Flowspace – A Hybrid Ecosystem

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ABSTRACT

In this paper an audio-visual installation is discussed, which combines interactive, immersive and generative elements. After introducing some of the challenges in the field of Generative Art and placing the work within its research context, conceptual reflections are made about the spatial, behavioural, perceptual and social issues that are raised within the entire installation. A discussion about the artistic content follows, focussing on the scenography and on working with flocking algorithms in general, before addressing three specific pieces realised for the exhibition. Next the technical implementation for both hard- and software are detailed before the idea of a hybrid ecosystem gets discussed and further developments outlined.

Keywords

Generative Art, Interactive Environment, Immersive Installation, Swarm Simulation, Hybrid Ecosystem

1. INTRODUCTION

This publication describes an installative artwork entitled "Flowspace" that was realised by the authors and shown to the public in the context of a thematic exhibition about sound, space and virtuality [7]. The installation creates an interactive, immersive, and generative environment for audiovisual compositions that are controlled via simulations of swarm behaviour. As such, the installation situates itself within the fields of Generative Art and Artificial Life. One of the most fundamental challenges in Generative Art relates to the establishment of meaningful and traceable mapping relationships between the underlying algorithmic processes and the resulting aesthetic output [2]. "Flowspace" shifts the focus away from the mapping issue in favour of an approach that places a stronger emphasis on the customization of the generative algorithms themselves in order to match a particular artistic goal [10]. The issue of interaction with complex autonomous systems constitutes another fundamental challenge in Generative Art. “Flowspace” approaches this challenge by providing an interaction model that is based on multiple levels of immediacy in control and feedback. "Flowspace" employs generative algorithms not only for the creation of aesthetic feedback but also to establish coherence among spatial, perceptual, behavioural and social phenomena that manifest themselves within the installation. We employ the term hybrid ecosystem to describe the characteristics of such an installative environment. This designation is related to the term hybrid ecology as it has been coined by Crabtree and Rodden [5], since both of them refer to the creation of collaborative situations in mixed reality environments. Rising interest in ecological approaches to musical composition [12,6] and recent examples in installation art [1,11] are a strong indication that this approach indeed constitutes a promising direction for Interactive Media and Generative Art.

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2. BACKGROUND

The installative artwork "Flowspace" represents a tangible result from two consecutive research projects that are conducted at the Institute for Computer Music and Sound Technology of the Zurich University of the Arts. The first project is entitled ISO – Interactive Swarm Orchestra – and its successor project is entitled ISS – Interactive Swarm Space. Both projects explore strategies for interrelating swarm simulations with the interactive and aesthetic properties of an artwork [2,4]. Furthermore, the projects try to promote artistic applications of swarm simulations by developing open-source tools in software and hardware that aid in the realisation of swarm based artworks [3,13].

3. CONCEPT

The realisation of “Flowspace” reflects our intention to create a hybrid environment in which the natural and simulated properties and behaviours of the space and its inhabitants overlap and interrelate. This situation creates an immersive experience that involves spatial, behavioural, perceptual and social aspects, which are described in more detail in the following sections.

3.1. Spatial Aspects

The architectural structure of “Flowspace” is realised in the shape of a Dodecahedron [see figure 1]. The shape of the installation conforms to the characteristics of the installation's generative feedback [see section 5.1.]. As a result, the architecture of the installation supports the blending of physical and virtual space. The simulation space overlaps with the installation space that surrounds the visitors. In addition, the simulation space is mapped onto a two-dimensional segment of the Dodecahedron surface and forms part of the installation's interface. This enables the visitors to experience a spatial immersion within the virtual swarm and to simultaneously assume a juxtaposed position outside of the swarm.

3.2. Behavioural Aspects

In “Flowspace”, the behaviours of visitors and the swarm agents affect each other on multiple levels that differ in immediacy and spatial extension. By touching the surface of the interface, visitors can directly manipulate the positions of particular agents. Other agents subsequently respond to these changes. These interrelating agent behaviours transform the visitors' interactions from an initially local and immediate

effect into an element in the emergent dynamics of the installation's audiovisual compositions. Different combinations of properties exist for swarm simulation and audiovisual processes and are organized as discrete states in a finite state machine. The selection of the states is controlled by the visitors' long term accumulated activities. The installation's characteristics as a hybrid ecosystem results from the interrelations among the activities of its natural and virtual inhabitants that occur on several temporal, spatial and causal levels. The simplicity and immediacy of the interface's physical manipulation and its subsequent effect on the installation's responses provides a natural form of interaction, which helps to balance the visitors' intuition, familiarity, curiosity and surprise.

