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ENVIRONMENTAL ADAPTATION FOR HEAD MOUNTED DISPLAYS

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DETAILED DESCRIPTION

[0001] Embodiments of virtual reality environmental adaptation are described herein. In the following description, numerous specific details are set forth to provide a thorough understanding of the embodiments. One skilled in the relevant art will recognize, however, that the techniques described herein can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring certain aspects.

[0002] In some implementations of the disclosure, the term "near-eye" may be defined as including an element that is configured to be placed within 50 mm of an eye of a user while a near-eye device is being utilized. Therefore, a "near-eye optical element" or a "near-eye system" would include one or more elements configured to be placed within 50 mm of the eye of the user.

[0003] In aspects of this disclosure, visible light may be defined as having a wavelength range of approximately 380 nm – 700 nm. Non-visible light may be defined as light having wavelengths that are outside the visible light range, such as ultraviolet light and infrared light. Infrared light having a wavelength range of approximately 700 nm – 1 mm includes near-infrared light. In aspects of this disclosure, near-infrared light may be defined as having a wavelength range of approximately 700 nm - 1.6 μm.

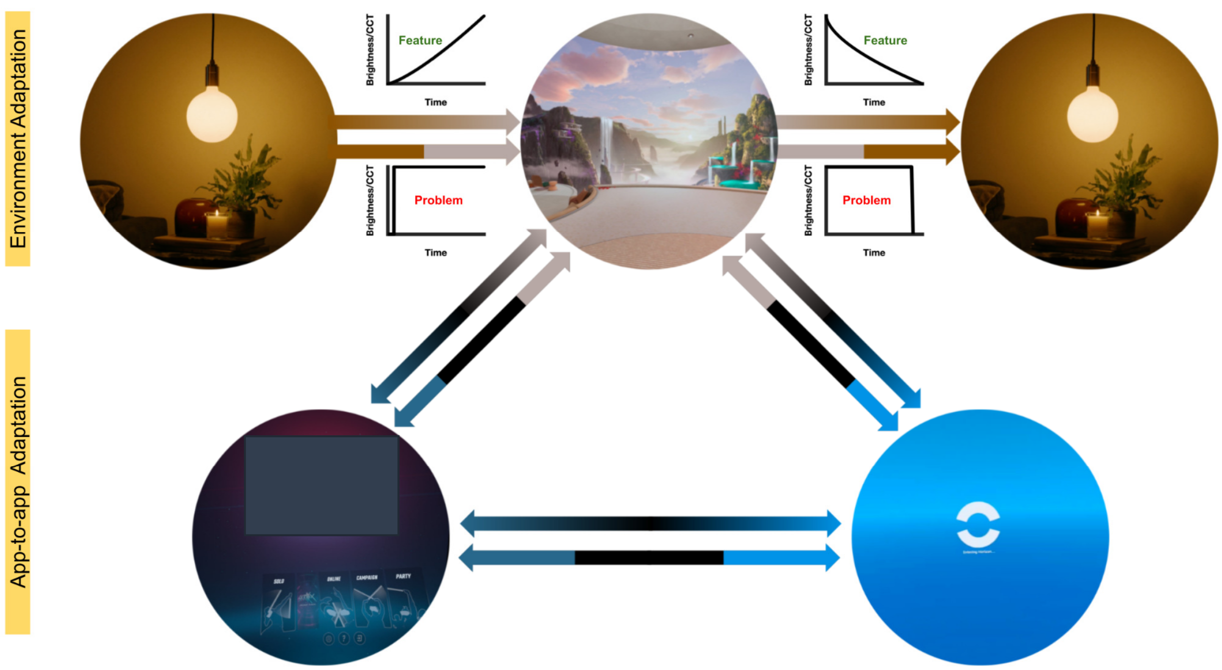
[0004] In aspects of this disclosure, the term “transparent” may be defined as having greater than 90% transmission of light. In some aspects, the term “transparent” may be defined as a material having greater than 90% transmission of visible light.

