

Volume of Voids: Artistic Visualizations of the Disequilibrium

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Abstract

Volume of Voids is a series of art projects that visualize and materialize the voids between different beings under the regulation of social distancing during the Covid-19 pandemic. It consists of two major artworks: *Volume of Voids I*, which creates data sculptures that visualize and materialize the voids, and *Vol II of Voids*, which brings an interactive art experience that emphasizes the mobility of the space-between humans. The purpose of this work is to create an artistic and conceptual response to the impact of a historical pandemic on complex social networking systems by rethinking the space-between. This paper introduces the conceptual background, design methodology, and technical implementation of this series of work, including the discussions of speculative design framework on computational art, experimental data visualization, volumetric capturing, and 3d fabrication.

Keywords

Data Visualization, Volumetric Capturing, 3D Fabrication, Generative Art, Interactive Art Experience.

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Introduction

Inspired by the social distancing regulations during the Covid-19 pandemic (see Figure 1), people are disconnected physically by keeping a social distance to avoid spreading the Coronavirus. The disruption of the fragile equilibrium in our system profoundly influences our way of living, communicating, and socializing.

Volume of Voids series starts with the conceptual What-If questions we posed during the historical Covid-19 pandemic: When people keep their distance from objects and other people, what is the shape of these invisible spaces? In what ways are these negative spaces evolving as a new entity, reshaping our society as a new normal of intricate social networks? Will the form of the empty spaces of disconnection inspire new ways of reconnecting?



Figure 1. AFP via Getty Images ©Oli Scarff. Accessed 6 June, 2020

Our list of design questions leads to a series of thought experiments that bring an alternative reality and artistic experiences to life: 1. *Volume of Voids I*: A set of 3D printed data sculptures that materializes the voids between objects and human bodies (see Figure 2) 2. *Volume of Voids II*: An interactive art experience that visualizes the mobile voids between humans (see Figure 3).

The *Volume of voids* series provides artistic responses to disconnection, dualism, and the possibility for a new structure and alliance that is more resilient and at ease in its alterity.



Figure 2. *Volume of Voids* documentation of one of the 3d printed sculptures, ©Weidi Zhang.

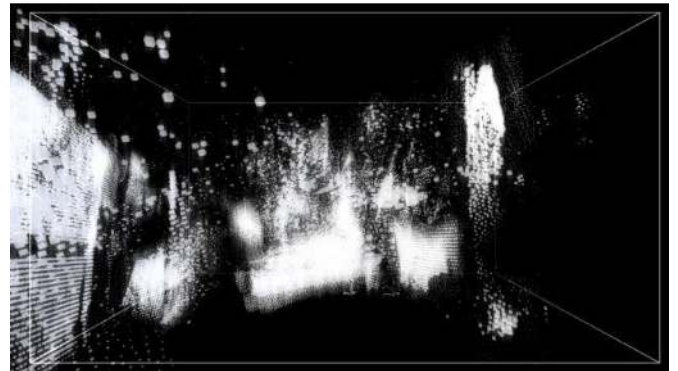


Figure 3. *Volume of Voids* documentation of one of the 3d printed sculptures, ©Weidi Zhang.

Conceptual Background: Dualism, MA (間), and Balance

The inspiration for this project comes from the concept of dualism, Yin and Yang, in ancient Chinese philosophy as well as the idea of MA in Japanese art and culture.

In Chinese cosmology, the universe is born out of a chaos of material energy ¹, which is categorized into the cycle of Yin and Yang. The beings and non-beings produce each other. These two opposite sides are possibly interconnected and complement each other ². Yin and Yang represent passive and active respectively, which exist in all forms of variation and difference in nature and world: female is Yin while the male is Yang, the growing wheat is Yang while the reaping wheat is Yin, eggshell is Yang while the yolk is Yin ¹, the morning fog is Yin while it is dissipated by the heat of the sun is Yang, the forest fire is Yang while the rainstorm extinguishes it is Yin ³. The Taoists suggest that the opposition of Yin and Yang unifies the harmony in nature. Yin and Yang not only can be found in nature, but they also exist in human bodies. Taoists believe

everything is part of the oneness of the universe, and there is no difference between the internal processes of the body and the external forces of nature ³. The idea of Yin and Yang from Taoism inspires us to rethink the relationship between the voids of social distancing with the internal processes in human bodies and minds.

