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STOCOS – Dance in a Synergistic Environment

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At the core of Stocos lies the notion of a synergistic environment whose physical and virtual characteristics are interrelated via simulations of natural phenomena. The environment is populated by natural and artificial entities whose mutual perception and engagement alternate between different forms of autonomy and dependency. The choreographic structure of the performance emerges from these changing behavioral relationships.

Stocos is centered on the analysis and development of gestural relationships between dancers, music and simulated entities. The activities of the dancers, music and visuals relate to each other via underlying processes of brownian movement and flocking behavior. A dense network of mutual influences emerges that establishes coherency among the spatial, perceptional and behavioral properties of its natural and artificial participants.

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STOCOS
Dance in a Synergistic Environment

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Abstract

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1. Introduction and Concept

Stocos represents the third part of a trilogy of dance works that experiment with gesture as a means to connect bodily movement to sound synthesis and sound spatialization. Stocos extends this focus by exploring not only relations between gestures of the human body and music but also relations between simulation based synthetic gestures and video imagery. The simulation based approach also serves as a unifying principle that underlies all the activities on stage. Accordingly, the natural and artificial characteristics of the stage arise from the interplay of algorithmic processes and thereby form a coherent and emergent whole, which we name a synergistic environment.

1.1. Gesture

Our usage of the term "gesture" derives its meaning from the performance of instrumental music. The musical gesture is a functional and expressive body movement that triggers the emission of sound. It has maintained a prominent role as an imaginary and metaphorical aspect in purely electronic music, in that it allows the composer and audience to relate an acoustic perception to a performative experience. Gestures in Stocos play a very prominent role as aesthetic and expressive elements of the performance as well as an algorithmic aspect of the underlying simulations. The emphasis on musical gesture becomes visible in the gestural repertoire of the dancers and the video imagery that emphasize qualities such as energy, continuity, and rhythmicity. The biophysical notion of gesture as "… an energy-motion trajectory which excites the sounding body.." [1] renders the generation and response to gestures accessible to physics based simulations. This algorithmic approach allows us to treat natural and simulated gestures as intrinsic aspects of the generative processes that give rise to synthetic sounds and imagery

1.2. Synergistic Space

The term "synergy" refers to the cooperative activities of several components of a system, which give rise to a property or behavior that is unachievable by each component alone [2]. In Stocos, the complexity of the performance arises from the interrelated activities of the dancers, the simulation based entities, and the generative music and imagery. We employ the term "synergistic space" to emphasize the fact that the appearance and behavior within the performance space is not dominated by one individual activity but rather results from the relations and feedback mechanisms that connect all activities. It is the changing characteristics of these relationships that form the choreographic structure of the performance.

1.3. Relationships

The relationships among the activities on stage encompass both spontaneous and improvised interactions as well as pre-determined forms of synchronization. To discuss these interactions in more detail, we distinguish the following three types of relationships: algorithmic relationships deal with interdependencies on the level of the generative mechanisms that form the basis of the performance, behavioral relationships address higher levels of interaction that involve aspects of agency and autonomy among the performers, spatial relationships concern issues of blending the natural and artificial characteristics of the stage by creating spatial correspondences.

1.3.1. Algorithmic Relationship

The simulations that underly the activities on stage are based on algorithms for modelling the movements of large groups of simple entities in space, in particular, the brownian movement of microscopic particles and the coherent movement of flocking animals. These algorithms form the main generators for creating the acoustic and visual feedback in the piece and they also control aspects of the dancers' movements. Due to the fact, that most aspects of the piece are based on identical algorithms, the performance is characterized by an algorithmic consistency.

Figure 1: Rain Scene. The swarm simulation behaves similar to rain that is perturbed by gusts of wind.

