Bridget Baird

Paper/Installation:
OBSTACLE/FLOW: interactive presence project

Topic: Art, Generative

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Pearson, Matt, "*Generative Art*", Manning Publications, Shelter Island, NY, 2011

www.generativeart.com

Abstract:

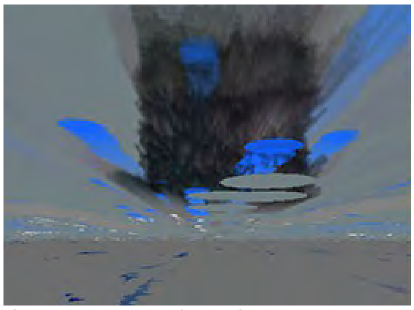
In this paper we will present the motivation and underlying research involved in the realization of our interactive collaboration, *Obstacle/Flow*. We will give an overview of the work's conceptual approach and describe the connections between the generative nature of the work and the interactive interface. We will also contextualize the work within a broader survey of related works including examples of fluid and water models, interactive sound installations and 3-dimensional (3D) dynamic terrain generation.

Obstacle/Flow's primary inspiration is the natural phenomena of *jökulhlaups*, the Icelandic term for glacier-burst. *Jökulhlaups* refers to a sudden flood-release of melt water from glaciers and ice sheets. This is realized within the work by generative elements that include: audio that sonifies invisible obstacles, small particles that aid in visualizing flow data, and exploding images of ice governed by random bursts of particles.

Random and changing variables of particle flow and obstacles create an unpredictable and dynamic audio/visual environment. Bursting ice imagery is able to dislodge the invisible sonic obstacles. As the user engages with the environment, she is gradually able to locate the obstacles. Sounds of flowing water are positioned in the stereophonic scene according to obstacle locations. These sounds are spectrally and dynamically processed so as to produce distinct sonic imagery for each obstacle. Within the virtual environment *Obstacle/Flow* creatively incorporates temperature, gravity, depth, turbulence, speed, drag, and burst force to create an immersive experience.

We present several potential future directions for *Obstacle/Flow* including additional planned interaction paradigms and user contributions to the environment. The development of *Obstacle/Flow* was supported by the Ammerman Center for Arts & Technology at Connecticut College.

Jökulsárlón, Iceland. 2011



Screen capture from Obstacle/Flow

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OBSTACLE/FLOW: Interactive Presence Project

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Abstract

In this paper we will present the motivation and underlying research involved in the realization of our collaboration, *Obstacle/Flow*. We will give an overview of the work's conceptual approach and describe the connections between the generative nature of the work and the interactive interface. We will also contextualize the work within a broader survey of related works including examples of fluid and water models and interactive audiovisual work.

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1. Background and Motivation

The authors have been working collaboratively on a number of interdisciplinary projects under the auspices of the Ammerman Center for Arts and Technology at Connecticut College (New London, CT, USA). The mission of the Center is to facilitate creative collaboration and experimental investigation at the intersections of Arts and Technology, forging interdisciplinary partnerships and creating opportunities for students and scholars to think outside of disciplinary boundaries.

Over the last ten years, the authors have worked on several interactive and generative audiovisual installation pieces featuring poetry, video processing, sound and audio processing, virtual reality exploration and intelligent agent-based software.

The current work developed from, and extended, a recent site-specific project by one of the authors that focused on connections between personal place-based narratives of Iceland citizens and the dynamic and unique landscape of that country. Struck by the ubiquity of ice-covered volcanoes that make the dynamic and unpredictable phenomena *Jökulhlaups* a common term of reference and experience, the authors sought to model and explore this powerful natural force.

To being with, we established a set of core guiding principles that would govern our investigations. These included:

1. A desire to connect the experience of this dynamic natural phenomena to identifiable behaviours within a virtual space, and
2. To develop agent-based models applied to generative visual art that are creatively inspired by glacial-burst motion behaviours, and
3. To iteratively develop and refine emergent visual behaviours that develop within our work and connect them to data-driven audio processing of natural sounds.

