APPLICATION NOTES MPN - 2018/24

Multi-Plane Volumetric 3D Image Display Technology as the X-Reality platform for Air and Mission Control

Overview

Historically, as no alternative competitive technologies were available, for tasks related to air traffic control and military mission control, 2D displays have been utilized. As the conventional 2D display is capable of displaying relatively limited information, these limitations have been transferred to the process operators and coordinators which observe the on-screen information.

Multi-plane Volumetric 3D Image Displays provide the following advantages:

- Allows to visualize highly complex 3D data sets in geospatial relevance
- Up to 40% faster situation awareness conclusions and decision
- Eliminate accommodation-vergence conflict for 3D images - substantially reduce eye stress and eye fatigue – allow operators work longer hours and longer professional career without eye vision degradation

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Background

Traditionally 2-dimensional flat displays offered only limited awareness as an accurate representation of the situation in 3D space isn't possible. An improvement is stereoscopic 3D display technology, such as head-mounted displays or displays with stereoscopic glasses which exploit the binocular disparity of the human visual system thus mimicking the 3D nature of the presented content. Nevertheless, head-mounted displays and stereoscopic methods, in general, suffer a number of limitations.

First of all, as at the core of stereoscopic methods is a conventional 2D display with fixed focus plane, an average user will experience accommodation-vergence conflict, which can manifest as excessive eyestrain, pain, and other adverse health-related effects. Consequently, this limits the viewing time to relatively short periods (30 minutes, as reported by Samsung, and other VR headset manufacturers), which isn't practical for tasks of air and mission control. Moreover, as the process controller is wearing a headset, the observable information is limited only by that presented on the stereoscopic 3D display and controller is separated from other visual sources of information.

Multi-plane 3D visualization technology

After evaluation of various 3D systems for air and mission control applications it is expected that the benefits of true 3D representation will be delivered without the adverse effects of stereoscopic methods and encumbering wearable addons. Essentially, the 3D display should be capable of truth fully presenting real-time 3D information streams from the involved in the process management data sources, which can be geo-spatial information, weather data, data from various radar sensors, aircraft transponder, GPS and other information etc. Schematic example of modeled content (Fig.1) shows an area of surveillance (interest) which includes a corresponding 3D terrain, airborne assets with an option to show the respective quantitative and qualitative characteristics.

Weather maps, mission-related information, aircraft trajectories, etc. The true 3D view, as presented in Fig.1 allows for a process coordinator to easily assess the situation – as the presented data has been visualized in relation to 3D geospatial data as close as possible to a real-world situation.

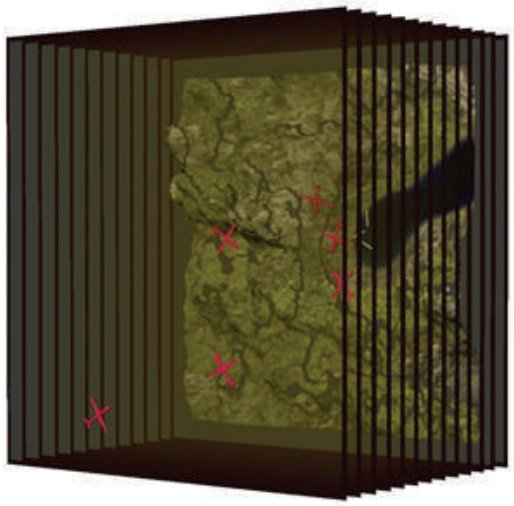

Figure 1. An example of a modeled 3D scene of the area of surveillance, as would be rendered by the multi-plane volumetric display

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Multi-Plane Volumetric Display

Volumetric displays are a Field of the Light class of 3D displays capable of truthfully representing 3D content. The image is reproduced within a physical volume, thus making the image have essentially all qualities of a similar real object or scene. Multi-plane volumetric display technology employs astatic [no moving parts] projection volume based on a stack of electrically controllable light diffuser elements. The 3D image is recreated by discretizing the 3D source into depth planes which then in a plane by plane are projected into respective diffuser elements (Fig.2).