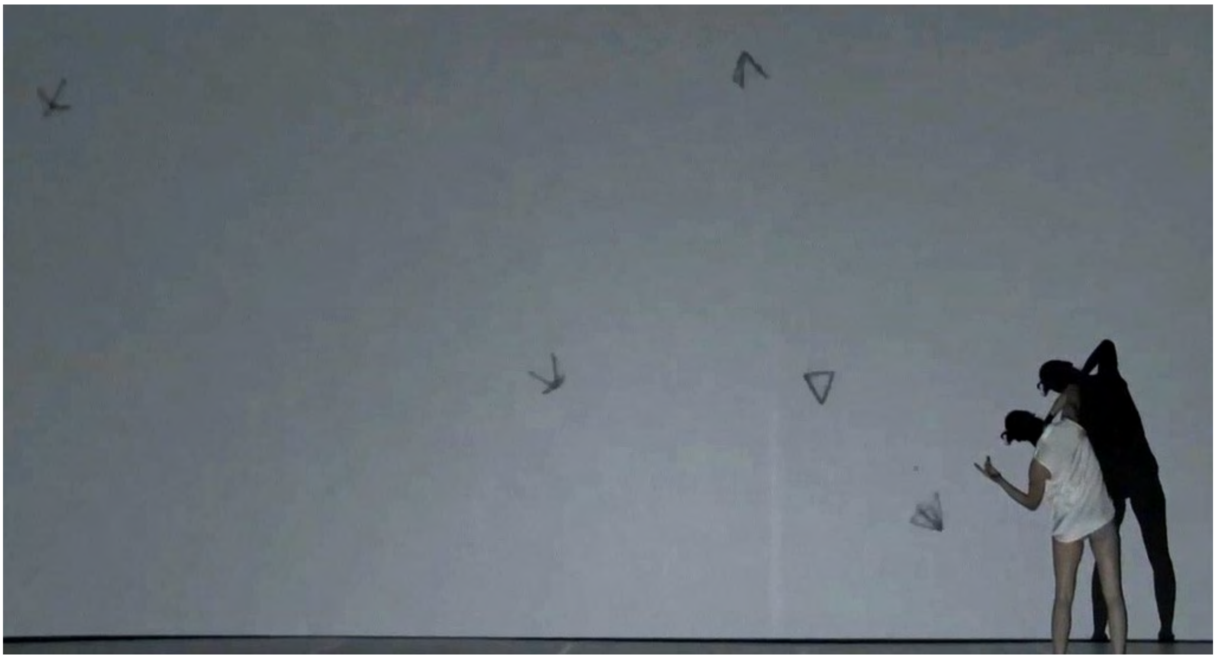

Figure 2: Five Elements Scene. A swarm that consists of five agents only engages into a improvised "duet" with a dancer.

The sound synthesis method, which is based on Dynamic Stochastic Synthesis (see section 2.5), directly creates the waveforms from the spatial movements of the simulated entities. The simulated behaviors of these entities are also executed by the human dancers, who engage during parts of the performance in synchronized activities and brownian movements. On the scale of the entire performance, pre-composed changes of the simulation parameters control both the musical and choreographic development.

1.3.2. Behavioral Relationships

The stage is inhabited both by human dancers and simulated entities, both of which possess a behavioral repertoire and the capability to perceive and respond to each other. With respect to the simulated entities, the perception based behavioral correspondence relies on computer vision software that detects the dancers' positions, contours and movements (see section 2.2) as well as simulation mechanisms that relate this tracking information to changes in the agents' number, behaviors and properties (see section 2.3). The human dancers can perceive the simulated agents via their influence on the generative creation of music and visuals. Most of the behavioral relationships throughout the performance involve spontaneous and improvised forms of interactions between dancers, swarm simulations, music and visuals. Depending on the complexity of the simulation, the agents either possess very little autonomy and behave like a physical phenomena that can be directly controlled by the dancers (see figure 1), or the agents maintain a high degree of autonomy and thereby act more akin to improvisation partners (see figure 2). Due to the simulation's influence on the generation of music and imagery, the agents also act as mediators between the dancers' physical movements and the audiovisual content of the piece. The dancers' role in the creation of the music depends on the degree of the agents' autonomy. If the agents possess very little autonomy, the dancer's bodies act as musical instruments that trigger an immediate sonification. In case of highly autonomous agents however, it is the agents themselves that act as musicians who loosely relate to the dancer's activities.

1.3.3. Spatial Relations

The appearance of the stage manifests itself via an acoustic and visual merging of physical space and simulation space. This merging is achieved by aligning the spatial characteristics of the dancers or the stage with the spatial characteristics of the simulation. The alignment includes both the spatial mapping of the video tracking based information and the spatial projection of music and imagery into the performance space. The musical composition is realized as an acoustic space that surrounds performers and audience. In addition, the stage is divided into distinct acoustic regions that allow the dancers to chose and modulate different sounds based on their position in space. The projections of the visuals are superimposed with the stage floor, the stage background and the dancers' bodies. As a projection on the entire stage, the video image creates an immersive and responsive visual environment that supersedes the visual appearance of the physical space and the dancers (see figure 3). As a stage projection within the vicinity of the dancers, the video image coalesces into clearly confined shapes that appear as visual counterparts to the dancers (see figure 4). By aligning simulation space and body space, the video image is projected solely on the dancer's body. In this situation, video imagery and the dancer's physical body merges into a single entity whose appearance possesses both natural and artificial properties (see figure 5).