2. Dynamic Landscape: *Jökulhlaups* and Iceberg Flows

One of Iceland's many unique and fascinating features is that many of its volcanoes are covered with ice. Because of this, when volcanoes explode, the ensuing behaviour is mysterious and hard to predict. Ash and melt water form under the ice cap. After some amount of time, this mixture finds its way out of the ice cap (Figure 1), and the sudden release of force dramatically alters the landscape below. Even after the eruption, no one is quite sure what will happen next and in which direction the water will flow.

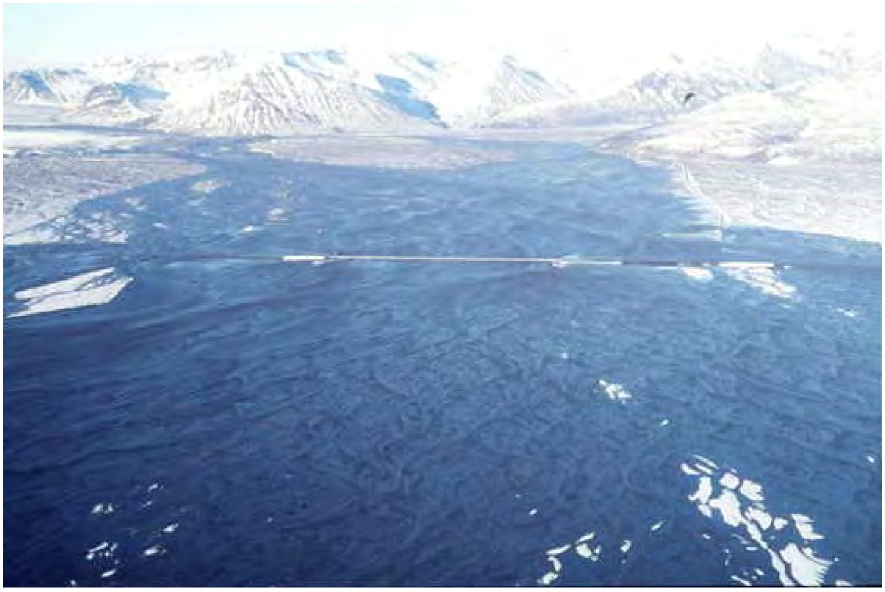

Figure 1. 1996 Iceland Jökulhlaup: subglacial eruption on the Vatnajökull ice sheet.

In addition to modelling the behaviour of *Jökulhlaups*, the authors were motivated by another common sight in Iceland — the small icebergs that break off from the ice caps during summer months and flow down rivers to the ocean, periodically running aground and colliding, and then clogging beaches until they melt or drift away (Figure 2). Within *Obstacle/Flow,* it was decided to use this iceberg spawning and lifecycle model as the inspiration for the physics-based obstacle interactions and collisions.

Figure 2. Ice released from glaciers, Jökulsarlon, Iceland 2010. Andrea Wollensak

3. Related Work – Inspiration

In addition to being inspired by the natural phenomena described above, *Obstacle/Flow*'s use of fluid dynamics, particle effects, interactive controls and audiovisual effects were influenced by both scientific and artistic models.

3.1 Fluid Dynamics

For *Obstacle/Flow*'s fluid dynamic behaviours and artistic representation, we were motivated both by recent development in software-based real-time fluid dynamic visual modelling as well as selected new media works featuring fluid elements.

Software fluid dynamic simulation has been driven in large part by developments in gaming and graphic processing unit (GPU) programming, for example Jos Stam's *Real-Time Fluid Dynamics for Games* paper based on Navier-Stokes equations which inspired Memo Atkin's open-source real-time fluid simulation library for Processing (Java) and openFrameworks (C++).

Artist Char Davies has created a number of immersive pieces featuring entrancing fluid textures including *Osmose* (1995). In *Stream* (1991, Figure 3), Ms. Davies made a series of computer-generated still images, produced by creating 3D models in virtual water-like space and then moving the computer's camera to capture the desired framing. In realizing Obstacle/Flow, we were inspired by the artistic use of fluid-based textures that Ms. Davies employed to dynamically enrich the synthetic landscape of virtual space.

