limit the disclosure to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practicing of the disclosure, without departing from the breadth or scope.

Claims

- [Claim 1] An immersive projection system, comprising:
an image generator configured to render images to be displayed;
a projection warping system configured to warp and blend rendered images received from the image generator;
an immersive room including ceiling having an opening and floor; and
a plurality of projectors configured to project images output from the projection warping system into the immersive room;
wherein one of the plurality of projectors is configured to project images onto the floor through the opening.
- [Claim 2] The immersive projection system according to claim 1, further comprising:
a video processing system configured to interface with the image generator through the projection warping system to produce a frame-synchronized image signal to the plurality of projectors.
- [Claim 3] The immersive projection system according to any one of claims 1 to 2, wherein,
a projector cover projected downward from the ceiling and concealing a corresponding projector behind the projector cover, wherein the projector cover includes bottom and side walls with one or more openings formed on one of the side walls, thereby to enable the corresponding projector behind the projector cover to project an image through the one or more openings of the projector cover onto a front, back, right or left wall of the immersive room..
- [Claim 4] The immersive projection system according to claim 3, wherein, the plurality of projectors comprise ceiling projectors installed behind openings defined by walls of the immersive room and oriented to project towards the ceiling.
- [Claim 5] The immersive projection system according to any one of claims 1 to 4, wherein, the immersive room inside an preselected room.
- [Claim 6] The immersive projection system according to any one of claims 1 to 5,
wherein the immersive room is made of drywall.
- [Claim 7] The immersive projection system according to any one of claims 1 to 6, further comprising,
a motion capture system; and

a plurality of motion capture devices installed at locations inside the immersive room, such that a user or object fitted with retroreflective markers forming pre-defined shape or battery-powered trackers with a pre-registered hardware identification number is identified by the plurality of motion capture devices, thereby allowing the motion capture system to resolve position and/or movement of the user or object.

[Claim 8] The immersive projection system according to any one of claims 1 to 7, wherein,

the image generator is configured such that an interactive content executed on the image generator uses motion capture information provided by the motion capture system as user input to update interactive content generated.

[Claim 9] The immersive projection system according to any one of claims 1 to 8, further comprising,

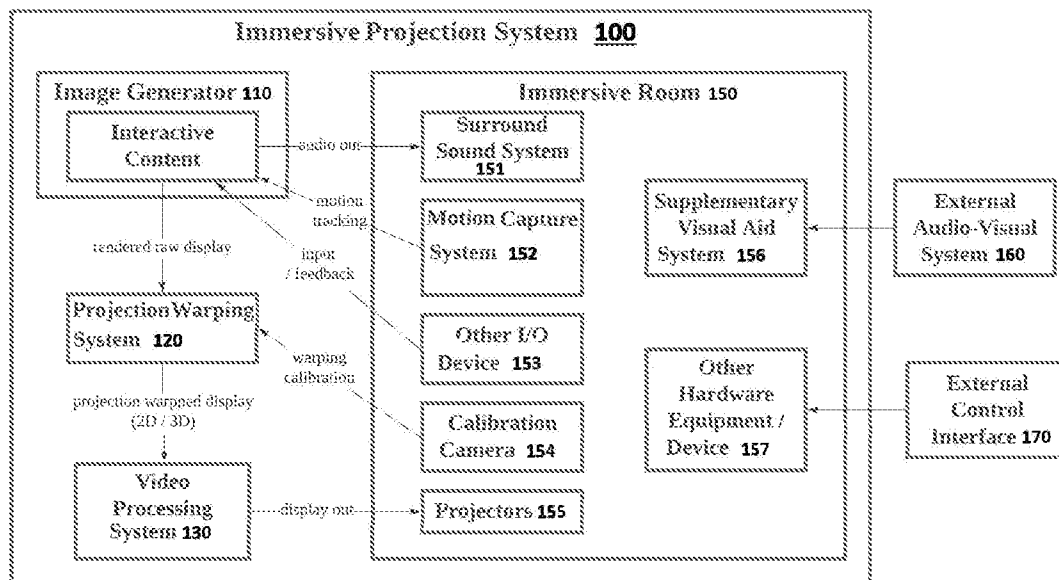
a surrounding sound system including speakers, wherein the speakers fit in openings defined by walls of the immersive room onto which a projected image is to be displayed, the system further comprises a perforated panel painted the same color as the wall for covering the openings, such that sound produced by the speakers is projected through the perforated panel to the inside of the room.

