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The first Call for Papers is for contributions that address one of the following
two areas: (1) The impact of the interactive arts on audience experience;
(2) New art practice that also advances science or technology.

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**GRAPH THEORY: LINKING ONLINE MUSICAL EXPLORATION TO CONCERT HALL PERFORMANCE**

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Recent technological and aesthetic developments have challenged us to become more engaged and active cultural consumers who help create the content we enjoy: we curate the playlists we listen to, we compete in the online games we play, and we collaboratively filter the media we watch. Within this context, traditional concert performance, particularly of classical and contemporary art music, seems increasingly anachronistic. Audiences sit in a dark hall, often looking at a conductor whose back is turned toward them, afraid to cough or sneeze lest they disturb their neighbors. *Graph Theory* aims to bridge this experiential gap. Through its availability on the Internet, it seeks to creatively engage audiences outside of the concert hall; the project then incorporates their activities into the context of a live concert performance. Web site visitors, who need not have specialized musical training, use a visual interface to navigate among short, looping musical fragments to create their own unique path through the open-form composition for solo violin. Before each concert performance, the violinist visits the web site to print out a new copy of the score, which linearly orders the fragments based on the decisions made by site visitors.

**Background**

Recent networked music research and practice has often focused on real-time, collaborative, networked performance systems. Termed “shared sonic environments” by Barbosa [1], they range from the NINJAM [2] software architecture, a networked, synced multi-track audio environment, to Phil Burk’s *WebDrum* [3] drum machine, in which users edit voices of a looping drum pattern through a step-sequencer interface. And several recent works have linked such online environments to live concert performances, including Tod Machover’s *Brain Opera* [4] and William Duckworth’s *Cathedral Project* [5].

Like Machover and Duckworth’s projects, *Graph Theory* links an online environment to concert performance, but it does so out of real time, following a paradigm closer to an online discussion forum than a chat. Each user contributes to an evolving musical score rather than improvising with other users in the moment. Participants need not log on during a live performance in order to influence it, and they need not participate simultaneously with others in order to contribute to a collective result. In this respect, *Graph Theory* is influenced by projects such as Splice Music [6], a collaborative remix tool; and Sergi Jordá’s *Faust Music On Line* [7], a novel collective composition and synthesis environment.

*Graph Theory* also draws from a tradition of dynamically generated musical scores whose visual appearances transform from one concert performance to the next. In Earle Brown’s *Calder Piece* [8], the movements of a mobile sculpture influence the music, and recent projects by Clay [9] and Winkler [10] render digital scores in real time based on the activities of performing musicians.

*Graph Theory*’s structural paradigm, in which small musical fragments are reordered, is inspired by Brown’s idea of open form [11], as exemplified in works such as Stockhausen’s *Klavierstück XI* [12], in which the performer’s wandering eyes select the order of fragments during performance, and Saariaho’s *Mirrors* [13], in which users manually order the fragments and play back the results. *Graph Theory* also refers to the graph structures common in computer science and to the hypertextual narrative structure of the web itself.

**Design**

The web interface (Fig. 1) enables users to explore the graph structure and create their own path through the composition. In the top section, they see piano-roll style representations of the current fragment, previous fragment, and possible next fragments. Because the work utilizes only twelve different pitches, with each pitch class frozen in a particular...
octave for the entire work, the fragments can be cleanly represented with 12 vertical steps.

The lower section of the interface features a visual representation of the entire graph structure. Different colors highlight the previous, current and possible next fragments, and the hues of possible next fragments indicate their relative popularity with previous web site visitors. The colors of the remaining fragments on the graph indicate whether the user has already visited them during the current session.

Users choose the next fragment by clicking either on the piano-roll representation or directly on the graph; they may move back to the previous fragment if they are unhappy with their decision. A path review button enables users to play through the entire series of fragments they have visited thus far; in this mode, each fragment in the path is played in succession a single time.

Musical Score
As users navigate through the musical fragments, each decision they make is logged on a server-side database. The server also records the number of times a fragment loops before a new decision is made. Each day, then, the server uses this data to regenerate a downloadable score file for use in future performances.

The score generation algorithm creates a linear path through the composition. It first assigns weights to the directed edges linking each pair of fragments in the graph; the more “votes” a particular edge has received from participants, the lower its weight. The software then finds the path that visits all fragments at least once but has the lowest total weight. It solves this optimization as a variation of the traveling salesman problem, allowing for a graph that is not fully connected and for the same fragment to be visited multiple times. In this manner, more popular path segments are more likely to appear in performance scores. And the decisions of recent web site visitors take precedence: a server-side variable configures how far back to look in the decision database when computing weights.