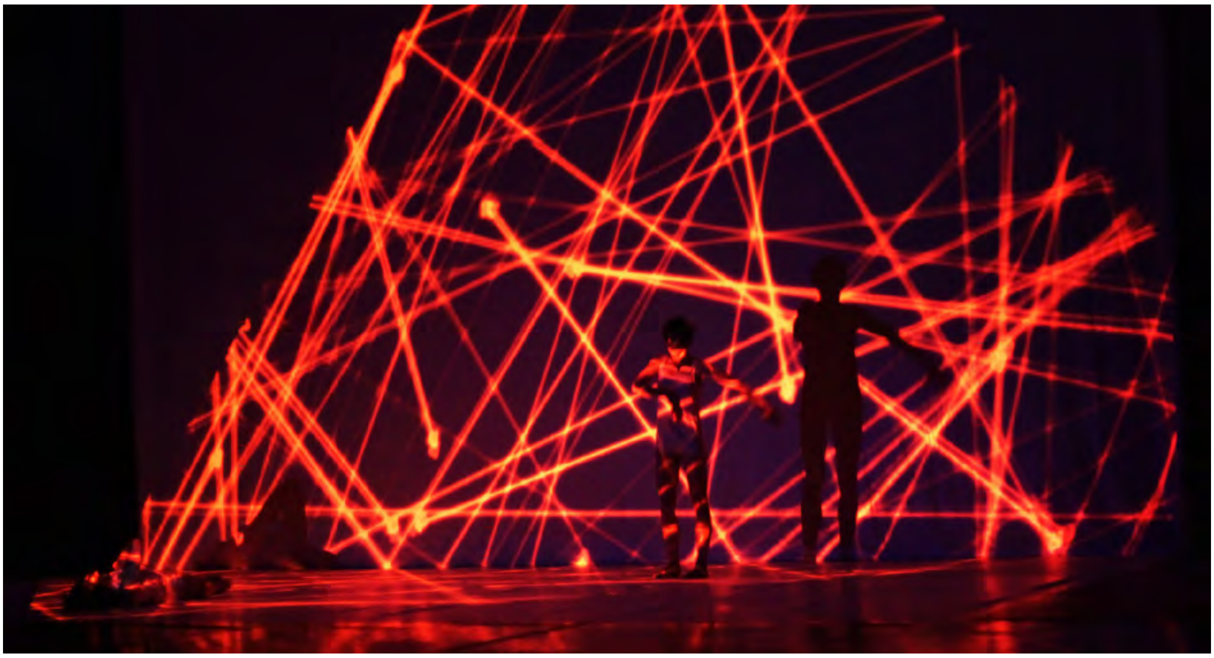

Figure 3: Plane Scene. The swarm's visualization moves within a rotating space that supercedes the physical appearance of the stage.

Figure 4: Contours Scene. The swarm creates afterimages of the dancers' body postures.

Figure 5: Blood Scene. The appearance of blood vessel like patterns on a dancer is caused by a swarm whose movement and appearance is confined to the dancer's body.

2. Realization and Implementation

Stocos has been developed throughout three residencies in 2011 as a collaborative work between the choreographer and dancer Muriel Romero and the two authors of this publication. The realization of the piece has been characterized by an iterative approach in which concept formation, technical development, audiovisual creation and choreographic experimentation continually informed each other. For instance, most of the customizations of the swarm simulations have originated from choreographic ideas of relating the dancer's movements to visual and acoustic changes that propagate through space. Fortunately, the residency situation enabled us to quickly evaluate even the most sketchy of ideas in a real stage situation. This allowed the creation of the piece to progress in a very exploratory fashion without a need to prematurely focus on preconceived decisions. It is this open minded and experimental situation that proved to be most fruitful for combining ideas from contemporary dance with generative music and art.

2.1. Stage Setup

The visual appearance of the stage is dominated by two white rectangular regions, that lie next to each other and delineate the horizontal and vertical extensions of the performance space (see figure 6). The dancers' activities and the video projection are confined to this rectangular regions. The video image is projected by two beamers that are located in front of the stage and above the stage. These beamers are aligned to match the white rectangular regions and to create a spatial continuity between the horizontal and vertical sections of the video images.