[0005] When virtual reality (VR) users initially don their headset, the initial scene displayed can be much brighter than the ambient light the users are adapted to. This can cause some levels of eye discomfort. Gradual transitions from the real world to the virtual environment (VE), and smooth transitions from one VE to another can increase immersivity of the virtual experience.

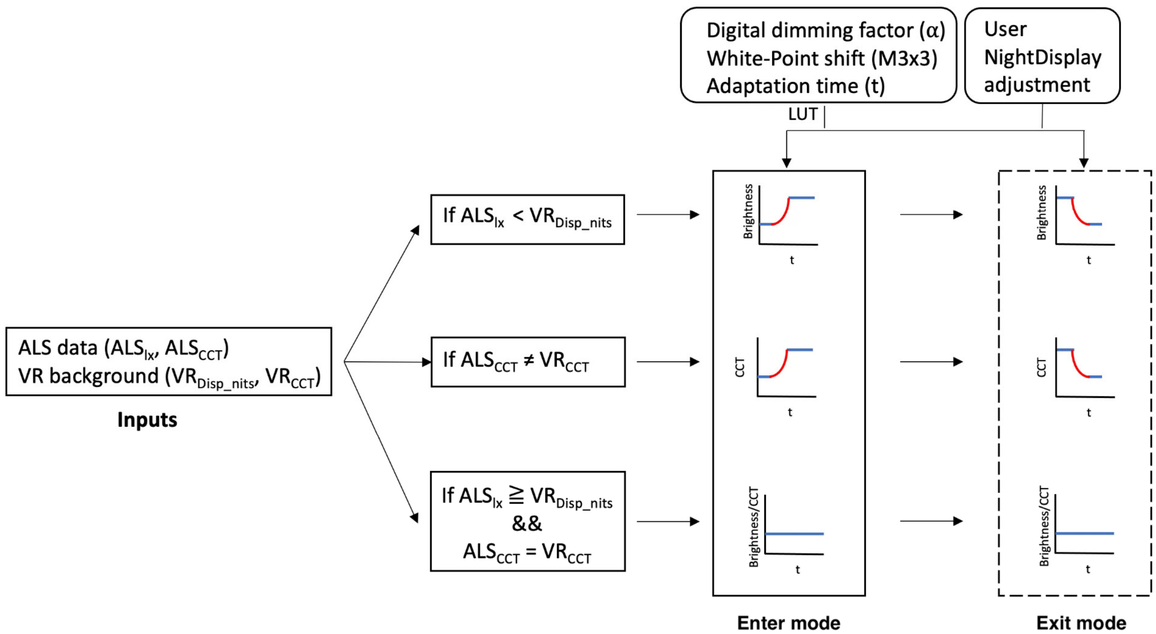
[0006] Virtual reality (VR) headsets may use ambient light sensors (ALS) or cameras to detect real world conditions in terms of illuminance and correlated color temperature (CCT). With this information, the virtual environment (VE) can be adjusted to match the real world conditions. When the user dons the headset, the VR environment (CCT, brightness) will initially be similar to the real environment conditions and then gradually change to the scene’s intended visuals. Within VR, the user may open various applications. Instead of the abrupt changes that are usually seen between the VR home environment, the loading page, and the VR application, we plan to implement gradual and smooth transitions to and from the dark loading screen.

[0007] In an implementation, the VE will gradually transition from the real world to the virtual world, and vice versa with respect to both correlated color temperature (CCT) and display brightness. Additionally, smooth transitions between VR environments and applications may create smoother virtual experiences and potentially reduce eye fatigue in users who may frequently enter and leave VR.

[0008] In an implementation, once the user is done with their VR session, they can exit VR smoothly by tapping the headset, pressing a physical button, or pressing an icon on the system interface, to indicate that the headset will soon be doffed. Once the user has tapped the headset to initiate the Exit mode, the display will gradually adapt the user from the VE to the environmental conditions detected by the ALS or camera. The ambient light sensors may include a complementary metal-oxide semiconductor (CMOS) image sensor or one or more photodiodes.