The algorithm also labels each fragment in the score with a suggested number of repetitions, based on the average number of times web site visitors let it play before moving on.

The meditative, minimal music is comprised of 61 fragments that range in length from 0.6 to 4 seconds; each fragment contains between one and five pitches. Linked fragments always differ by only a single added, removed or changed pitch, and each fragment links to either three or four other fragments on the graph. I composed the rhythmical and metrical content of the fragments intuitively, with the goal of avoiding a regular sense of pulse and meter between fragments.

Performance
While no technology is required in the performance of the piece, presenters are asked to direct audiences to the web site in advance of the concert, and they are encouraged to place computer kiosks running the web site in the concert hall lobby. Each performance is also recorded and archived online.

On the web site, sound is continuous; a fragment loops until the next one is chosen. The fragment recordings, which were performed by violinist Maja Cerar and recorded with a click track, are identical every time they play back.

In each 7-10 minute concert performance, the violinist exercises considerable interpretive freedom to modify dynamics, timbre and tempo, to insert pauses, and to vary fragment repetitions, musically shaping groups of fragments into larger-scale musical phrases.

Discussion
In the nine months since Graph Theory’s public launch, over 9,000 users have explored the work online, and the work has been presented in five live performances. Many web site participants enjoyed the visual and aural experience of the score and the ability to control their own path through the composition. However, it was difficult for participants to understand exactly how their own decisions related to those made by other users or to scores performed in concert. Instead, they tended to focus on the individual product they created, and they often wished they could generate downloadable audio files based only on their personal paths through the composition.

I plan to further explore this duality of individual and collective creation in upcoming works in this series, which will more clearly visualize and auralize the role individual contributions play in the evolution of the collective musical product. I also plan to link participants via a social network so that they can communicate directly with each other, develop versions of the music within social groups, and collaboratively filter each other’s contributions.

And while Graph Theory’s simple interactive structure is compelling, user influence remains limited. I plan to enable participants to gradually modify the connections between fragments and even to edit the content of the fragments themselves.

I originally wrote Graph Theory for a virtuosic violinist, and the music is correspondingly challenging to perform. I would like to make future projects in this series more accessible to amateur performance, creating another avenue to participation in the work.

Acknowledgments
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References and Notes
THE SEVEN VALLEYS: CAPTURING THE NUMINOUS IN A 3D COMPUTER GAME ENGINE

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If an artist of the calibre of Leo Tolstoy had access to the creative, interactive technology provided by first-person 3D computer games, what would he create? Tolstoy's famous novels are an example of where a classic literary genre has been used to minutely examine the human condition with depth, insight and compassion. The success of this undertaking is reflected in the continued popularity of these works, and the constant references that are made to the conceits and constructions made within them. This paper asks the question: is it possible that an artwork intended to deal with equally serious human issues could be created with this new interactive technological medium?

Introduction
Over the past 15 years a new creative medium has been introduced in the form of 3D computer games. The revolution began in 1992 with the release of the first-person shooter computer game Wolfenstein 3D [1]. Today millions of people over the world spend hours each day engaged with this powerful cultural phenomenon. Most games are produced as light entertainment and are based on action, fantasy or horror, relying on fast-paced violent gameplay as their main attraction.

Artists have been quick to pick up on the new medium and have begun to explore its potential [2]. Although the technology behind computer games has been put to some serious use, examples that examine the human condition with depth, insight and compassion are rare. The interactive artwork entitled The Seven Valleys aims to explore this largely uncharted territory.

Religion and spirituality are a core part of human experience and are often seen as the topic of artistic investigation [3]. The nineteenth-century theologian Rudolph Otto coined the term “numinous” [4], which he used to describe the a priori non-rational human response to religious experience. The numinous relates to close or direct contact with the Divine, a theme that is also found at the centre of the practice of mysticism.

This paper describes the interactive 3D artwork inspired by The Seven Valleys [5] and created using the first-person shooter game Unreal Tournament 2003 [6, 11]. The artwork has been designed to portray the numinous and mystical qualities of The Seven Valleys, highlighting the ability of the medium to tackle serious human issues.