Ensuring a high volumetric refresh rate, which typically surpasses 60 volumes per second, a flicker-free 3D image can be achieved. The advantage of passive multi-plane technology in contrast to sweeping screen approach is its mechanical robustness, as no moving parts are used for the projection volume. Furthermore, by optically laminating the optical diffuser elements together in a single unit, its overall mechanical reliability is also increased thus minimizing the number of required maintenances and providing extended operational lifetime (MTBF).

Key advantages of multi-plane volumetric display technology:

- No accommodation-vergence conflict
- Natural support of multiple viewers
- Real-time data display and interactivity
- Volumetric resolution up to 80 MVoxels
- Support of wide color gamut
- Diverse user-content interaction options
- Support of multiple data sources

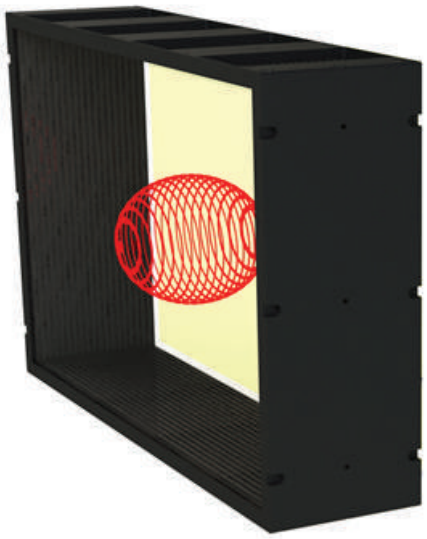

Figure 2. The principle of 3D image recreating in the passive volume of multi-plane volumetric display technology by Lightspace Technologies.

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Principle of operation

The key enabling proprietary technology of any LightSpace display system is a solid state volumetric multi-plane image screen that consists of sequentially switchable multi-plane optical diffuser device composed of a stacked liquid crystal diffusing optical elements. The high-speed 2D image projector projects a sequence of image planes into the multi-plane switchable optical screen where each slice is halted at the proper depth. Proprietary multi-plane rendering and interpolation anti-aliasing algorithms smooth the appearance of the resultant stack of image slices to produce a continuous appearing truly three-dimensional image (Fig. 3).

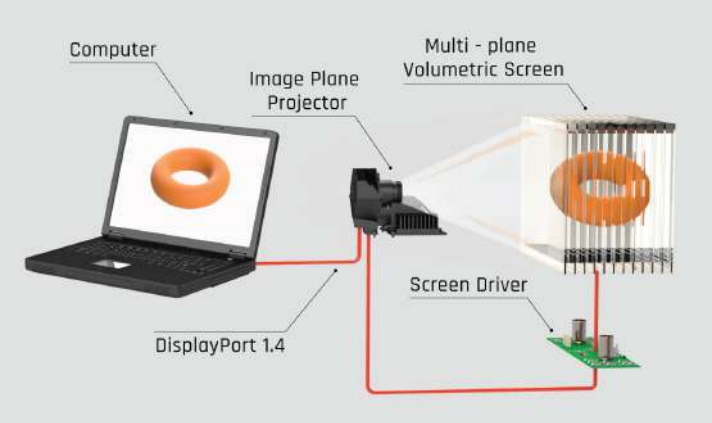

Figure 3. The principle of operation.

The very nature of the volumetric type display system ensures, that the viewer is presented with all physical depth cues (Fig. 4), similar as observing a real object, thus no adverse effects related to accommodation-vergence conflict are experienced even after long viewing periods.