In Japanese culture, the concept of MA describes the connection between positive and negative space. MA refers to the artistic interpretation of emptiness. It draws people's attention to the negative space, which helps to perceive the positive space. The empty space is often full of possibilities—for example, the artistic practices of calligraphy experiment with the concept of MA. Chinese and Japanese calligraphy not only focuses on the depiction of characters but also creates careful relationships between the forms of characters and the surrounding non-form. Calligraphy artists use the blankness to link forms and take the design of the void spaces into artistic consideration.

Volume of Voids implements the concept of MA and Yin Yang by rethinking the meanings of the space-between, the messages these silence spaces deliver, and how the voids influence the intricate networks of society and the internal processes in human bodies.

Related Artworks

Fine artists have explored the positive and negative spaces in their poetic artworks, for example, American photographer Ellen Garven's *Ambivalence* and English artist Rachel Whiteread's artworks *Ghost*.

In Ellen Garven's *Ambivalence* [see Figure 4], she photographed a set of prosthetic devices. These devices reflect their history of making and the patients' experiences ⁴. Ellen thinks the devices raise awareness of disability and its intimate relationship to all bodies ⁴. The grace of the forms, the devices' surfaces with textures of traces, and the way Ellen stage and photograph the devices make the still life monumental, which evoke audiences' feelings of loss and intimacy.



Figure 4. *Blue* ©Ellen Garvens.

English artist Rachel Whiteread visualizes the invisible space by “mummifying the air in the room” ⁵. In her work *Ghost*, she cast the interior of a Victorian rowhouse in plaster and reassemble the panels facing out towards the viewers. In Whiteread's words, the *ghost* causes “the viewers to become the wall” ⁶. She draws attention to the space and its inhabitants and connects objects with their surrounding area with personal stories. Her mausoleum-like work materializes the invisible spaces of everyday life powerfully and poetically.

Similar to these two artworks, *Volume of Voids* seeks to represent invisible spaces by giving a shape to the air. By employing computational design methodologies of data visualization, 3D fabrication, and volumetric capturing artistically, *Volume of Voids* distinguishes itself from fine art techniques explored previously. Generative art and computational design emphasize the fluidity and interchangeability of the voids, which reinterprets negative space in the context of the new media art practices.

Volume of Voids I

From Photogrammetry to 3D Fabrication

The computational design method for *Volume of Voids I* consist of three stages: collecting data, experimental visualization, and fabricating 3D data sculptures.

We set up different news-inspired scenes for capturing. For instance, one of our scenes is based on an ABC news report about people keeping social distance during line waiting at a cafe shop. This was staged during the pandemic and volumetrically captured to collect spatial information on the voids. Overall, we staged twelve different scenes and used photogrammetry techniques to capture each of them, generating point clouds of position data for the following stages of visualization and fabrication.

Data Visualization

The photogrammetry point cloud position (XYZ data) generates multiple boundary edge curves on the XY planes (see Figure 5). These curves create planar surfaces with corresponding position data on Z-axis.

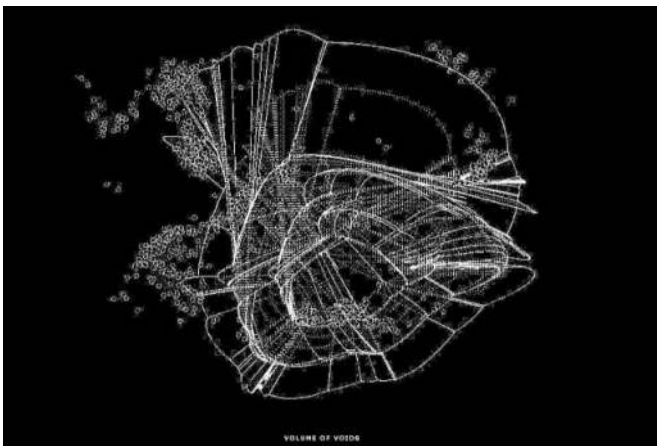


Figure 5. *Volume of Voids* software view of the sculpture skeleton (top view) generated by photogrammetry data, ©Weidi Zhang.

The planes with different heights are connected, lofted, and controlled by using algorithms (such as bezier and Perlin noise). These mathematical algorithms are added to Z-axis curves in order to add uncertainty to sculpture constructions (see Figure.6) to represent inherently unstable, fluid, and unpredictable invisible spaces between humans (see Figure.7).