Spiritual Experience and Mysticism: The Numinous
The term ‘numinous’ [4] refers to the mysterious non-rational, fundamental quality found in religion and religious or spiritual experience. Non-rational in this context refers to that which cannot be grasped by the intellect. Human response to the numinous is comprised of two almost paradoxical reactions: dread and fascination. The dread element Otto refers to as mysterium tremendum, which is likened to normal mortal fear, but is also fundamentally different and peculiar to encounters with the numinous. Myst-erium tremendum implies three qualities of the numinous: absolute unapproachability; power; and urgency and energy. The fascination element is referred to as mysterium fas-cinosum, an almost irresistible force that draws people to the numinous and counters the dread invoked by the mysterium tremendum. According to Otto, human beings have an in-built a priori capacity to experience the numinous. Although everyone has the potential to perceive the numinous not everyone has it to the same degree. It is also impossible to accurately describe the numinous to another soul, since it is a fundamental state of mind and irreducible to any other state. It can only be evoked in a person, or alluded to from one who has experienced the numinous to another who has also experienced it. Thus art has a special place in attempting to convey or evoke the feelings of numinous experience.

The Mystical Treatise: The Seven Valleys
Numinous experience and mystical experience deal with the same theme: personal communion with the Divine. In exploring the numinous, the main inspiration and structure for this creative work is taken from the mystical treatise The Seven Valleys [5]. This work of literature comes from the writings of the Bahá’í Faith and describes the journey of the soul through seven stages of consciousness: Search; Love; Knowledge; Unity; Contentment; Wonderment; and True Poverty and Absolute Nothingness. The journey is characterized by the lover’s search for the divine Beloved, a theme made famous in Arabic lore in the story of Majnun (literally insane) and his quest for Layli. This mystical theme

Fig. 1. Image from the Valley of True Poverty and Absolute Nothingness. (© Chris Nelson, Saadatollah Monjazeb)
transcends any specific faith and is found in all the world’s major religions.

The lover (user) begins this journey in the Valley of Search, where eventually he/she catches a glimpse of the Beloved and is transported to the Valley of Love. Here, the pain of separation acts as a ‘refining fire’ [6] [7] that burns away the dross of ego and self and leaves the ‘pure gold’ of the ‘true self’. When the lover “... escapes from the claws of the eagle of love” [5 p 11] they find themselves in the Valley of Knowledge, where they “privily converse with [the] Beloved.” This state leads to still higher levels of consciousness and in the Valley of Unity the lover perceives the whole of creation as reflecting the qualities of the Divine. In the Valley of Contentment, suffering and hardship become “delight and rapture,” leading to the Valley of Wonderment, where the lover is “… struck dumb with the beauty of the All-Glorious.” Finally the lover yields up everything in the path of the Beloved, leaving self behind and entering the Valley of True Poverty and Absolute Nothingness.

The Interactive Artwork: The Seven Valleys

The work has been designed as an exploration of, and allusion to, the often subtle and illusive concepts found in the treatise. It is comprised of eight distinct sections, one for each valley and one for the introduction. The sections are designed to be traversed linearly, although each one stands as a separate artwork and can be explored on its own.

The user is invited to take an experiential journey through The Seven Valleys where they are faced with conditions and situations which motivate them to question, explore and attempt to fathom what is being presented. Individual sections contain their own mysteries while also telling a collective story. Figure 2. shows sample images from each of the valleys. Further information can be found at www.thesevenvalleys.com.

Exhibition Feedback

The goal of creating The Seven Valleys was to capture and reflect the numinous quality of the mystical treatise. The work has been shown internationally [8, 9] to a variety of audiences and the response has ranged from people walking out after a few minutes to others giving it their rapt attention through the entire 40 minutes. The most poignant unsolicited responses have come from two individuals: one who in an obviously emotional state described how moved he was by the experience; and the other commenting on the spiritual depth and multiple layers of the work. As Otto explains, the numinous can only be evoked in a person, or alluded to from one who has experienced the numinous to another who has also experienced it. The fact that even a small number of people are able to connect deeply on an emotional level to The Seven Valleys gives credence to the claim that the technology of FPS games is indeed capable of dealing with serious human issues.

Conclusion

The Seven Valleys is just one step along the path of exploring the power and potential depth of this new medium. Responses from a number of individuals who have experienced the work provide credence to the claim that the technology behind first-person computer games can be used to effectively tackle topics of depth and meaning. Over time, as people become more familiar and comfortable with this technology it will come to encompass themes as diverse as those seen in film and literature.

References and Notes

11. The treatise and the artwork are both called The Seven Valleys. To distinguish between the two, the name is italicized when referring to the treatise.