3.3. Perceptual Aspects

“Flowspace” provides feedback through the modalities of touch, hearing, and vision. Correlations among these modalities shape the aesthetic experience, direct the visitors' attention and influence the traceability of the installation's behaviours. In “Flowspace”, the audiovisual compositions and the visual and tactile feedback of the interface are all linked via the swarm simulation. Again, multiple levels of immediacy exist in the creation of the installation's output. In order of decreasing immediacy, they range from the very basic tactile experience from touching the interface, the presence of bright circles underneath the visitors' fingers, the abstract graphical depictions of the swarm simulation on the interface, to the presentation of the audiovisual compositions themselves [see figures 2-4]. In addition, these perceptual phenomena also differ with respect to their spatial characteristics. The most immediate feedback of the visitors' hand movements is localized on the surface of the interface. The presentation of the audiovisual compositions is spatially distributed and forms part of the visitors' immersive experience.

3.4. Social Aspects

In “Flowspace”, the installation space and its interface are sufficiently large to allow several people to become involved at the same time. Due to the installation's relatively open forms of interaction and exploration, different social situations may appear. Some social settings resemble performance situations when individual visitors become performers that actively interact with the interface while the remaining visitors act as an audience. Other social settings are more collaborative in that most of the visitors try to collectively affect the installation's behaviour. The fact that various social situations appear and disappear forms part of the installation's characteristics as a hybrid environment.

4. ART WORKS

The “Flowspace” installation was part of an exhibition entitled “Milieux Sonores” that was shown in two separate occasions: in the Kunstraum Walcheturm in Zürich in 2009 and in the Gray Area Foundations for the Arts in San Francisco in 2010.

4.1. Scenography

The scenographical integration of the installation into the environment of the exhibition was realized in close collaboration with the curator Marcus Maeder. The crystal-like characteristics of the Dodecahedron shape [see figure 1] is partially resumed in the form of black wooden shards that gradually transform the exhibition space into the spatial situation of the installation.

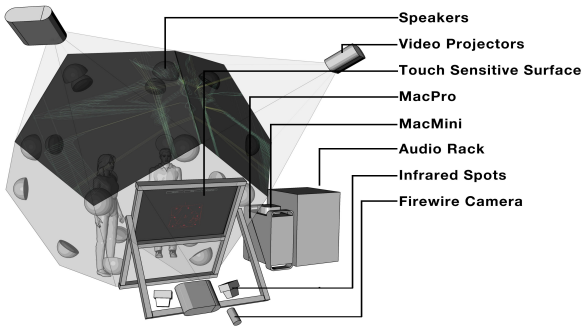

Figure 1: Schematic Representation of the Installation

4.2. Swarm-based Artworks

The installation forms an environment for the interaction with three different swarm-based artworks. The swarm simulations are displayed as simple graphical renderings on the surface of the interface. Visual compositions are projected as panoramic imagery on two pentagonal surfaces above the interface. Musical compositions are spatialised via speakers that completely surround the visitors. The detailed implementation of the swarm simulations and the audio generation mechanisms is described in a different publication [10].

4.2.1. Impacts

Starting from a strongly interactive premise, the flocking algorithm in this piece explores the possibility of hierarchical relationships between several flocks, similar to the interdependence within an ecosystem or food chain. There are three types of entities present in the "Impacts" model: the first type of agent is the attractor. Its behaviour is fully dependent on the visitor’s action since it can't move by itself but is displaced by the visitor's touch. The agents of the secondary swarm influence their own kind and react to the attraction forces of the first swarm. They serve as attractors to the agents within the third swarm. The behaviours of the agents within the second and third swarms are parameterized in such a manner as to create very dynamic motion patterns. The music consists of a background layer of Ambisonic ambience of the Notre Dame cathedral in Paris. The individual collisions between agents in the swarm simulation trigger piano samples on impact and a granular echo of the same pitch when an escape point is reached. In the true spirit of emergent structures, the mixture of all of these events alone is what generates the characteristic texture of sounds. The user interaction controls the choice of pitches: the higher the level of interaction, the more active the