Figure 6. software rendering of a sculpture ©Weidi Zhang.



Figure 7. software rendering of twelve sculptures ©Weidi Zhang.

Materialization of the visualization

To materialize the voids visualized, we then 3d printed these generative models as a series of physical artifacts (12 in total). The 3D fabrication of each sculpture of the generative 3d model is typically completed within 24 hours using PETG clear filament. We experimented with different materials and colors when fabricating the sculpture, including ABS filaments in opaque white color. During our experimentation process, we realized that rather than creating the monumental aesthetic of the voids, we tend to make the forms more transparent, light, and dynamic, which represents the accumulation of possibilities and imagination artistically. Therefore, we used the clear filament to transmit LED light, making it luminous (see Figure.8).

These luminous sculptures capture the historical moment of disconnection in a poetic and abstract way and emphasize the fragility of disconnections in social networking. The finished product measures approximately 7 to 8 inches in height and is mounted on 4-inch LED pedestals.

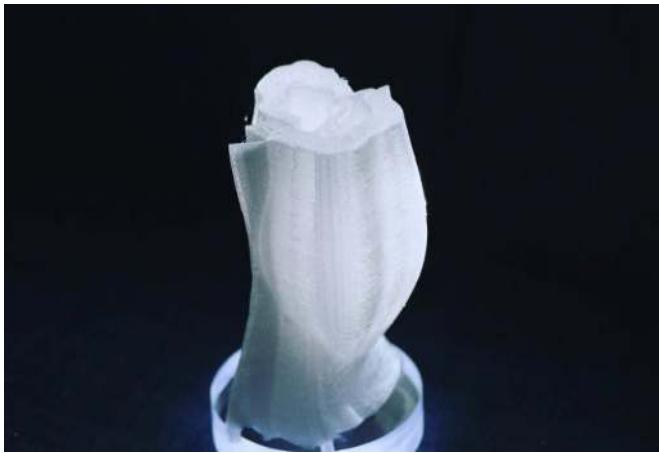


Figure 8. *Volume of Voids* 3D printed sculpture ©Weidi Zhang.

Vol II of Voids

After finishing the first phase of the *Volume of Voids*, our interest in visualizing the invisible and transforming it into an interactive experience motivated us to continue our artistic research on visualizing the mobility of voidness (see Figure.10).

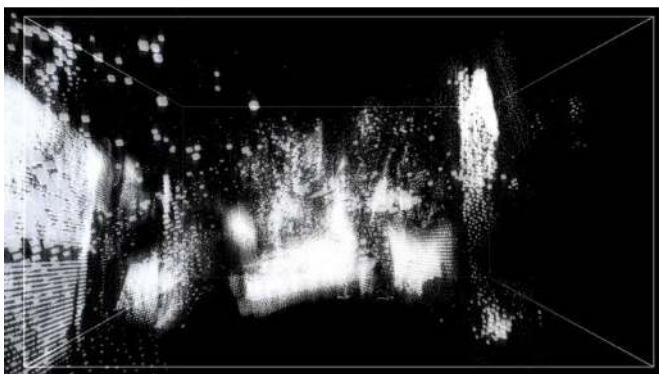


Figure 10. *Vol II of Voids* Visualization of mobile voids between two audiences ©Weidi Zhang and Shaoyu Su.

With the techniques of volumetric capturing, machine learning algorithms, and experimental visualization strategies, *Vol II of Voids* visualizes the ever-changing voids between people in real-time. Specifically, a 6-DOP volumetric capturing system fabricates the spatial literacy of reality in real time. In the new system, multiple layers of experimental visualization strategies, coupled with machine learning algorithms, can detect humans and generate real-time interactive voids between them.

Volumetric Capturing and Intelligent System Design

In order to capture the space between humans specifically, we utilized an intelligent system for human identification. Our system aims to recreate spatial reality

in a human-centric way. The system is realized through two stages of development (see Figure.11).

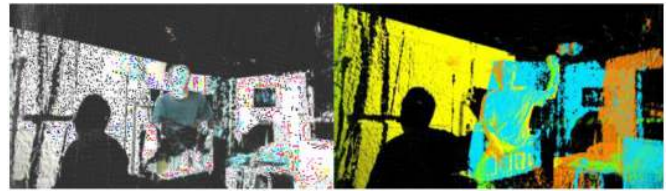


Figure.11. Color-based merged point cloud (left), color-coded merged point cloud from four LiDARs (right), ©Weidi Zhang and Shaoyu Su.