Fig. 2. Images from each of the valleys.
(© Chris Nelson, Saadatollah Monjazeb)
OBLITERATED BODIES: AN INSTALLATION

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Encounter between art and technology is a cumbersome issue. There is an ever-growing inclination in contemporary arts to draw on sophisticated technology. In numerous artistic instances, however, the operative modes of these devices remain obscure. What matters more to us is the illumination, through aesthetic experience, of the very conditions in which we engage with technological apparatuses in everyday life. The central focus of the installation project Obliterated Bodies is obstetric examination as one such engagement site – at the heart of which lies ultrasound-based scanning technologies.

The Fetal Image

A historical glance confirms that medical knowledge relies on a whole-sensory communication between the physician’s sensory faculties and the patient’s story/body. The physician listens, hears, touches, even smells and tastes, and therefore imagines corporeally “at the very bedside of the patient.” With the opening up of cadavers in the 19th century, however, physicians’ sensory capacities begin their seamless journey towards converging at sight; hence the development of numerous imaging technologies (from X-ray to MRI) as extensions of the medical eye. From then on, the physician sees. Perhaps his body is still next to the patient, but his gaze is diverted away from the patient’s body onto an image or a monitor.

Among other techniques accompanying this bargain, obstetric sonography is exceptional – not only in employing sound to envision a body’s interior in a non-invasive manner, but in uncealing another body in the female body via the fetal image. Coming to stand for the origin of life, this image arouses a feeling of amazement. Moreover, it becomes equivalent to the fetal body it represents with a great sense of semblance and immediacy – both of which need to be problematized.

The Caesura

In the specific case of the obstetric exam, the ability to strip the female body to survey the womb (along with the ability to read the resulting image, which requires professional translation) endows the obstetrician with a governing position. The cost of such power, however, is a double-sided obliteration. On the one hand, the female body is somewhat eliminated and subordinated to the image – the very mise-en-scène of examination authorizes the monitor’s centrality. On the other hand, the doctor him- or herself is desensitized towards his/her bodily capacities and the stakes of this act (penetration and surveillance of the female body). Although enhanced, the contact between doctor and patient, along with their relation to their own bodies, is cut.

It is this caesura that we tried to reveal by constructing an installation, titled Obliterated Bodies, based on a linear circulation pattern (Fig. 1). We aimed at deciphering the operational protocols of obstetric imaging, its modus operandi, so as to transform it into a critical experience – by way of inviting visitors to participate in a displacement of all subjective positions involved in the obstetric examination.

The Installation

The installation welcomes the visitor at Room 1, where she is dictated instructions by an obstetrician, while watching a fetal image sample (Stage 1) (Fig. 2). Then, she enters a dark corridor, where the same image can be seen at a distance, projected from the other end on a transparent sheet suspended mid-air. (ST2). Approaching the sheet, the visitor recognizes a mirror covering the back wall, simultaneously seeing the superimposition of the image on her own body (ST3). While adjusting herself...
accordingly before the transparent sheet, she is guided to realize a second corridor to the right, at the end of which there exists another monitor. Displayed here is the live-video of herself shot by a camera from behind the mirror through a pin-hole (ST4). Inevitably, she can see herself on the second monitor only with her head rotating right and her gaze directed off-screen. As she approaches the monitor, the exit is revealed on the left. Once outside, she finds herself in Room 2, facing a third monitor. On this monitor, finally, is another live-video from a second camera located behind the mirror, framing only the superimposition of the transparent sheet on the abdominal area of the next visitor (ST5) (Fig. 3).

In constructing this installation, it is not our intention to reproduce or condemn the obstetric experience, but to expose its underpinnings by dramatizing in respectively separate stages: the subjection to the obstetrician’s governing voice over the image (ST1); the representational status of the ultrasound image as an externalized image on a screen, but not the actual site/body of pregnancy (ST2); the necessity of appropriate positioning and superimposition of the fetal image on the body (ST3); the aversion of the gaze away from the body (ST4); and the mechanisms of surveillance and spectacularization at the site of obstetric examination (ST5).

Fig. 3. Perspective view of stages in succession. (© Ersan Ocak and Safak Uysal)
PICBREEDER: COLLABORATIVE INTERACTIVE EVOLUTION OF IMAGES


Picbreeder [1] is a new website that is open to the public for collaborative interactive evolution of images. A unique feature of Picbreeder is that users can continue evolving other users’ images by branching. The continual process of evolving and branching means that images can continue to improve and increase in complexity indefinitely, yielding a proliferation of artistic novelty that requires no explicit artistic talent to produce.