[Claim 10] The immersive projection system according to any one of claims 1 to 9, further comprising,

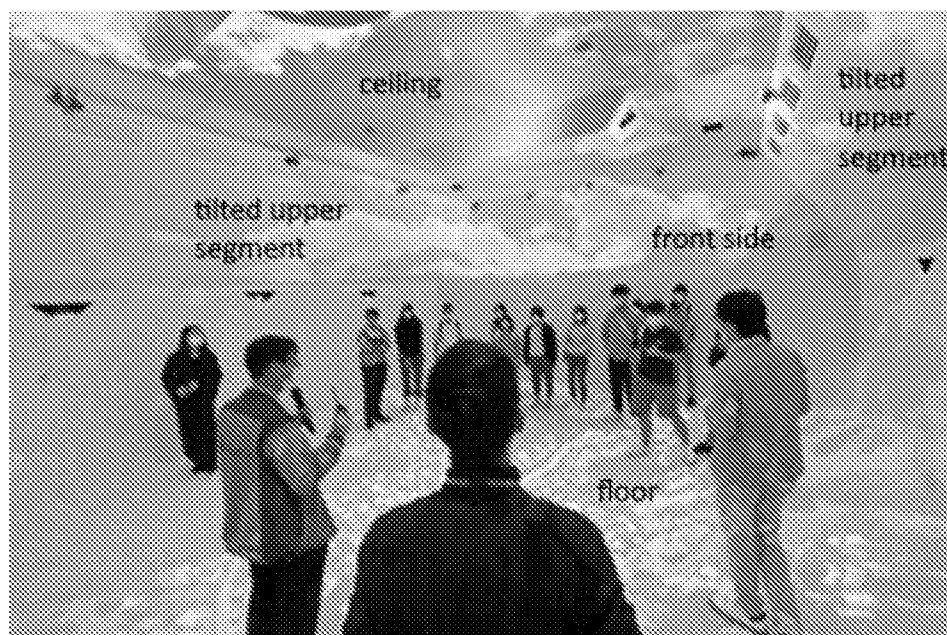
air ventilation panels embedded in walls of the immersive room and painted the same color as the wall.

[Claim 11] An immersive projection system implemented as a Cave Automatic Virtual Environment (CAVE) 6-sided projection system.

[Fig. 1]



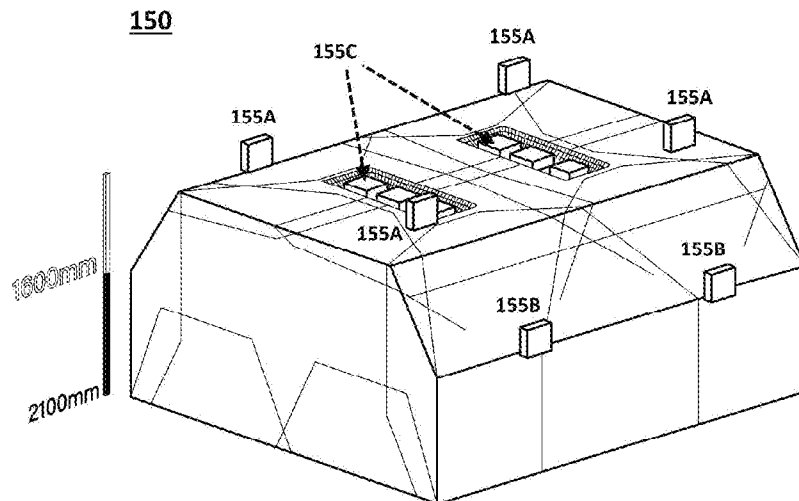
[Fig. 2A]



[Fig. 2B]