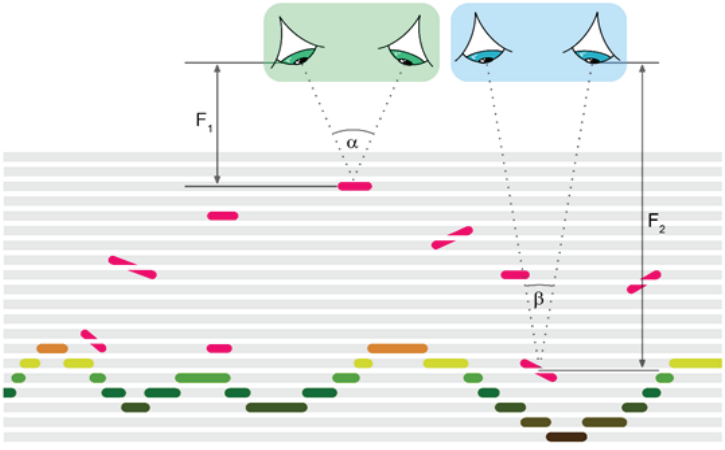

Figure 4. A 3D scene of the area of surveillance showing topographical data and airborne and terrestrial objects as rendered in the 3D volumetric display.

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Air Control and Situation Awareness X-Reality platform – Control4X

Summary

LightSpace Technologies Air Control and Situation Awareness platform Control4X is a demonstration system that visualizes air traffic management, rescue and military mission tasks, and commonly used assets is 3D image visualization form. In its essence, Control4X represents complex X-Reality (Cross Reality) system which is implemented using volumetric spatial data representation with visualization onto front view x-Series and Bench Top surface s-Series multiplane volumetric 3D image displays.

Air Control and Situation Awareness X-Reality platform Control4X in real-time fuses and visualizes complex geo-spatial data in a form of a surface, subsurface and seabed 3D maps that can be overlaid with the real-time streamed sensor data from surface and subsurface Radar, Lidar, SAR (synthetic aperture radar), hyper spectrum satellite and drone captured imagery. Platform visualizes and traces virtual flying or floating, surface or subsurface assets like aircraft, drones, ships, and subs that are displayed at proper altitudes, 3D coordinates and also at subsurface depths. At defined viewpoints platform displays immersed real-time streaming 2D video feeds.

Such rich datasets displayed in the multi-plane 3D display in connection with geo-spatial data greatly expands the spatial awareness and consequently increases confidence of the process controller. Also, it has been proved by scientific study that situation recognition and decision speed increases by up to 40% in comparison to 2D display systems.

Figure 5. Control4X Screen Control Panel with visualized 3D geospatial maps overlaid with aircraft 3D positions and related data tags.

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Main features and benefits

All the visualized assets have been visualized in reference to quasi-rectangular coordinates of visualized segment provided by geo-spatial information in form of 3D maps with the landscape with elevation information. Subsurface objects and seabed profile can be visualized in 3D if required by a task. In addition to basic landscape and seabed layouts atmospheric (weather), objects can be visualized at required altitudes (Fig. 5).

Flying assets and their traces which would normally intersect on 2D maps - would be visualized in 3D as avoiding each other with clearly observable separation at different altitudes (image layers). See Figure 6. Aircraft climb or descent or any other changes of flight direction can be conveyed by changing the angular position of aircraft 3D body or by any other means – for example, displaying projected trajectories making early detection of intersecting or closely spaced trajectories an easy task.