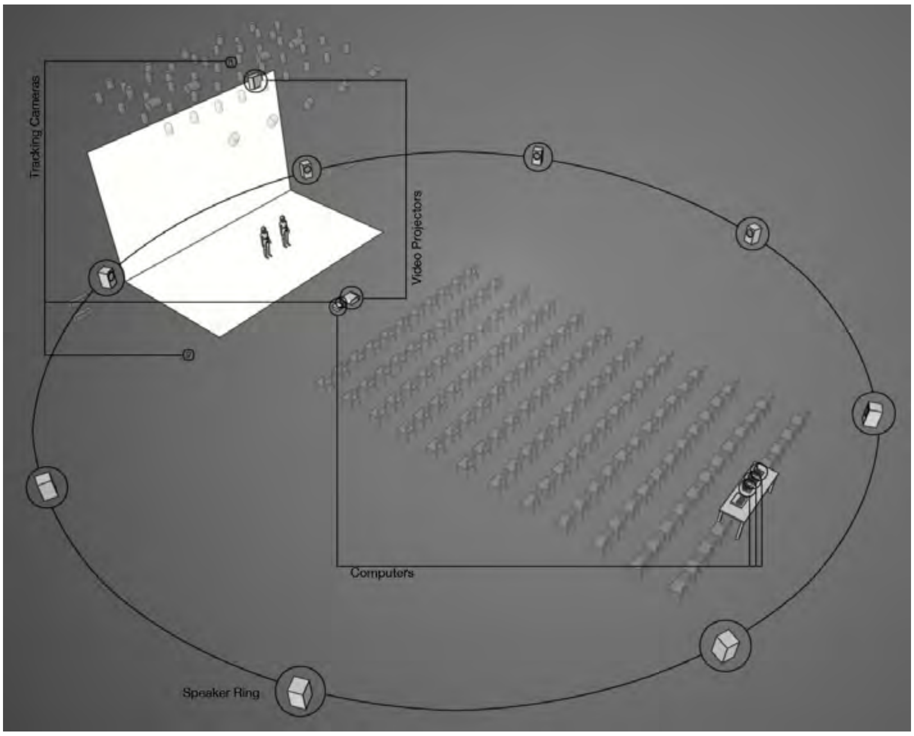

Figure 6: Stage Setup. A graphical depiction of the stage situation showing the white rectangular projection surfaces, light setup, video projectors, tracking cameras, octophonic speaker ring and computers.

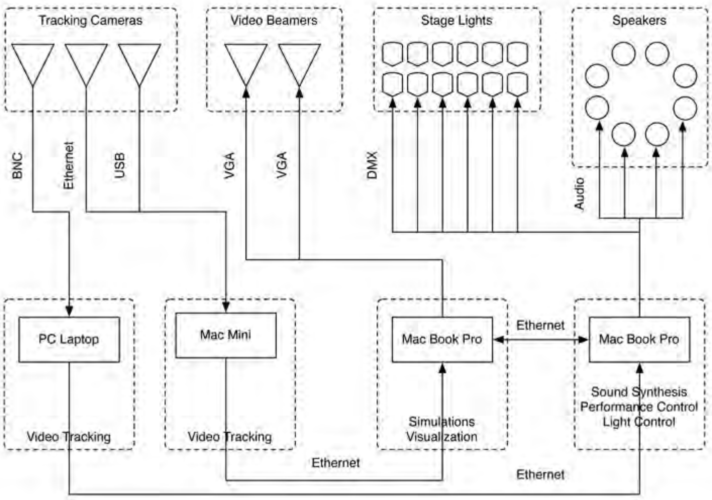

Figure 7: Communication Setup. A schematic depiction of the computers' tasks and communication with the light setup, video projectors, tracking cameras and speakers.

The audio setup consists of an octophonic speaker ring that surrounds the stage and audience space. This speaker ring provides the means to spatialize audio within a horizontal plane. The dancer's activities are tracked via three video cameras that are located on the ground in front of the stage, on the ceiling above the stage and at an elevated ground position on the front left side of the stage. The different characteristics of these cameras and their different points of view provide the means to quickly and accurately detect the dancers' positions, postures and movements on stage (see section 2.2).