[0009] FIG 1. (above) Environmental and app-to-app adaptation workflow. The upper half of the figure represents the workflow for the VR environmental adaptation feature, which makes use of the headset's ambient light sensor (ALS) or camera. For our feature, there will be a smooth transition between real environment conditions and the initial VE, with respect to display brightness (nits) and/or CCT (K). The lower half of the figure represents the workflow for adaptations between VR applications, and between VR applications and home environments. Between virtual scenes, whether applications or home environments, there will be smooth transitions from the initial scene brightness to black before entering the loading page. Once the application is done loading, there will be a gradual brightness transition as well. Stacked arrows represent color and brightness comparisons between the feature ON (upper) and feature OFF (lower; problem statement) across time.



[0010] FIG. 2. Virtual reality environment adaptation algorithm implementation: Enter and Exit mode. Regarding the algorithm workflow, the main inputs include the sensor data (e.g., brightness (lx) and CCT (K)), and VE information (e.g., display brightness (nits), and CCT). If the real environment matches the conditions of the VE, the environmental adaptation feature does not need to change anything in the VE.

[0011] ENTER MODE: IF the ALS or camera data indicate that the user's real environment is dimmer than what would be displayed in VR, the environmental adaptation feature would enable the initial VR scene to have the same brightness as the user's real environment and then gradually increase the display brightness until the desired brightness condition of the VR scene is reached. If the ALS or camera senses that the user's real environment is of a different CCT than what would be displayed in VR, the environmental adaptation feature would similarly match the conditions of the real environment and slowly adapt the user to the VE.

[0012] IN-USE MODE: When the user wants to change VE (e.g., VR home to app, app to app, or app to VR home), the current scene will gradually change in brightness: (1) Exiting initial VE: brightness gradually ramps down from 100 nits to 0 nits; and (2) Entering target VE: brightness gradually ramps up from 0 nits to 100.

[0013] EXIT MODE: Before the user takes off the VR headset, the user can click a button and the environmental adaptation feature will quickly adapt the user from the VE to the real environment with respect to brightness and CCT. Exit mode will provide both a brightness indicator for room condition for safety purpose and an adaptation procedure. Please note the adaptation in Exit mode is optional since some users may not have time for taking the adaptation due to reasons like picking up phone calls, emergencies, etc. In some implementations, Exit Mode is initiated by a voice command or a software interface (e.g. a software button) with a virtual environment.

[0014] In an implementation, a CCT and/or brightness level of the display is transitioned between a virtual environment and a passthrough experience. A passthrough experience includes images of the external environment (the images typically being captured by an image sensor of the VR headset) being presented to the user on a display of the VR headset. By way of example, if the images of the external environment are much brighter than an application the user was using, the transition between the VE and the passthrough images are gradually transitioned, or vice-versa.

[0015] In an implementation, transitions between other senses are gradually transitioned, for example, audio volumes in speakers or headphones of the VR headset may be gradually transitioned between applications or between the external environment and the VE.

[0016] Embodiments of the invention may include or be implemented in conjunction with an artificial reality system. Artificial reality is a form of reality that has been adjusted in some manner before presentation to a user, which may include, e.g., a virtual reality (VR), an augmented reality (AR), a mixed reality (MR), a hybrid reality, or some combination and/or derivatives thereof. Artificial reality content may include completely generated content or generated content combined with captured (e.g., real-world) content. The artificial reality content may include video, audio, haptic feedback, or some combination thereof, and any of which may be presented in a single channel or in multiple channels (such as stereo video that produces a three-dimensional effect to the viewer). Additionally, in some embodiments, artificial reality may also be associated with applications, products, accessories, services, or some combination thereof, that are used to, e.g., create content in an artificial reality and/or are otherwise used in (e.g., perform activities in) an artificial reality. The artificial reality system that provides the artificial reality content may be implemented on various platforms, including a head-mounted display (HMD) connected to a host computer system, a standalone HMD, a mobile device or computing system, or any other hardware platform capable of providing artificial reality content to one or more viewers.