Figure 3. Char Davies, Stream, 1991 digital print from The Interior Body Series

3.2 Particle Effects

Particle Effects have been used extensively for CGI and games to generate realistic explosions, trails, smoke and other dynamic transient effects. Particles are often combined with agent behaviours and simulations of physical forces. In *Obstacle/Flow*, particles interact with obstructions, are subject to physical forces and fluid simulation, and follow the contours of 3D-surfaces towards the viewer. We were inspired by artworks that contain playful uses of particles such as Camille Utterback's *Text Rain* (1999). Additionally, since we were using the software environment Processing, we carefully reviewed many of the tutorials, examples, and art work found in the Processing web site and exhibition area [1].

3.3 Interactive Features and Audio

In the past, the authors have collaborated on a number of interactive audiovisual virtual environments and installations. For ***Obstacle/Flow,*** we decided to allow the user to trigger Jökulhlaups and to trigger the creation of randomly placed obstacles in the virtual landscape.

In previous works the authors have examined the ability of the user to control the interaction through gestures and movements (in works such as DEEP/PLACE [2], Red Ball [3], virtual conducting [4], dance pedagogy [5]). Various input devices have been used in these works, including gloves, sensors, Kinect, motion capture and even haptic. *Obstacle/Flow* represents the first time the authors have used the Processing java-based programming framework for rendering the visual environment and handling user interactions, incorporating them more closely with the random and generative processes used to spawn entities and influence their behaviour.

The authors have long been interested in the interaction of the various senses in determining a user experience. In particular, audio has occupied a significant place in these considerations. Thus, for example, the authors have investigated the role of audio in way-finding [6], on how the conductor's motions influence ensemble performances [4], in the design of interactive multi-modal objects and the effects of multi-modal interactions in virtual environments [7, 8, 9, 10], and in cross-modal generative presentations [11, 12].

4. Generative Art Processes

A high-level taxonomy of Generative Art [13] typically distinguishes three major categories (Figure 4). ***Ordered*** approaches use deterministic and/or rule-based procedures as creative methodology, and include data visualization mappings of data sets to visual structure and parameters. ***Disordered*** approaches make use of non-deterministic randomness, probability and distributions to control and influence actions. ***Complex*** approaches contain both ordered and disordered processes and are typically characterized by the potential for unexpected emergent behaviour, such as many of the notable objects of Chaos Theory and aggregate agent behaviours such as swarming and flocking. Artwork that is *interactive* offers additional possibilities for allowing user input and gestures to influence these generational processes.

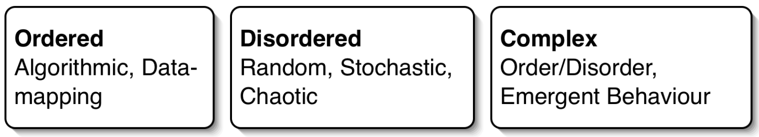

Figure 4. High-Level Taxonomy of Generative Art Processes

Obstacle/Flow makes use of these approaches as follows:

- Ordered physical simulation of fluid dynamics (producing current in which the particles move).
- Random parameters used to place particles and construct obstacles in the flow.
- Random associations between sonic resources, parameters and the obstacles.
- Ordered and chaotic behaviour to produce the obstacles, resulting in emergent forms.
- Probabilistic methods that govern the spawning of particles and add noise and jitter to their movement (in addition to the physical forces acting on them).
- Interactive user interventions to spawn Jökulhlaups burst behaviour, associated ice-oriented imagery and to generate new obstacles.

5. High-Level Obstacle/Flow Structure

Figure 5 shows the high-level structure of the *Obstacle/Flow* environment.