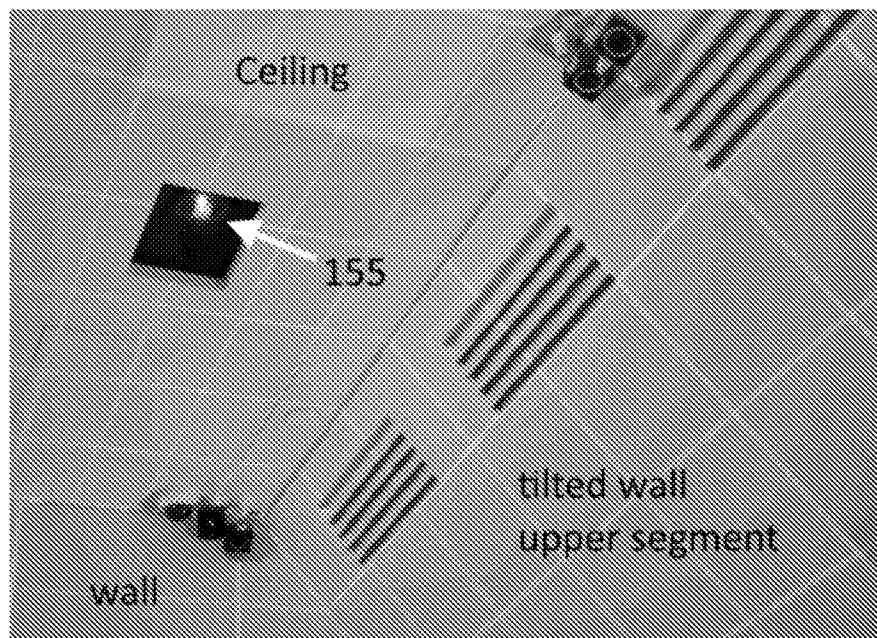
[Fig. 3]



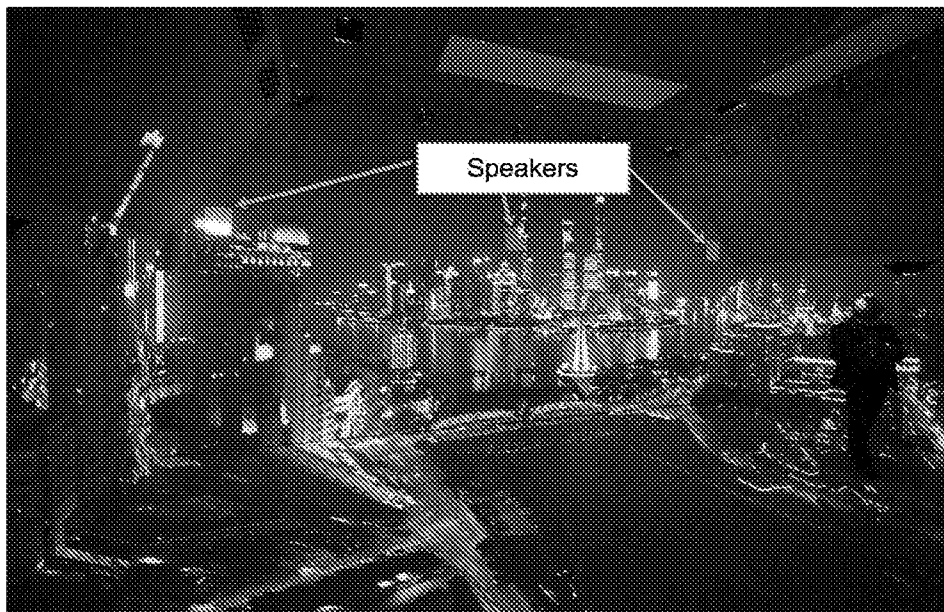
[Fig. 4]



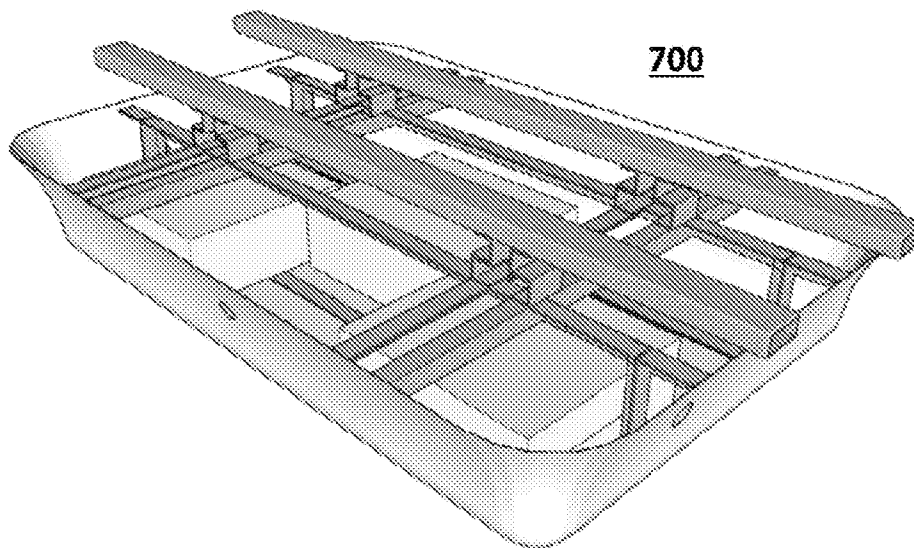
[Fig. 5]