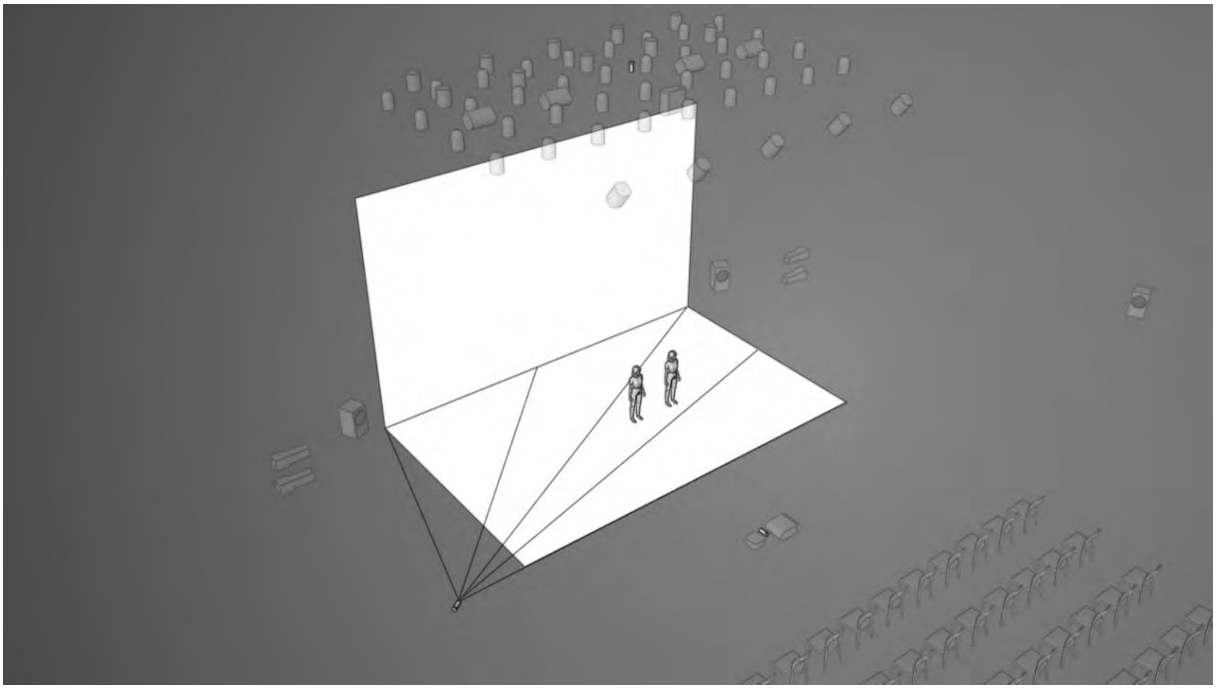

Figure 8: Tracking Regions. The stage is divided into several tracking regions that are associated to different sounds.

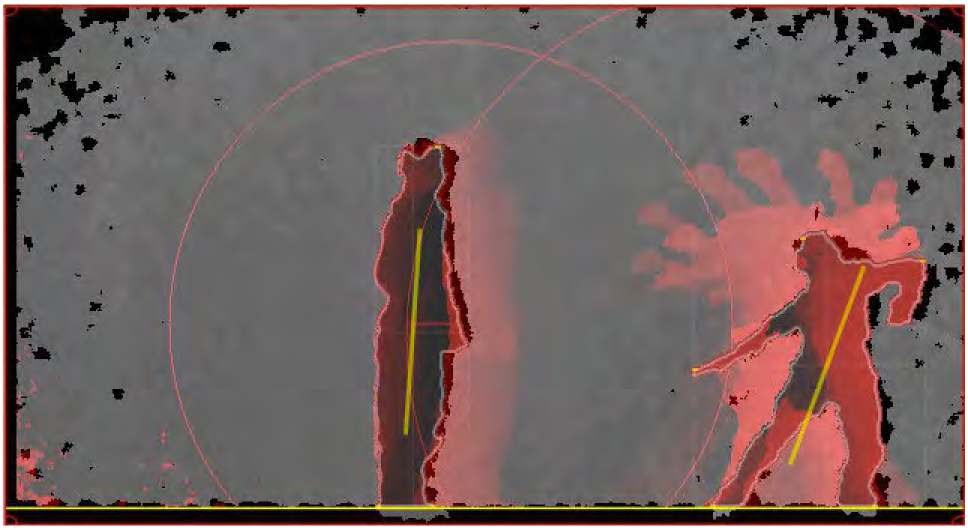

Figure 9: Tracking Software. A custom developed tracking software detects the dancers' positions (grey bounding boxes), postures (yellow direction lines), contours (grey silhouettes) and movements (red circles and gradients).

The computer-setup for the performance consists of four machines that share the computational load for handling the simulations, video tracking, image rendering, audio generation and light control. These computers synchronize their activities and exchange messages via a local network (see figure 7).