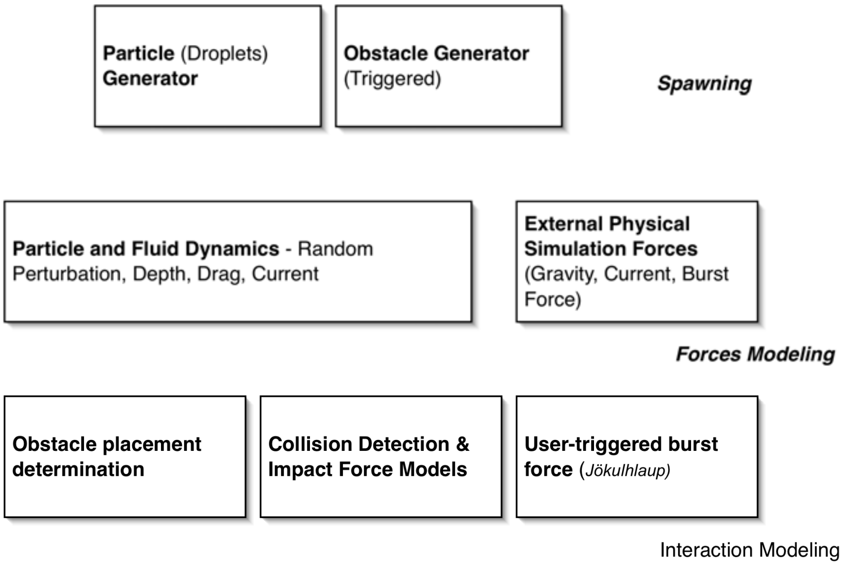

Figure 5. High-Level Organization of Obstacle/Flow Simulation models

The three main layers of the *Obstacle/Flow* architecture can be characterized as:

- *Spawning*—rules that govern the creation and initial characteristics of particles as well as the rules that govern the creation and initial characteristics of obstacles.
- *Forces Modeling*—the forces that act on the particles can be broken down further into the dynamic ways in which particles respond to their environment, the movement and simulation of the fluid, and the presence of physical forces.
- *Interaction Modeling*—the ways in which user-controlled interventions (burst behaviour and obstacle creation) and entity interactions (collisions, bursts, exiting the boundaries of the virtual environment) are realized.

6. Generative Components

The 3D environment represents the flow of water in a river, punctuated by Jökulhlaups, and populated with ice obstacles. The entire environment is also informed by audio that is associated with the ambient environment and localized to, and influenced by, the ice obstacles. Droplets of water advance toward the user, leaving a memory trail; as they encounter the ice obstacles their flow is diverted. The force of droplets hitting individual obstacles causes the obstacles to move downstream. Bursts of Jökulhlaups cause ice particles to be released; Jökulhlaups are also characterized by images that fill the screen and then explode.

Figure 6 shows both the droplets and the presence of several ice obstacles. The user's point of view is from a position in the river, considerably downstream from where the droplets start their journey. The user is able to control certain aspects of the environment, for example, triggering the occurrence of a Jökulhlaup, optionally constrained to appear in certain zones of the screen.