In the first step, we developed a ToF(time-of-flight)-based multi-LiDARs system for 3D data acquisition. (see Figure.12). With the technique of affine transformation and mapping, each adjacent pair of LiDARs are calibrated in the same matrix space as master and slave so there is no limitation on the total number of LiDARs being used. As a result, a daisy-chained LiDAR array is able to capture accurate, high-density 3D point clouds of the designated 3D space in 30FPS real-time. In the current phase of this project, we use four LiDARs for capturing the installation.



Figure 12. The volumetric capturing system utilized four lidar units ©Weidi Zhang and Shaoyu Su.

Following the first step of building a ToF-based multi-LiDAR system, we use and combine two machine learning algorithms to process the camera streaming on each LiDAR. We implement YOLACT++⁷ for real-time human identification in 2D and BackgroundMatting V2⁸ for real-time human keying into the Touchdesigner software environment. We translate 2D identifications received on texture buffers into 3D spatial data with OpenGL Shading Language, which runs on the GPU. Then we utilize the signed bounding boxes of humans to acquire accurate spatial relationships between the audiences.

There are inevitably interferences between the LiDAR units when they face each other. The following steps were taken to minimize that: 1. We applied genlock for hardware synchronization. 2. We programmed a denoise pattern as compensation using a GLSL pixel shader then

composited it with the texture buffer storing positions of the point cloud. Finally, color channels got aligned with depth channels.

Compared to the multi-RGBD cameras system, the LiDar system provides better fidelity and precision, even under poor illumination.

Experimental Visualization and Aesthetic Exploration

To represent the voids between audiences dynamically in real-time, we process the visualization by designing voxel grids, point clouds, and movements. The voids of the space between audiences are rendered as the following components:

The voidness between the audiences is calculated by the boolean operation between the volume of the detected humans and the total volume of the defined area. Therefore, the visualization is presented using 3D texture and compute shaders to translate space into a dynamic signed 3D voxel grid. We then calculate each work group's (on the compute shader buffer) local density of the point cloud and apply it to the global density. Inspired by cubist paintings in the 20th century, a vector field is represented by the white-colored voxels (cubes) indicating the relative movements by the distances between humans.

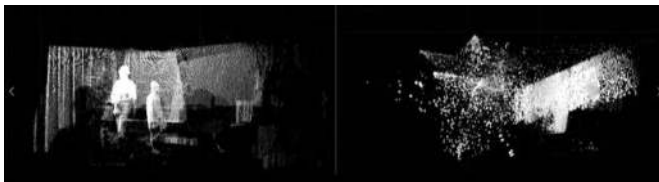


Figure.13. Point cloud of the audiences (left), visualization of the voidness (right), ©Weidi Zhang and Shaoyu Su.

The movements of point clouds illustrate the stability of voids. (see Figure.14) For example, when a certain number of the audience move fast together, their locomotion will be detected to activate the movements of point clouds. It is achieved by applying a Despiking algorithm and calculating the difference from the raw data. Thus, the voxels representing voids disperse and accumulate, flee and return, converge and explode, conceptually mimicking human social behaviors.

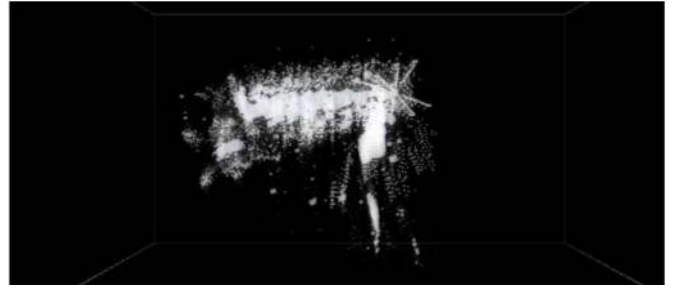


Figure 14. *Volume of Voids II*, visualization of the voids between two audiences ©Weidi Zhang and Shaoyu Su.

Sound Design and User Interaction

In the art installation (see Figure.15), audiences are captured by our 6-DOF volumetric capturing system in real-time. The visualization of the voids between audiences is presented on a LED screen set in the art installation. The audience's body movements will alter the visualizations in real-time and generate ever-changing fluid voids in the virtual space.