Interactive Evolutionary Computation

Picbreeder borrows ideas from Evolutionary Computation (EC), which allows computers to produce a myriad of digital artifacts, from circuit designs to neural networks, by emulating the process of natural selection. In EC, a population of individuals is evaluated for fitness and mutated and/or mated, to produce the next generation. This cycle continues until evolution produces an individual considered significant. Interactive Evolutionary Computation (IEC), originally explored by Dawkins [2], is a type of EC in which a human evaluates the fitness of individuals (see Takagi [3] for a review). This technique is particularly effective at evolving artifacts that are too subjective for the computer to evaluate itself, including artwork, music, and designs.

Picbreeder uses a specialized evolutionary algorithm called Compositional Pattern Producing Networks-based NeuroEvolution of Augmenting Topologies (CPPN-NEAT) [4], which is extended from the original NEAT algorithm [5]. A property unique to NEAT is its ability to complexify, which means that, as evolution progresses, the individuals become more complex. Therefore, the potential complexity and sophistication of images evolved in Picbreeder is unbounded. The genetic art created by this process thus tends to look organic and often resembles familiar objects (Fig. 1).

The Picbreeder client program presents the user with several grayscale images (Fig. 2a). The user selects which images to reproduce. The program then performs crossover and mutation on the chosen images to produce the next generation. As this process iterates, images increasingly satisfy the users’ desires. Interactive evolution finally terminates when the user is satisfied.

Picbreeder Principles

A primary aim of Picbreeder is to allow a large group of unskilled individuals to collaborate and produce interesting output. Good taste, rather than explicit artistic talent, powers the process.

This goal faces several challenges. For example, in some other online, interactive evolution communities (e.g. in [6]), input from a large number of users produces an averaging effect, wherein the votes of individual users are washed out by the masses. In addition, in IEC, producing a significant output can take a long time, in many cases longer than the user is willing to continue the process. If, for example, 1,000 one-minute generations are required to produce an interesting image, it would take a single user almost 17 hours to complete. While the output may be significant, such an investment is typically impractical.

Picbreeder solves these problems by allowing users to branch from the works of other users. Once a user has created an interesting image through the IEC client, he or she then publishes the image, making it visible to the rest of the community. Any other user that discovers this image on the website can subsequently branch from it, thereby continuing evolution with his or her own copy of the image. Because of this mechanism, a chain of successive branches can be evolved by many users through thousands of generations, potentially producing otherwise unreachable images. While branching allows many users to contribute to the final image, each can take artistic liberty in the part of the series that they own. Furthermore, branching can produce a diversity of lineages originating from a single source.

While branching is an effective mechanism for IEC, it cannot work properly unless users can find appropriate images from other users. To make finding good images easy, users can rate the images of other users and thereby promote images that are generally interesting. However, Picbreeder protects nascent images by showing the newest in addition to the most highly rated (Fig. 2b). This policy gives the newest images a chance to be seen and rated by users who might be interested. Finally, because often “beauty is in the eye of the beholder,” users can search or browse for images by text tags given to images by their respective owners. Tags allow small groups of users to jointly create images that specifically interest them.

The Picbreeder Online Experiment

The Picbreeder website, recently opened to the public, allows users across the Internet to participate in Collaborative Interactive Evolution (CIE) to produce images. We anticipate exciting benefits from this system. The images produced, because of unique properties of the CPPN-NEAT algorithm, can be rendered at infinitely high resolution, making them ideal for prints. Thus, interesting images may end up in a variety of places, from websites to t-shirts. Furthermore, we plan to examine data from Picbreeder to learn more about evolving art. This information will help produce more effective CIE systems that can better harness the power of unskilled groups to produce significant works. For example, Fig. 2c exhibits an evolutionary tree produced by five separate users collaborating. It is evident that children tend to resemble their parents, yet with increasing variation. This phylogenetic tree shows how users actually collaborated to produce artistic concepts that expand in both breadth and depth.

Fig. 1. Example images evolved in the Picbreeder system.
Future Applications of CIE

Images are only the beginning of what Picbreeder-like services can evolve. CPPN-NEAT is currently being tested in evolving digital artifacts such as music, particle systems [7], and three-dimensional designs. All can potentially be adapted to a CIE system like Picbreeder. We envision a future in which companies deploy systems like Picbreeder to evolve new designs, images, and songs through a population of users. For example, in the future, a car company may open such a website to users, and perhaps even manufacture the top designs that users evolve. Large user communities may evolve two-dimensional and three-dimensional artwork that others download to obtain a full sized portrait or three-dimensional representation for output through a personal rapid prototyping machine. Eventually, such systems could even one day evolve intelligent agents, speech synthesizers, or other computational intelligence products that are difficult to explicitly design, yet easy to evaluate.

References and Notes