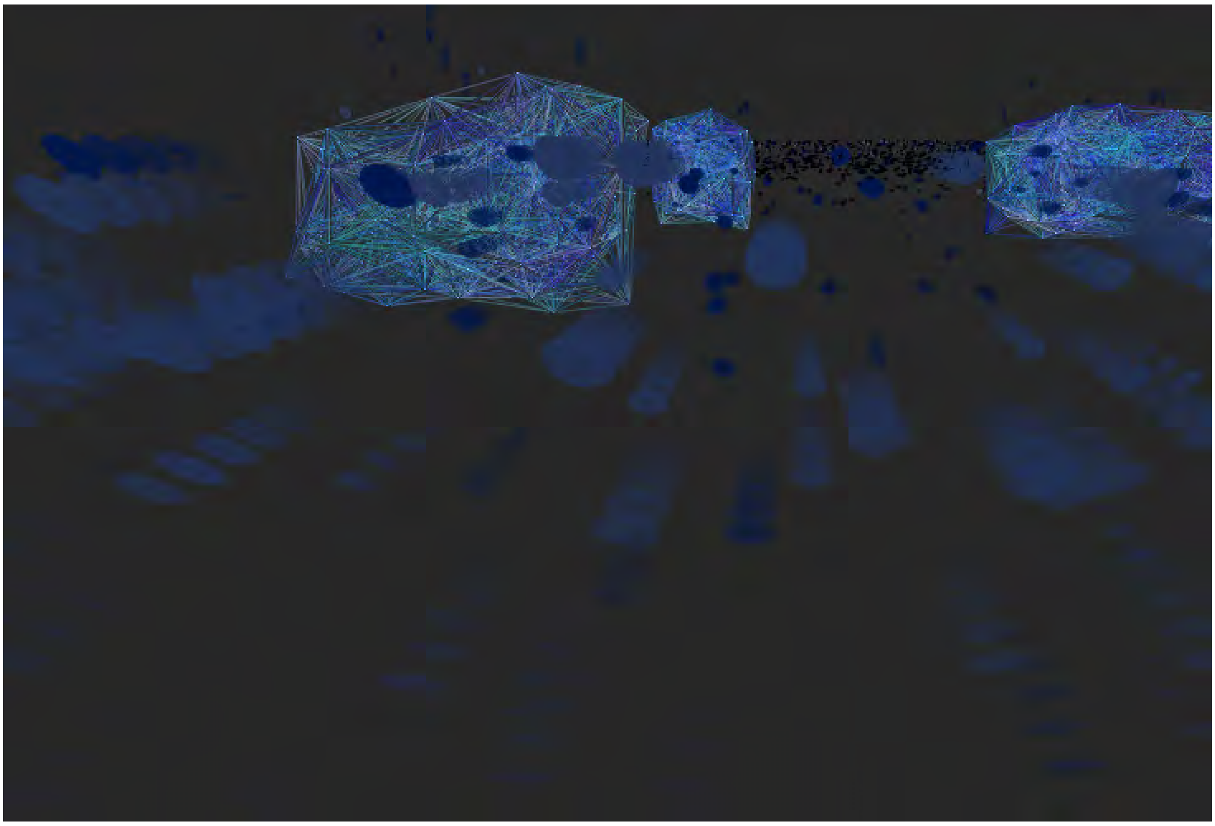

Figure 6. Image capture of Obstacle/Flow virtual environment showing three obstacles and droplet particles moving towards the viewer

6.1 Water and Ice

The two main generative components are the spawning of droplet particles and the spawning of ice obstacles. Droplets are represented by ellipses with randomized dimensions and randomly determined locations in 3D space. The initial placement of droplets is weighted so that there is a greater probability of originating near the center of the virtual space. The size of each droplet is also determined by a random procedure and constrained within a specific range. The droplets are released in a systematic fashion. When a Jökulhlaup occurs, bursts of additional droplets are formed in a similar fashion. Their density is probabilistically determined to reflect the bursting action of a Jökulhlaup.

Ice obstacles are also spawned in a generative fashion. They are constructed by (1) randomly placing primary points in a box, (2) randomly selecting additional points near the surface, (3) moving points along a line joining the pairs of points and then (4) connecting pairs of primary points that are within a select distance from each other. The constantly changing locations and their periodic random movement to other locations create dynamic fluid behavior that evokes both the rigid and the fluid characteristics of melting ice. The dimensions of the obstacle, the color of lines joining primary pairs of points and the location of the obstacle are also random, within certain parameters controlled by the user.

6.2 Physics of Environment: Flow, Terrain and Obstacles

Principles of physics ground the behavior of both obstacles and droplets. Just as the idea of Jökulhlaups inspired the creation of the piece of generative art, the principles of physics provide a foundation for the environment. Both of these ideas are crucial to the vision of the collaborators and provide a touchstone for the artistic components.

Particle and fluid dynamics control some aspects of the flow of droplets. Gravity, current and the terrain affect the speed at which the particles flow; droplets are also subject to perturbations and to friction. The closer the particles are to the river bed the stronger the drag on them. The depth of the particles above the river bed influences their transparency. As each particle descends the river, it leaves a disappearing trail of previous positions. Droplets also interact with the obstacles. As droplets hit an obstacle they either pass through (if their size is small enough) or they are forced to go up along the surface of the obstacle, travel across the top and then descend on the other side to the depth originally assigned to them. At this point their velocity starts from 0 and progresses according to gravity and the terrain.