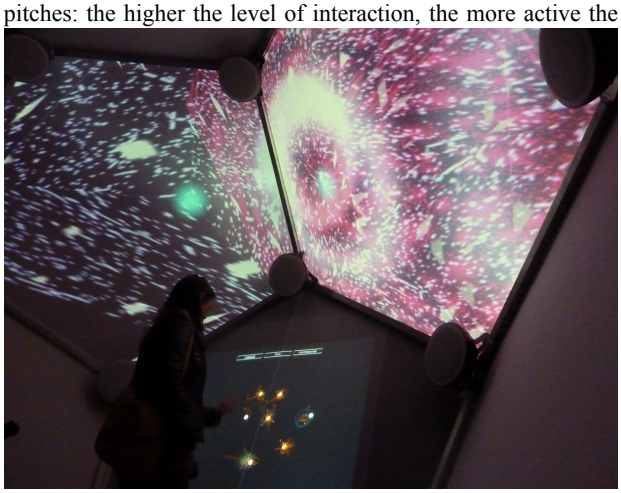

Figure 2: The “Impacts” Piece

entire swarm simulation is and the richer and more dissonant the pitch-sets become. Since the note-events are spatialised according to the position of the generating agents, these pitch clusters are perceivable as being located in certain sectors of the surround field. The visualisation re-interprets the idea of impacts and escape points by tracing these points into a Delaunay triangulation and showing growing concentric circles around the points of impact [see figure 2].

4.2.2. Flow

The "Flow" piece exploits the existence of periodically recurring events within the simulation in order to generate rhythmical structures in the acoustic and visual output. These recurring events originate from repeated changes in the neighbourhood relationships between two different swarms: a predominantly static swarm whose agents are attached to the visitors' touch positions and a highly dynamic swarm, that traverses the static swarm. As long as the visitors do not move the static agents, the dynamic agents settle into cyclic trajectories that cause them to periodically approach the static agents and thereby trigger the generation of sound grains whose content is created via additive synthesis. The duration and acoustic spatialisation of the grains and the frequencies of the oscillators is controlled by the dynamic agents' position, velocity and jerk. Accordingly, the musical motif is dominated by stable rhythmic patterns whereas the texture of the individual sounds constantly varies. The visual output renders the static agents as a mesh of lines that interconnect the agents' positions [see figure 3]. The discrepancy between the large scale repetitions and local variations in the trajectories of the dynamic agents is visually emphasized by drawing the trajectories as thin lines that rapidly widen into series of spokes according to the agents' jerk.

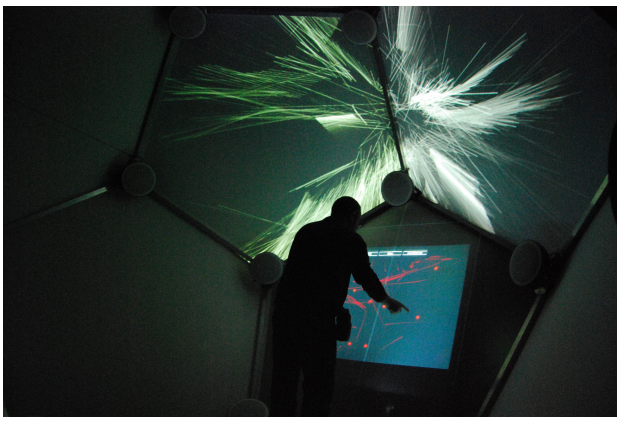

Figure 3: The "Flow" Piece

4.2.3. Membranes

The "Membranes" piece employs models of physical springs for both swarm simulation and sound synthesis in order to create a perceptual and aesthetic proximity between the two. The simulation consists of two types of swarms: a static swarm that is directly manipulated by the visitors, and a dynamic swarm whose agents behave as end points of interconnected springs. Depending on the distance between spring agents, new springs are created or old springs are destroyed. The static agents repel the spring agents. Whenever the visitors move the static agents, the previously established network of interconnected springs is disrupted. The musical algorithm employs a non-linear model of a physical spring for sound synthesis [8]. Each of these acoustic springs corresponds to a spring in the swarm simulation. The movement of the spring agents drives the excitement of the acoustic springs. Whenever an agent spring is created or destroyed, a strong excitement is applied to the acoustic spring. The location of the acoustic spring in the sound-field is determined by the centre position of the spring agent. The musical output consists of a slowly undulating texture that is occasionally interrupted by discrete and loud sounds that result from the creation and destruction of springs. The visual output displays the connectivity of the springs' mesh as stacks of triangles and the small fluctuations of the springs' mass points as interconnected lines the follow the points' trajectories [see figure 4].

Figure 4: The "Membranes" Piece

5. IMPLEMENTATION

The implementation of the "Flowspace" installation relies on hard- and software tools that have been developed in the context of the ISO/ISS research projects.