2.2. Video Tracking

Two different types of video tracking systems are employed during the performance. For those sections of the performance during which the dancer's movements directly affect the life generated synthetic sounds, an analogue video camera in conjunction with the Eyecon video tracking software and the Supercollider programming environment [3] is used to provide a low latency movement detection. In this situation, the stage is divided into distinct regions, that are associated with different sounds (see figure 8). These sounds are triggered and modulated via the dancers' movements in space (see section 2.5). This system is also used for a very immediate control of simulated agents, such as the agents' creation or destruction via discrete dance movements or the agents' freezing and unfreezing via tracking movement thresholds.

Spatially more intricate interactions between the dancers and the simulation based entities rely on a tracking software that has been custom developed in C++ by one of the authors and that provides more extensive albeit slower tracking information about the dancers' positions, postures, contours and movements (see figure 9). This software acquires a video image from a ceiling mounted digital camera and a distance image by a Kinect camera that is located in front of the stage. The tracking data is sent to the simulation software. Tracked movement and position information controls the creation, location and speed of simulated agents that are hidden to the audience but that can be perceived by the other agents. Tracked contour information serves to manipulate spatial structures within the simulation space. Many of the swarms' behaviors that have been specifically developed for the performance deal with perceiving and responding to these tracking based spatial structures.

2.3. Simulation

The computer simulations that have been developed by the authors for this piece model the movements of large groups of simple entities in space, in particular, the brownian movement of microscopic particles and the coherent movement of flocking animals. The implementation of these simulations is based on a C++ simulation library that has been developed by one of the authors as part of a research project about swarm based music and art [4][5]. One of the main benefits of this simulation library is its ability to enable the creation of highly customized swarm simulations that can be extended and modified during runtime. These simulations can easily interact with other software due to their OSC based control and communication mechanisms.

In the case of Stocos, the behavior and visualization of the simulations change fundamentally throughout the piece. These changes are synchronized with the musical composition via OSC commands that are sent from a Supercollider based program to the simulation and visualization software. Several agent behaviors have been specifically designed for this piece. Most of the new behaviors deal with the capability of the agents to respond to the presence of the dancers. Agent creation and destruction behaviors serve to change the number of simulated agents depending on the dancer's movements. In most cases, no movement causes the destruction of agents whereas large movement triggers the creation of agents. Other behaviors cause the agents to experience forces of attraction and repulsion in relation to the dancers' body contours. The creation of tangential forces causes agents to follow the body contours. Attraction forces pull agents towards particular features of the body contours such as the tip of the head or the center of the fastest moving body part.

The simulations that have been created for the performance differ with respect to the number of swarms and the number and type of agent behaviors. Simulations that implement only tracking based behaviors are highly responsive and predictable. They therefore tend to resemble physical phenomena that can be directly manipulated by the dancers. At the other extreme are simulation that combine tracking based behaviors with typical swarm behaviors that control interactions among the agents themselves. These simulations exhibit a much higher degree of behavioral diversity and complexity and their response to the dancers is less predictable. In this case, the simulated agents participate in the performance as autonomous artificial dancers.

2.4. Visual Rendering

The visualization of the swarm simulations is implemented in C++ and employs fairly simple OpenGL based rendering. Throughout all the renderings, the agents themselves are either hidden or depicted as small solid bodies such as spheres or pyramids whose orientation is derived from the velocity of the agents. Agent trajectories are visualized as trails by drawing line segments that sequentially connect previous agent positions. Some visual diversity is achieved by rendering to multiple textures, which are then modified via image post-processing and finally blended together. Most of the visual diversity results from the influence of the agent behaviors on the spatial distribution and dynamics of the agent trails. This emphasis on agent behavior as a main source of visual diversity represents a gestural approach to visualization that draws inspiration from the role of musical gestures in shaping an acoustic result. In order to preserve the continuity of the simulation space when projecting the visualization onto the vertical and horizontal surfaces of the stage, the final rendering is split into two partial images that can be independently aligned for the two video projectors. To further control the overlapping of the projected video image with the stage setup and the dancers, the tracked contours of the dancers are used to create grayscale images. These images serve as alpha channels that fully or partially mask those parts of the projected video image that lie outside of the dancers' bodies. To achieve an accurate alignment of these masks with the dancers' physical positions, the offset and scaling of the mapping from tracking space to visualization space is calibrated at different depths of the stage.