The ice obstacles are also grounded in principles of physics. As droplets hit an obstacle they begin to cause it to move down the river. The number of droplets needed to move the obstacle is a function of the size of the obstacle (which is randomly generated). Then as an ice obstacle begins to move it obeys the laws of gravity and the terrain beneath it, picking up speed as it descends. Figure 7 shows an ice obstacle about to move beyond the viewer.

6.3 Obstacles and Sound Field

The sound system consists of a layered architecture to model water and ice-based phenomena specifically during Jökulhlaups. The sounds are produced in four separate layers, each serving a different purpose.

The first layer consists of continual ambient sounds. These form the substrate of the soundscape and mostly consist of natural sounds. Accompanying the continual sounds are rare ambient sounds that have starting times triggered by Jökulhlaups. These represent large-scale, but rare events, such as eruptions and displacement of large bodies of ice. Their presence is correlated to the overall water activity.

The third layer consists of localized sounds organized in a generative sense with each sound being driven by the properties of the visual obstacles. In this layer, each obstacle sound is composed of many overlapping sound grains whose density, volume and location are controlled by the location of the obstacles and their proximity to the viewer. For example, figure 7 below shows an obstacle about to pass the viewer and the localized sound for that obstacle will reinforce that proximity. In order to enrich the sonic scene and make it more accessible to the viewer, obstacle sounds are designed to have differentiable sound textures.

The sound grains are of varying length and different for each obstacle. They are organized on-the-fly to depict the intensity of the flow of water as experienced by its associated obstacle. In addition to the three general parameters for each obstacle sound, the grains that make up the sound are also internally randomized to obtain a range of gain and pan values around their target values. Similar to the third layer, sounds in the fourth layer are controlled by the location of the visual obstacles and proximity to the viewer, but in this case these affect the sound filtering parameters. The sounds in this layer are filtered abstract, noise-like sounds. Time-varying filters allow spectral modifications to take different forms according to the obstacles' properties.