5.1. Hardware Setup

The structure of the installation [see figure 1] is built from an aluminium frame that is about 4.2 meter in diameter and has the shape of a Dodecahedron. This shape was initially chosen because of its suitability for positioning loudspeakers in a spherical arrangement for three-dimensional ambisonic sound projection [9]. Later on, the frame was extended for video rear projection by covering its surface with projection screens. The latest improvement consists of the integration of a tactile surface into one of the Dodecahedron's pentagonal faces. The video projection setup consists of three ultra-short throw projectors. The projection surface covers three neighbouring pentagonal surfaces. The two upper surfaces are used for a panoramic video projection of the visual compositions and the lower surface is used for the interface display. The touch interface is based on video tracking with rear diffuse infrared illumination.

5.2. Software Setup

The software part of the installation consists of a number of applications for swarm simulation, finger tracking, audio and video generation and installation state control. Many of the applications rely on a set of open source C++ libraries that were developed as part of the ISO project. These so-called "ISO" libraries [3] are available for both Mac OS X and Linux operating systems and can be downloaded from the project website [13]. The swarm simulations for the three different audiovisual compositions are implemented with the "ISO Flock" library. Several audio applications generate the acoustic output of the installation. The analysis of the swarm data and the control of sound generation and spatialisation is implemented differently by the three artworks. The audio for

"Impacts" is created in Max/MSP whereas "Flow" and "Membranes" employ sound synthesis algorithms implemented with the "ISO Synth" library. Two of the three applications for the visual rendering of the swarm simulations are implemented using the "ISO Visual" library. The visualisation for “Impacts” as well as the finger tracking and the master state control software are implemented in openFrameworks [14]. The master state control software is in charge of managing the different installation states and acts as a communications hub between the simulations, tracking software and audio and video engines. Inter-application communication is based on the OpenSoundControl protocol.

6. RESULTS AND DISCUSSION

The installation "Flowspace" creates an environment in which natural and artificial entities and their respective physical and virtual surroundings merge into a hybrid ecosystem. Based on the positive feedback that we have received from visitors during the exhibition of the installation, we believe that this approach is successful in creating an engaging experience for the visitors. We attribute the installation's positive reception to several aspects that are inherently part of our notion of a hybrid ecosystem. Firstly, the installation provides an environment that encourages intuitive and explorative forms of interaction. We have emphasized this aspect by allowing the visitors to engage with the installation and to experience its reactions via several levels of immediacy and across different modalities. Secondly, the installation's spatial, behavioural and perceptual properties are correlated via a single underlying swarm model and thereby allow the visitors to experience the installation as a coherent whole. Thirdly, the ecosystem characteristics of the installation offers the visitors the ability to become involved on perceptual, behavioral and social levels. When this involvement is sufficiently intense, each of these levels achieves immersive qualities.

7. CONCLUSIONS AND OUTLOOK

We believe that the notion of a hybrid ecosystem can inform artistic approaches in creating interactive and immersive environments. The realization of such an environment is an inherently interdisciplinary endeavour that combines knowhow and methods from various fields such as Artificial Live, Generative Art, Interaction Design, and Scenography. Since ecological approaches in Generative Art are relatively new, a vast range of scientific questions and artistic challenges exists that should be addressed. In particular, we would like to explore the following aspects that up to now have played only a marginal role in our work: In “Flowspace”, the capabilities of the swarm simulations and the characteristics of the audiovisual feedback mechanisms are predefined and never change during an exhibition. Because of this, the short-term behaviour of “Flowspace” is surprising and engaging for visitors, but its long-term behaviour tends to be repetitive and predictable. It would be interesting to augment the installation with the capability to undergo long-term changes through learning or evolution. The aesthetics of the audiovisual compositions in “Flowspace” are largely defined by its authors. Visitors can explore these compositions within relatively narrow aesthetic boundaries. It could provide additional interest if the role of the visitor's creative contribution is strengthened by expanding the range of interaction-based effects both with respect to the compositions and the underlying simulations. Finally and most importantly, we believe that the hybrid ecosystem approach provides an excellent context to experiment with rarely used modalities and unconventional interfaces. In “Flowspace”, the usage of sonic, visual and tactile feedback and its combination with a touch sensitive surface is interesting mainly due their correlation via a common generative mechanism. Other than that, neither the interface nor the feedback modalities are very unconventional. We are currently in the process of designing different types of interfaces that are specifically adapted to interaction with a spatially distributed and highly dynamic entity such as a simulated swarm. These new interfaces will play a dual role as control interface and display of swarm activities and will employ the same modalities for input and output in order to bridge the gap between the physical and virtual aspects of the hybrid ecosystem.

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