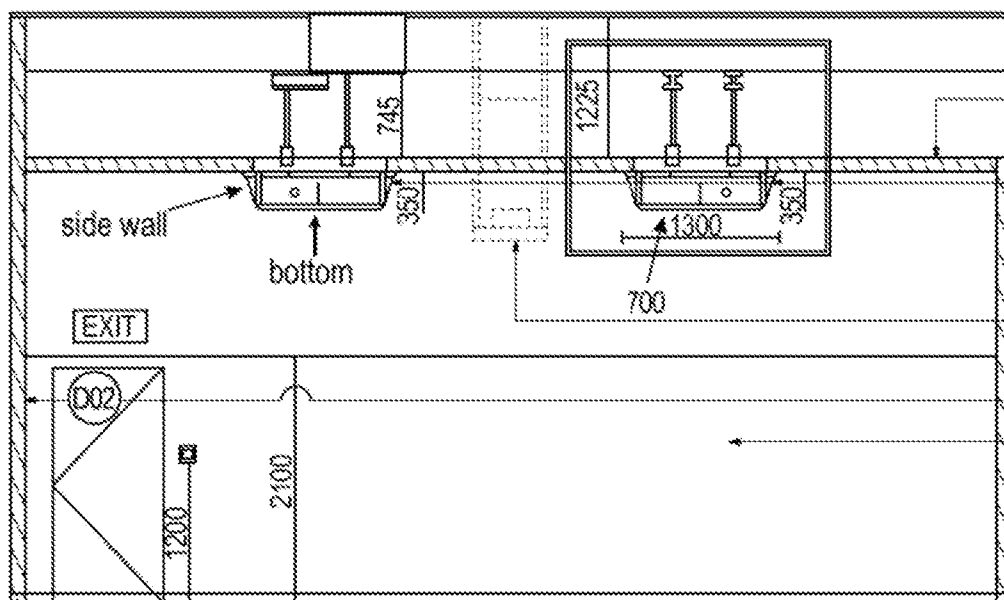
[Fig. 6]



[Fig. 7A]



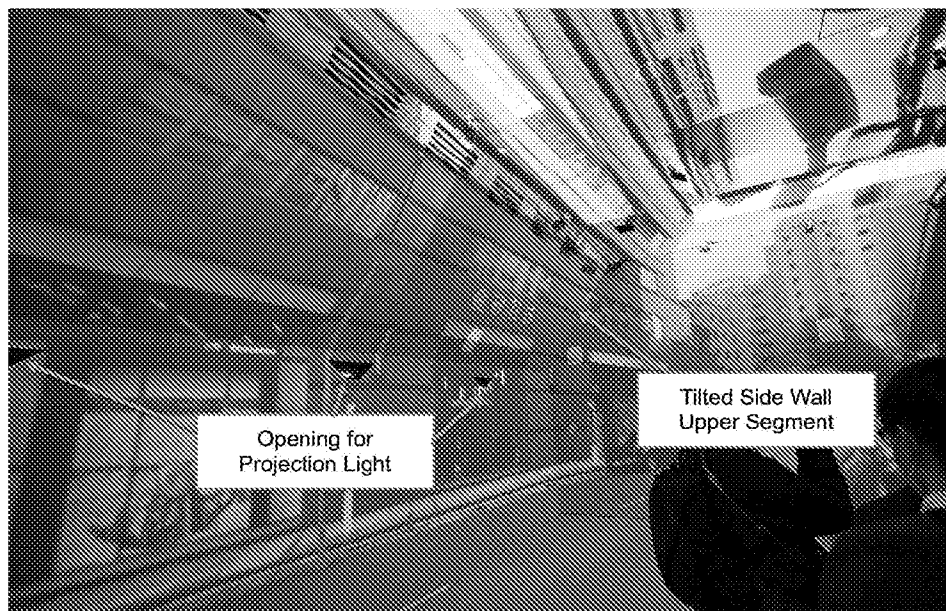
[Fig. 7B]