[0017] The term "processing logic" in this disclosure may include one or more processors, microprocessors, multi-core processors, Application-specific integrated circuits (ASIC), and/or Field Programmable Gate Arrays (FPGAs) to execute operations disclosed herein. In some embodiments, memories (not illustrated) are integrated into the processing logic to store instructions to execute operations and/or store data. Processing logic may also include analog or digital circuitry to perform the operations in accordance with embodiments of the disclosure.

[0018] A "memory" or "memories" described in this disclosure may include one or more volatile or non-volatile memory architectures. The "memory" or "memories" may be removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules, or other data. Example memory technologies may include RAM, ROM, EEPROM, flash memory, CD-ROM, digital versatile disks (DVD), high-definition multimedia/data storage disks, or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other non-transmission medium that can be used to store information for access by a computing device.

[0019] Networks may include any network or network system such as, but not limited to, the following: a peer-to-peer network; a Local Area Network (LAN); a Wide Area Network (WAN); a public network, such as the Internet; a private network; a cellular network; a wireless network; a wired network; a wireless and wired combination network; and a satellite network.

[0020] Communication channels may include or be routed through one or more wired or wireless communication utilizing IEEE 802.11 protocols, short-range wireless protocols, SPI (Serial Peripheral Interface), I^2C (Inter-Integrated Circuit), USB (Universal Serial Port), CAN (Controller Area Network), cellular data protocols (e.g. 3G, 4G, LTE, 5G), optical communication networks, Internet Service Providers (ISPs), a peer-to-peer network, a Local Area Network (LAN), a Wide Area Network (WAN), a public network (e.g. “the Internet”), a private network, a satellite network, or otherwise.

[0021] A computing device may include a desktop computer, a laptop computer, a tablet, a phablet, a smartphone, a feature phone, a server computer, or otherwise. A server computer may be located remotely in a data center or be stored locally.

[0022] The processes explained above are described in terms of computer software and hardware. The techniques described may constitute machine-executable instructions embodied within a tangible or non-transitory machine (e.g., computer) readable storage medium, that when executed by a machine will cause the machine to perform the operations described. Additionally, the processes may be embodied within hardware, such as an application specific integrated circuit (“ASIC”) or otherwise.

[0023] A tangible non-transitory machine-readable storage medium includes any mechanism that provides (i.e., stores) information in a form accessible by a machine (e.g., a computer, network device, personal digital assistant, manufacturing tool, any device with a set of one or more processors, etc.). For example, a machine-readable storage medium includes recordable/non-recordable media (e.g., read only memory (ROM), random access memory (RAM), magnetic disk storage media, optical storage media, flash memory devices, etc.).

[0024] The above description of illustrated embodiments of the invention, including what is described in the Abstract, is not intended to be exhaustive or to limit the invention to the precise forms disclosed. While specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize.

[0025] These modifications can be made to the invention in light of the above detailed description. The terms used in the following claims should not be construed to limit the invention to the specific embodiments disclosed in the specification. Rather, the scope of the invention is to be determined entirely by the following claims, which are to be construed in accordance with established doctrines of claim interpretation.

CLAIMS

What is claimed is:

1. A method comprising:

receiving an input on a motion sensor of a head mounted display (HMD);

sensing an ambient light level of an external environment of the HMD in response to receiving the input; and

adjusting a brightness level of a display of the head mounted display to approximate the ambient light level.

2. The method of claim 1, wherein ambient light level is sensed with an image sensor or one or more photodiodes.

3. A head mounted display (HMD) comprising:

a motion sensor;

a light sensor configured to sense an ambient light level of the HMD;

a display for presenting virtual images; and

processing logic configured to:

receive an input from the motion sensor;

measure, with the light sensor, the ambient light level in an external environment of the HMD in response to receiving the input from the motion sensor; and

drive a brightness level of the display to approximate the ambient light level in the external environment of the HMD.

4. The HMD of claim 3, wherein light sensor includes an image sensor or one or more photodiodes.

5. The HMD of claim 3, wherein the processing logic is further configured to drive a color temperature of the display to approximate an ambient color temperature of the external environment of the HMD.

6. The HMD of claim 3, wherein the brightness level is gradually increased.

7. The HMD of claim 3, wherein the brightness level is gradually decreased.