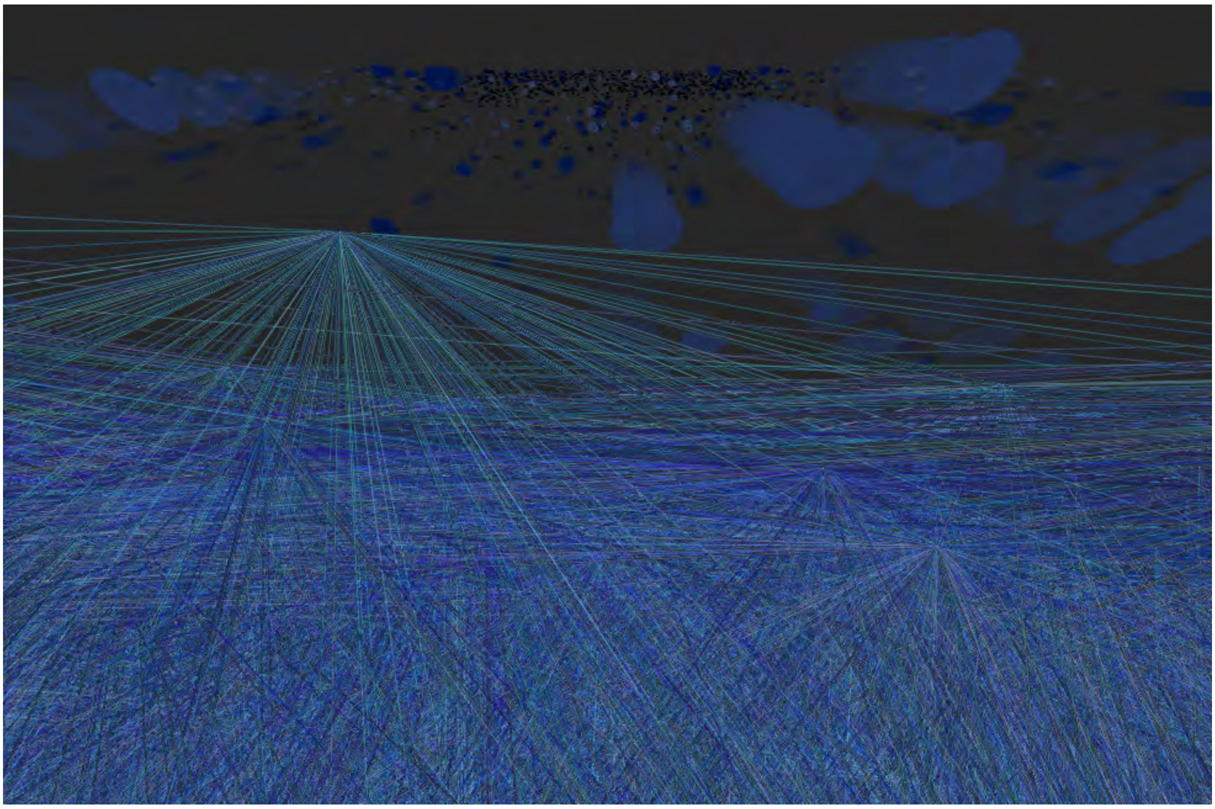

Figure 7. Obstacle form leaving screen

6.4 Jökulhlaups

The user is able to cause a Jökulhlaup with a key press. When this occurs there is a burst of ice particles at the top of the screen. In addition, to help depict the explosive nature of this event, an image related to such an event is randomly chosen from a collection and it appears on the screen, filling it up. Then, very quickly, the image explodes into a 3D world, moves toward the viewer and disappears. The image is divided into blocks of pixels, each colored with the original tint and whose z-position is determined by the brightness of the pixels (thanks to Daniel Shiffman for this idea). In Figure 8 below this phenomenon is illustrated.

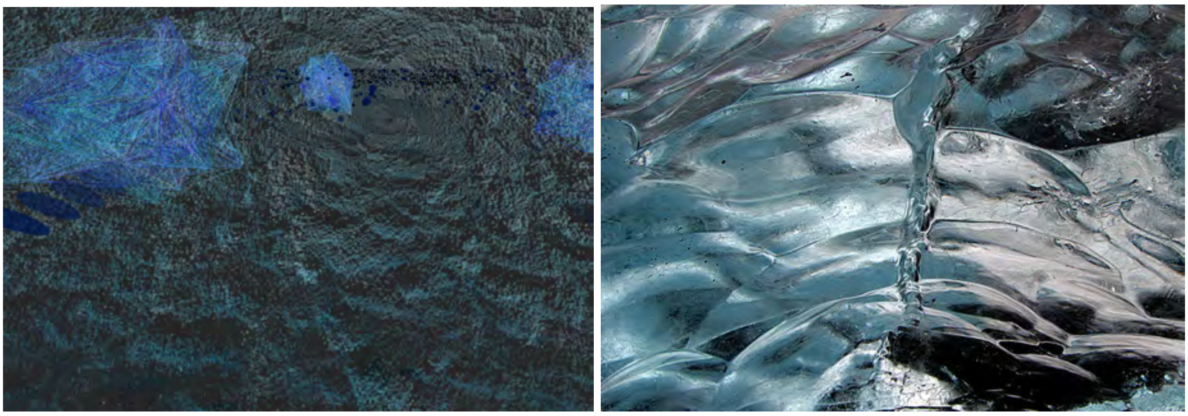

Figure 8. Jökulhlaup image burst and source image

7. Summary and Future Directions

This collaborative piece of generative art is grounded in natural phenomena and natural sounds. But then it uses the flexibility of the digital to create a more randomized, unpredictable and abstract interpretation of these natural phenomena.

Additional plans for this environment are to give the user more control over the speed and density of the droplets as well as more control over the ice obstacles' size and behaviour. Future plans include developing this project as a projected video installation where the user is able to control the events through gestures tracked by devices, such as the Kinect, that conveniently help acquire depth and image information. In addition, the viewer would herself become an obstacle and droplets would move around her. Another version could involve 3D viewing and spatialized audio to increase user immersion.

Acknowledgement
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