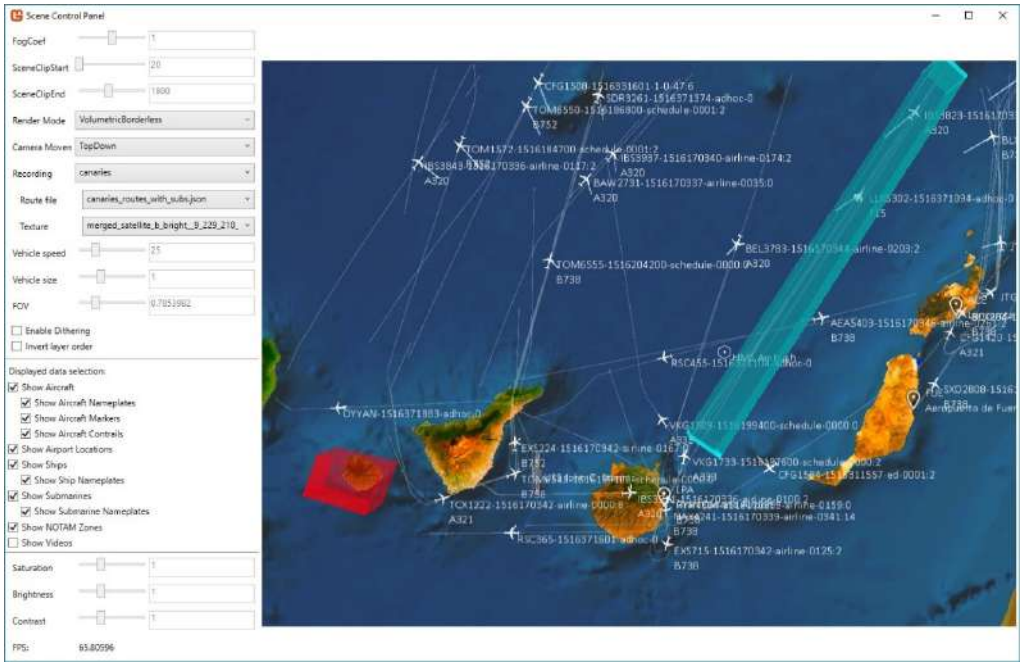

Figure 6. Control4X Screen Control Panel with visualized 3D geospatial maps overlaid with aircraft 3D positions, related data tags with showed contrails and traces. Added fly corridors and no fly zones.

As visualization image segment includes all required 3D space, additional control objects, like shapes of certain 3D areas – flight corridors or no-fly 3D segments, can be easily fused into the 3D scenery (Fig. 6). Equally important for mission control are a visualization of floating and submersed assets.

Figure 7. Shows example of visualization of aircraft carrier and submarine. Due to the 2D image limits those objects are only seen when output in multi-plane 3D format to multi-plane 3D image display. Equally well visualization can be used for displaying of positions, movements of surface or submerged assets, such as ships, submarines, underwater objects in relation to surface and seabed terrain.

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Figure 7 shows an example of an oversized aircraft carrier model and submarine pointer positions. When viewing such a scene in multi-plane 3D display it is quite easy to see and capture each submersed and surface asset at its 3-dimensional position. Provided that speed of finding and tracing of flying and surface assets in 3-dimensional view is up to 40% faster it also provides operator abilities to control more complex missions.

Additionally to sensor information about the position of certain assets very likely there are important real-time video feeds received from drones, satellites or any other sources that need to be monitored. Control4X provides means that such 2D video feeds can be placed at the 3D scenery at relevant positions as small embedded 2D screens. Some of the real-time imagery can be overlaid over static 3D topographic maps to provide a live update of terrain or assets located at the terrain.