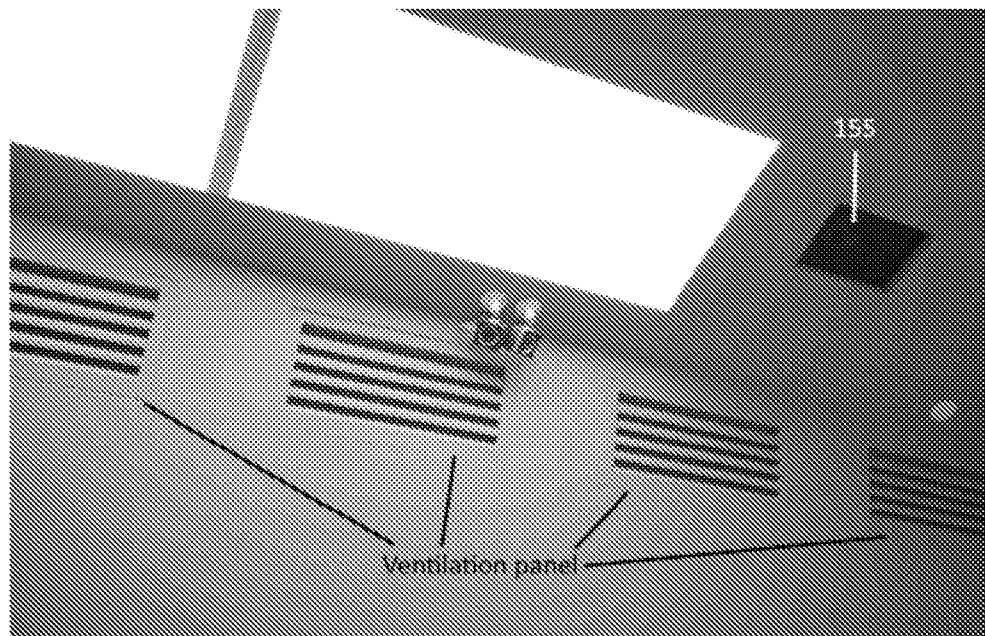
[Fig. 8]



[Fig. 9]

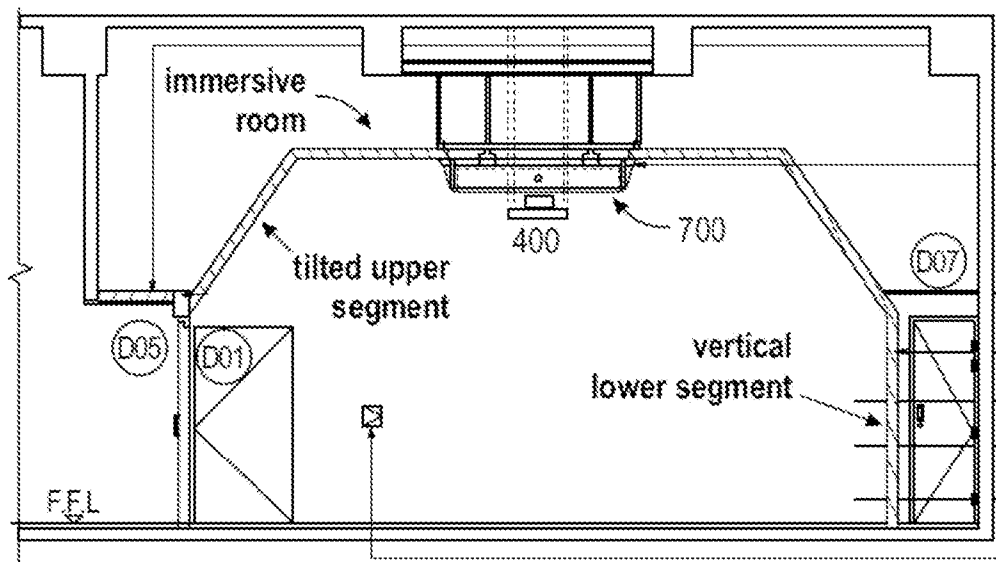


[Fig. 10]