2.5. Sound Synthesis and Music

The music of the piece combines life generated and precomposed acoustic material. This material is synthetically generated via a method of sound synthesis entitled Dynamic Stochastic Synthesis. This method has initially been devised by Iannis Xenakis [6][7] and employs simulated brownian movements as a stochastic mechanism to modify individual digital samples and thereby directly manipulate the sound pressure curve of an audio waveform. According to this method, the waveform is polygonized via a number of breakpoints (see figure 10). Each of these breakpoints is constantly perturbed by two random walks that control the amplitude and duration of the waveform. The values generated by the random walks are delimited by so called mirror barriers.

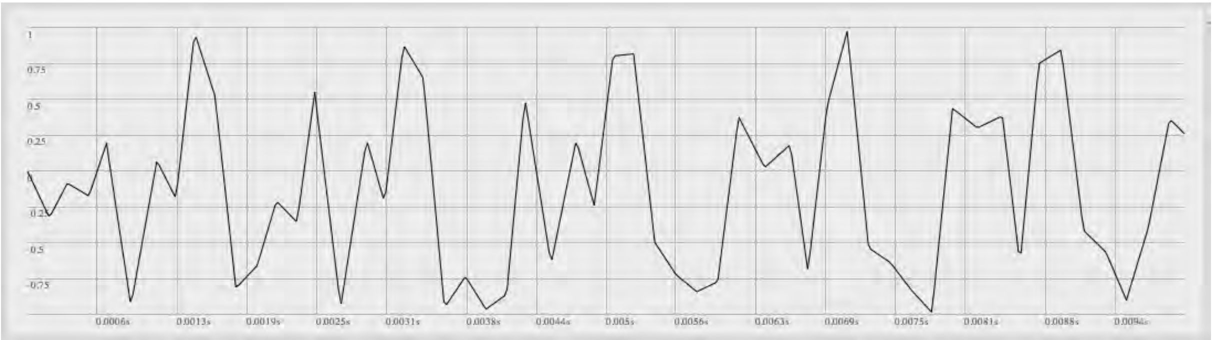

Figure 10: Dynamic Stochastic Synthesis. Time domain plot of a waveform's that has been created via Dynamic Stochastic Synthesis.

For Stocos, the method of Dynamic Stochastic Synthesis has been implemented in the Supercollider programming environment by one of the authors. The implementation was necessary because the unit generators that implement this method of sound synthesis and that form part of the standard Supercollider environment suffer from several simplifications that limit their flexibility. Our implementation of Dynamic Stochastic Synthesis has been specifically customized and extended for the performance.

On an algorithmic level, the constraints on the simulated brownian movements that give rise to the synthesized sounds are modified by the activity of the simulated agents. Each agent is coupled to one stochastic synthesizer via a variety of relationships. One relationship maps an agent's vertical position to the position of the synthesis mirror barriers. Another relationship employs the similarity among the agents' velocities to control the step size of the synthesis random walks. A third relationship connects the spatial trajectories of the agents to the spatialization of the synthesized sounds via the octophonic speaker ring.

Another extension of the Dynamic Stochastic Synthesis model that has been created for Stocos allows the dancers to interactively control the synthesis algorithm. As a result, the process of sound synthesis and the spatial projection of the resulting sounds is tightly intertwined with the dancers' activities.

Finally, the compositional structure of the music is generated via temporal patterns that also affect the properties and visual rendering of the swarm simulation. This creates a feedback loop that in turn affects the stochastic synthesis.

2.5. Dance

The dancers' activities form an integral part within the network of relationships that underly the generative creation of music and imagery. The simulation based approach in the piece is reflected in the development of their movements. During highly formalized sections of the choreography, the dancers organize their spatial movements and gestural patterns strictly according to algorithmic rules that are derived from the simulation of brownian movement. These random walks are used by the dancers to "walk" among the different parts that comprise previously composed dance variations and thereby give rise to reverberations of the original choreographic structure. Both of the dancers employ different random walks, which results in two quasi similar movement patterns. The algorithmic procedures that are followed by the dancers have been created in Supercollider.

For their improvised movements, the dancers heavily relate to the behaviors of the simulated entities that manifest themselves in the changing acoustic and visual properties of the stage. Depending on the characteristics of the simulation, dancers and simulated entities relate to each other differently. Simulations that mimic the behavior of physical phenomena respond very directly and predictably to the activities of the dancers. These simulations allow the dancers to amplify the spatial extension, duration and intensity of their movements. Those simulations that model highly autonomous agents respond to the dancers activities in less predictable ways. In these situations, the human dancers relate to the agents as artificial dancers. Depending on the quickness and strength with which the simulation responds to the human dancers, these artificial dancers act as improvisation partners or independent soloists.

