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Systems and Methods for Generating, Stabilizing, and Interacting with Volumetric Projection Media

Field of the Invention

The present disclosure relates to systems and methods for volumetric visual display and interaction, and more particularly to controllable projection media generated in open air for use in wearable, mounted, fixed, and distributed devices.

Background

Traditional visual displays rely on physical screens or head-mounted devices, which constrain interaction to predefined surfaces or require worn optics. Existing augmented reality systems depend on external display hardware and do not generate visual content directly within free space.

Large-scale fog or mist-based display systems exist; however, these systems are typically fixed installations that lack fine-grained control, portability, or interactive capability. Such systems are not well suited for compact, wearable, or modular applications and generally do not maintain a stable volumetric display region under varying environmental conditions.

Accordingly, there remains a need for systems capable of generating, stabilizing, and interacting with controllable volumetric projection media in open air, particularly in compact or wearable form factors, while supporting real-time interaction and adaptive control.

Summary

The present disclosure relates to systems and methods for generating, stabilizing, and interacting with volumetric projection media in open air. In various embodiments, a controllable projection medium is formed using mist, aerosol, droplets, or similar particulate media and is actively stabilized using airflow management and feedback control.

Visual content is projected into a stabilized volumetric region using one or more projection subsystems, enabling mid-air visualization without reliance on physical screens, head-mounted displays, or pre-existing surfaces. Interaction with the volumetric region may be supported through sensing of user gestures, proximity, or disturbances of the projection medium, with real-time adjustment of system parameters.

The disclosed systems may be implemented across multiple form factors, including wearable devices, body-mounted or clip-on devices, vehicle- or object-mounted devices, fixed installations, and distributed multi-node configurations, enabling scalable volumetric visualization and interaction across personal, environmental, and architectural contexts.

Detailed Description

Volumetric Projection Medium

In some embodiments, a volumetric projection medium is generated using ultrasonic atomization, piezoelectric mist generators, aerosol emitters, or similar mechanisms capable of producing fine particulate media suspended in air. The projection medium may be continuous or quasi-continuous in nature and may be replenished dynamically to maintain volumetric stability.

The volumetric projection medium is treated as a controllable scattering volume rather than as individually addressable discrete particles.

Stabilization and Containment

Airflow control structures, including shrouds, ducts, flow-straightening elements, or directional airflow channels, may be used to reduce turbulence and maintain a stable volumetric region suitable for projection. Feedback from one or more sensors may be used to adjust airflow, atomization rate, or other parameters in real time.

Stabilization may be performed to satisfy one or more control objectives, including volumetric stability, visual uniformity, interaction responsiveness, or energy efficiency.

Projection Subsystem

One or more projection systems, including micro-projectors, scanning light sources, or other optical emitters, may be used to introduce visual content into the volumetric projection medium. Projection parameters may be dynamically adjusted to compensate for variations in density, geometry, or motion of the volumetric projection medium.

Sensing and Interaction

Sensors such as cameras, infrared detectors, time-of-flight sensors, structured-light sensors, or other proximity or environmental sensors may be used to detect interaction with the volumetric projection medium. User gestures, proximity, or disturbances of the medium may be interpreted as input, enabling interactive control of displayed content.

Control System

A control system may receive sensor input and adjust atomization, airflow, and projection parameters using closed-loop, adaptive, or model-based control techniques. The control system may operate continuously or intermittently to maintain visual stability and interaction responsiveness under varying conditions.

Example Embodiments

Wearable Embodiment

In one embodiment, the system is implemented as a wrist-worn device comprising a reservoir, atomizer, airflow components, projection system, sensors, and control electronics, generating a localized volumetric display region above the arm.

Mounted Embodiment

In another embodiment, the system is mounted to a vehicle, object, or structure, generating a volumetric display region for signaling, visualization, or interaction.

Fixed and Distributed Embodiments

In further embodiments, multiple modules are combined to form fixed installations or distributed volumetric display fields spanning larger environments. Modules may communicate with one another to coordinate projection, stabilization, and interaction across multiple volumetric regions.

Drawings (Illustrative)

Figures may include block diagrams of the system, wearable embodiments, airflow containment structures, and control loops. The drawings are illustrative and not intended to limit the scope of the disclosure.

Figure 1 is a block diagram of a system for generating, stabilizing, and interacting with a volumetric projection medium. A projection medium generator produces a controllable particulate medium suspended in air. Airflow control components maintain a stable volumetric region suitable for projection. One or more projection subsystems introduce visual content into the volumetric region. Sensors detect properties of the volumetric medium and user interaction. A control system receives sensor input and adjusts atomization, airflow, and projection parameters using feedback control techniques.

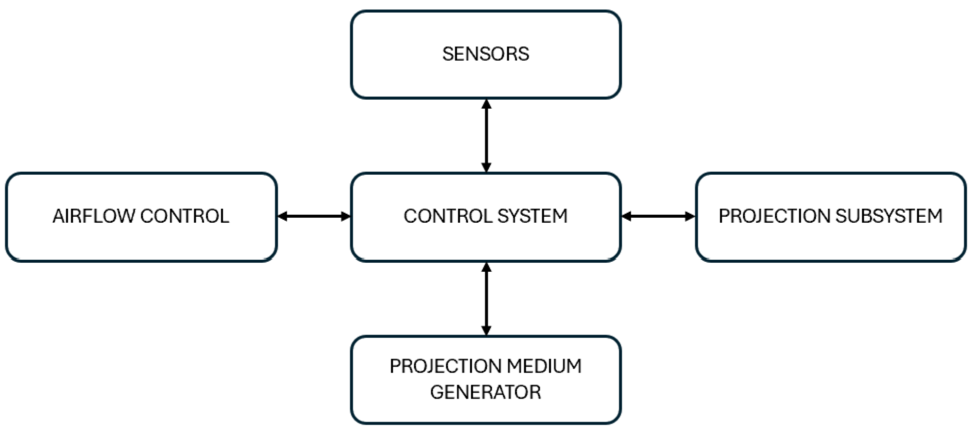

FIGURE 1