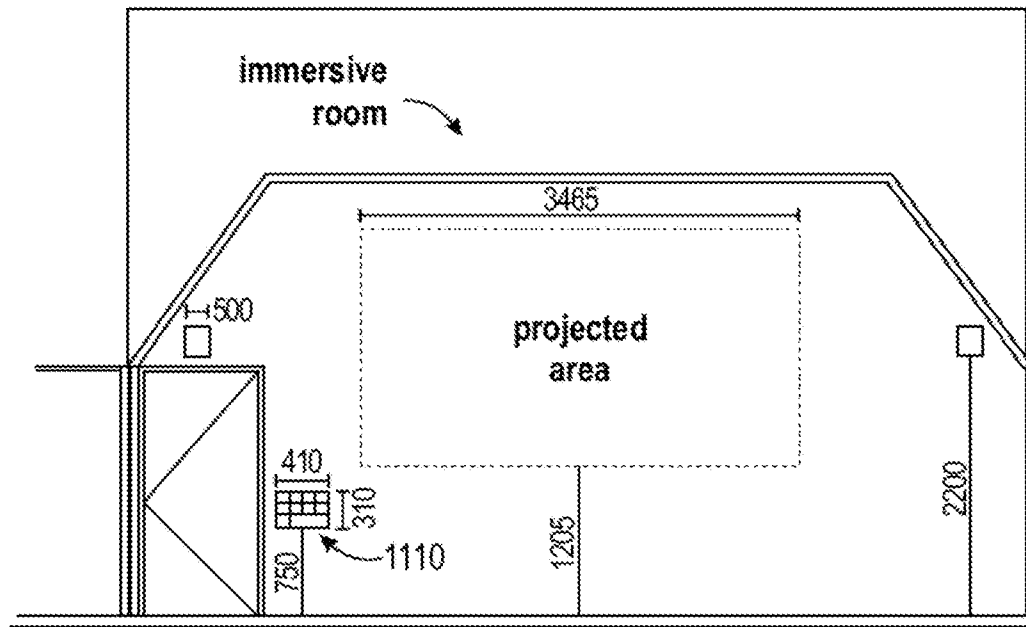
[Fig. 11A]

preselected
room



Rule 26,
05.06.2024

[Fig. 11B]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/085121

A. CLASSIFICATION OF SUBJECT MATTER

H04N13/363(2018.01)i; H04N9/31(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT,ENTXTC,ENTXT,VEN,DWPI,IEEE:immersive,project,image,generator,warp+,blend+,render+,room,ceiling,floor, opening,motion captur+,speaker,CAVE,cave automatic virtual environment,HiVE,hybrid immersive virtual environment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015350628 A1 (LUCASFILM ENTERTAINMENT CO. LTD.) 03 December 2015 (2015-12-03) description, paragraphs 0029-0110	11
Y	US 2015350628 A1 (LUCASFILM ENTERTAINMENT CO. LTD.) 03 December 2015 (2015-12-03) description, paragraphs 0029-0110	1-10
Y	WO 2016010360 A1 (KIM, Jingab) 21 January 2016 (2016-01-21) description, paragraphs 0045-0187	1-10
Y	US 2020404226 A1 (SONY CORPORATION) 24 December 2020 (2020-12-24) description, paragraphs 0026-0078	1-10
A	CN 111047925 A (SHANDONG UNIVERSTIY) 21 April 2020 (2020-04-21) the whole document	1-11
A	US 2018117465 A1 (DISNEY ENTERPRISES, INC.) 03 May 2018 (2018-05-03) the whole document	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

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“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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“&” document member of the same patent family

Date of the actual completion of the international search

16 May 2024

Date of mailing of the international search report

30 May 2024

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/085121

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017192134 A1 (HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.) 09 November 2017 (2017-11-09) the whole document	1-11

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/085121

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2015350628	A1	03 December 2015	None			
WO	2016010360	A1	21 January 2016	KR	101486959	B1	29 January 2015
US	2020404226	A1	24 December 2020	WO	2019188121	A1	03 October 2019
CN	111047925	A	21 April 2020	None			
US	2018117465	A1	03 May 2018	None			
WO	2017192134	A1	09 November 2017	None			