The dancers' presence and activities play an important role for the creation of the music. Throughout most of the piece, it is via the dancers influence on the behavior of the swarm simulation that they indirectly affect the creation of the music. In this situation, the dancers' musical role resembles that of a conductor, who tries to control a more or less compliant orchestra. During other sections of the performance, the swarm simulation cedes control of the music entirely to the dancers. In these situations, the dancers' gestures are directly linked to sound synthesis. The dancer's bodies become musical instruments and their gestures become musical gestures. In combination with the segmentation of the stage into different acoustic regions, the dancers' movements through space change the characteristics of their "instrument" bodies and thereby reveal new acoustic qualities of their gestures.

2.6. Choreography and Composition

Due to the synergistic characteristics of the performance, it is the interrelationships and feedback loops between dancers, swarm simulations, music and imagery that shape most of the choreographic content of the piece. The dramaturgy of the performance, on the other hand, follows a pre-determined structure that is tightly associated with the musical composition of the piece. The progression of the composition not only controls the music but also modifies the properties of the simulation and its visualization. Accordingly, the algorithmic, behavioral and spatial relationships of the synergistic space undergo a precisely timed progression of changes and therefore are part of the global compositional structure of the performance.

3. Conclusions

The realization of Stocos was motivated by our curiosity whether ideas from algorithmic composition and generative art can be transferred to contemporary dance and vice versa. In particular, we were hoping that by sharing and interrelating the same generative processes among dance, music and imagery, the piece would exhibit a high degree of aesthetic coherence and dynamic synchronicity rather than drift apart into individual parts that compete for the audience's attention. The notion of musical gesture that played a central role in the previous two pieces provided a very fruitful context for the creation of the current work. The phenomena of a moving body whose energy trajectory triggers and modifies perceivable phenomena is very well suited to link algorithmic abstractions with a performative experience that is very familiar to both the dancers and the audience. The decision to employ simulations of brownian motion and swarm behavior is based on this gestural focus of the piece.

The extended period of time that all the participants could work together turned out to be extremely important for the development of the piece. Due to the trans-disciplinary and experimental setup of this collaboration, an explorative and non-sequential approach to the development and evaluation of conceptual, aesthetic and technical ideas was essential to discover the potentials and pitfalls of the approach. Some of these pitfalls are common to all combinations of improvisation and technical development, in that the practicability to quickly experiment with new ideas are very different between the participants. Another challenge concerns the possibility and necessity to preserve felicitous surprises that occasionally turn up during collective experimentation. Especially when finalizing a piece, creativity can suffer from the fact that most of the work tends to get consumed in these preservation efforts. In the final version of the piece, almost all of the pre-determined changes in the global development of the performance have originated from such preserved lucky coincidences. These preservations certainly play an important role in maintaining a well planned dramatic development and in providing the dancers with reliable cues that guide them through the performance. On the other hand, they cause the work to fall somewhat short of the possibly utopian goal to create an entirely improvised and generative performance.

At the current stage, we are in the early planning phase for a new dance performance that again tries to combine dance improvisation with a simulation based approach to the generative creation of music and imagery. Since we intend to move away from the previous gestural focus and try to employ entirely different types of simulations and relationships, it remains to be seen, if we manage to create a similarly plausible coherence on both the algorithmic and experiential level. But regardless of the outcome, we are convinced that contemporary dance and generative art are promising allies in the search for new forms of audiovisual performances.

4. Acknowledgements

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5. References

[1] D. Smalley, "Spectromorphology: Explaining Sound-Shapes", Organised Sound, Vol. 2, Issue 2, pages 107 -126, Cambridge University Press, New York, USA , 1997.

[2] B. Fuller, "Synergetics - Explorations in the Geometry of Thinking", Macmillan Publishing Co. Inc., New York, USA, 1979.

[3] S. Wilson, D. Cottle, and N. Collins, "The SuperCollider Book", MIT Press, Cambridge, USA, 2011.

[4] D. Bisig, M. Neukom, and J. Flury, "Interactive Swarm Orchestra - A Generic Programming Environment for Swarm Based Computer Music", in Proceedings of the International Computer Music Conference, Belfast, Ireland, 2008.

[5] D. Bisig and P. Kocher, "Tools and Abstractions for Swarm based Music and Art", in Proceedings of the International Computer Music Conference, Ljiubljana, Slovenia, 2012.

[6] I. Xenakis, "Formalized Music", Revised Edition, Pendragon Press, New York, USA, 1992.

[7] R. Luque, “The Stochastic Music of Iannis Xenakis”, Leonardo Music Journal, Vol. 19, MIT Press, Cambridge, USA, 2010.