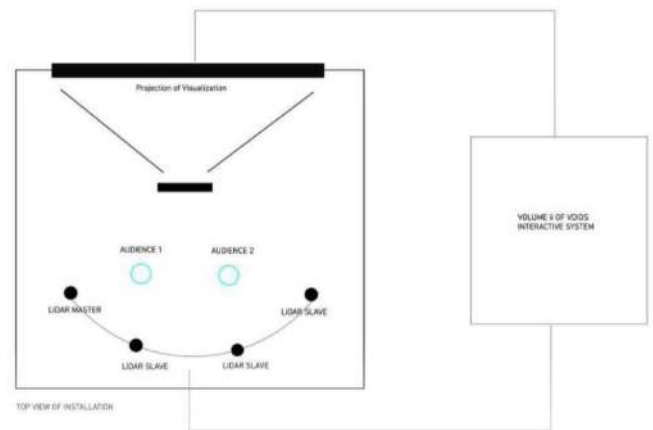


Figure 15. *Vol II of Voids* Installation Diagram ©Weidi Zhang and Shaoyu Su.

The background sound is non-interactive and looped in the art installation. We transform field recordings of cityscape sounds into abstract compositions through the technique of granular synth. Inspired by the musique concrete in the 20th century, Multilayered sound clips are dynamically organized in this composition to create an atmosphere of emptiness and transiency.

During the pandemic, our physical installations were canceled due to social distancing regulations. We presented this work in the virtual platform with documentation photos and videos. While the virtual exhibition is suitable for 3D-printed artifacts, it is not ideal for the interactive experience. In light of the fact that the pandemic regulations have been removed, we demonstrated our installation to the local community internally in our research lab space. It is evident that our

participants are interested in the visualization and engaged in the interaction during our demonstration. Rather than providing specific instructions, we encouraged our participants to move freely within the space and observe the responsive visualization on the screen. Within a few minutes of interacting, most participants establish a connection between their existence and the visualization they are producing. Additionally, the experience creates an interesting connection between participants, they are adjusting their positions in the space in order to capture the interesting spaces between them.

Future Direction

Presenting the voids as an interactive visualization for participants to perceive and building a collaborative empathetic experience for disequilibrium are our goals for this series of art experiments. This historical pandemic not only caused human suffering but also created new possibilities for healing and reconnection. These invisible spaces bring isolation but also unfold possibilities.

Through presenting this installation to the local communities and the online version to global communities, we are interested in developing this work further as an art experience using the augmented reality (AR) technique in a theatre setup. In the future, we will focus on the following developments: 1. We will investigate the real-time projection-based augmented reality system to present the visualization of voids as a performative element in space instead of showing the visualization directly on the LED screen. 2. We will further develop the visualization and redesign it to better fit the new format and medium.

Conclusion

This paper presents the conceptual background, technical implementation, aesthetic and design decisions, and future directions of *Volume of Voids*. This project consists of two artistic experiments: 1. Data-driven sculptures of the voids between humans, 2. Interactive visualization represents the voidness between participants.

Volume of Voids was initiated and developed during the Covid-19 pandemic when humans keep social distancing to avoid viral transmission in the air. The voids between humans form an evolving and unstable abstract volume.

According to Taoists, beings and non-beings produce each other. Humans' activities form the voids while the voids form the new relationships between humans. The disequilibrium caused the disconnection in the social network but popularizes interactive technology to reconnect humans in the virtual space.

Volume of voids emphasizes the value of artistic visualization to raise people's awareness of the possibilities invisible spaces offer, providing a critical response to human network transformation. Through data visualization and computational design, this work aims to provide a collective experience that emphasizes alienation between different beings and sustains our curiosity about the world, nature, and social relations.

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Authors Biographies

Dr. Weidi Zhang is a new media artist and researcher. Currently, she is an assistant professor at Arizona State University. Her interdisciplinary art and design research investigates A Speculative Assemblage at the intersection of immersive media design, experimental data visualization art, and interactive art. She holds her Ph.D. degree in Media Arts and Technology at the University of California, Santa Barbara.

Shaoyu Su is a new media artist, developer, cinematographer and curator. His artistic practices and research employ interdisciplinary methodologies from computer graphics, photography, physics and literature, investigating concepts about deep spacetime-mining: alternative projection from ancient history to the far future. From mid-2016 to present, Su has been working at the Immersive Media Lab, USC School of Cinematic Arts as Director of Technology, leading research and production in cinematic and generative XR and real-time animation.