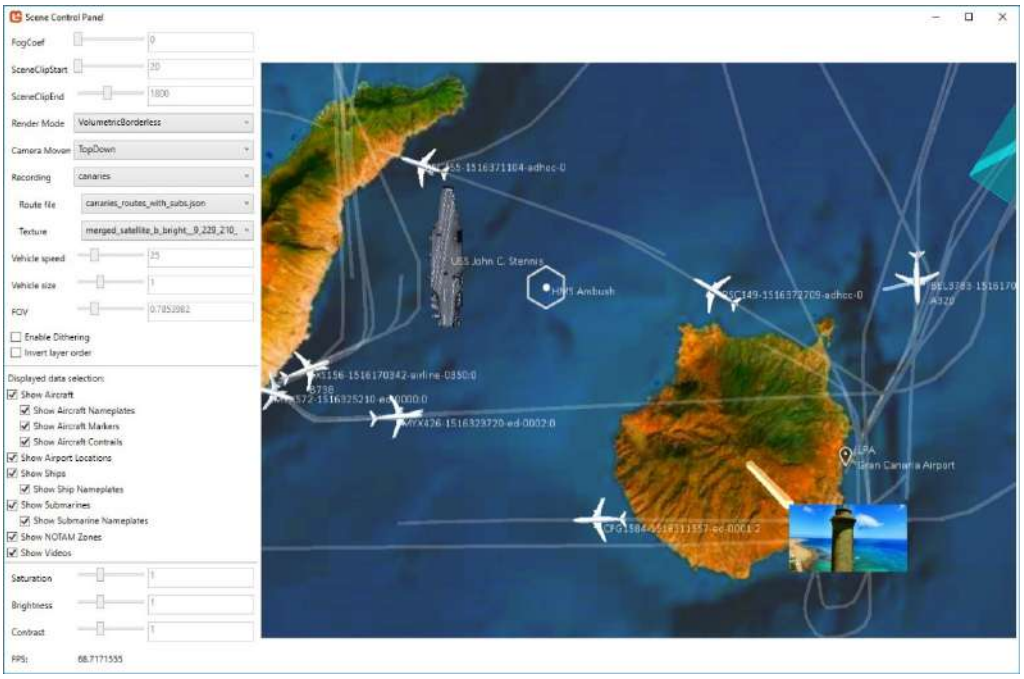

Figure 7. Control4X Screen Control Panel with visualized 3D geospatial maps overlaid with aircraft 3D positions, related data tags with showed contrails and traces. Added real-time streaming 2D video feeds.

Such rich datasets displayed in the multi-plane 3D display in connection with geo-spatial data greatly expands the spatial awareness and consequently increases confidence of the process controller. Also, it has been proved by scientific study that situation recognition and decision speed of operator with volumetric 3D displays increases by up to 40% in comparison to 2D display systems and allows the person to control more complex missions.

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Product summary

LightSpace Technologies develop solid-state multi-plane static volume volumetric 3D image displays in two modifications:

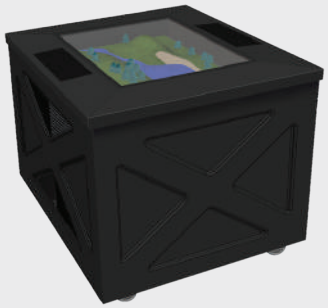
+ **Direct view 3D image display** – where viewer directly observes image visualized into multi-plane volumetric screen. Developed product types – Conventional Front View Display; Benchtop AR "Sand Box" Display

+ **Expanded view 3D image display** – where viewer observes optically transformed (expanded) image from volumetric 3D image screen. Product types – Head up Augmented Reality display; Head Mount near-eye display with or without optical combiner

Air and mission control workstations and team or command center 3D displays require large linear observation 3D areas and Direct view volumetric 3D image displays are most suited for such deployment.

CONVENTIONAL FRONT VIEW DISPLAY

Redesign of X-series models will present fully new model workstations withtwo versions – 24 and 27-inch screen with 8 to 16 image planes and higher single plane resolution - 4MPx. The new model is conveniently deployable into multi view control workstation. Real-Time Volumetric 3D display brings digital content to life and enables people to visualize in a method with no barriers to the 3D experience. The content is viewable in the same way as a real 3D objects, from all angles.



BENCH TOP DISPLAY
"AUGMENTED REALITY SAND BOX"

"Augmented Reality Sand Box" or S-series bench top (table-top) volumetric 3D image display workstations. Volumetric 3D image AR "Sand Box" S-series display workstations aimed at professionals in fields requiring visualization of scientific and medical 3D data sets; security related, tactical and traffic information in civil and military environments in relation to geographic and terrain datasets, architectural, urban and environmental 3D designs. S-series bench top displays will visualize very high resolution data-rich 3D images with interactivity and fusion of real-time data.

HEAD MOUNT DISPLAY - VR/AR SYSTEM

Multi-plane volumetric 3D image near eye display technology is capable of delivering volumetric 3D images with wide field of view in circular coordinates and matched focus depth in whole observable depth space, which eliminates the visual fatigue of the human eyes that are typically caused by fixed focus depth of stereoscopic 3D displays. Multi-plane volumetric head mount displays ensure that virtual 3D objects are displayed rendered at the proper focal distances. The viewer perceives 3D scenery and objects naturally as if they were objects in a real environment.

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