JAM-O-WORLD: Evolution of the Jam-O-Drum Multi-player Musical Controller into the Jam-O-Whirl Gaming Interface

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ABSTRACT

This paper discusses the Jam-O-Drum multi-player musical controller and its adaptation into a gaming controller interface known as the Jam-O-Whirl. The Jam-O-World project positioned these two controller devices in a dedicated projection environment that enabled novice players to participate in immersive musical gaming experiences. Players' actions, detected via embedded sensors in an integrated tabletop surface, control game play, real-time computer graphics and musical interaction. Jam-O-World requires physical and social interaction as well as collaboration among players.

KEYWORDS

Collaboration, computer graphics, embedded sensors, gaming controller, immersive musical gaming experiences, musical controller, multi-player, novice, social interaction.

INTRODUCTION

The Jam-O-World project was designed to bring people together to participate in collaborative musical gaming experiences in an immersive 3D environment. The experiences are multi-player interactive games that encourage team building and cooperation. A custom table known as the Jam-O-Whirl was devised as a next-generation Jam-O-Drum to project computer graphics on an integrated surface with four player stations to control visual and aural elements of the games. Each station has a custom-built turntable device with an embedded electronic drum pad that together provide players with two methods of input. Each station is also equipped with a built-in directional speaker for audio feedback. The immersive aspects of the games are accentuated by 3D computer graphics that are influenced by the players' collective actions. These graphics are projected onto the tabletop and the walls of the exhibit space.

BACKGROUND AND MOTIVATION

The creation of musical controllers to facilitate group interaction and encourage spontaneous behavior has been a focus of Blaine's work for many years. Inspired by global traditions, new technology and communal music making in non-Western countries, Blaine co-founded the multimedia ensemble D'CüCKOO. This group built custom MIDI controllers and interactive "show-toy" devices that integrated music and computer graphics to create opportunities for audience interaction in live performance venues [1]. This work led Blaine to assemble a creative team at Interval Research in 1998 for the development of an interactive electronic drumming table known as the Jam-O-Drum [2]. Initially conceived with Tim Perkis, this device was designed to give people opportunities for shared audiovisual experiences by integrating interactive music elements with real-time computer projections in a collaborative, ensemble setting. Rather than designing an immersive musical environment with projections displayed on a vertical surface, the team invented a seven-foot diameter circular projection surface with embedded drum triggers that people could gather around and play as a shared instrument. By informally changing the context of making music to a casual group experience integrating rhythmical music and graphics, the community drum circle [3] emerged as a metaphor to guide the form and content of the team's work. A Jam-O-Drum that scales to accommodate six to twelve players is on permanent exhibit at the Experience Music Project in Seattle, WA.

JAM-O-DRUM INTERACTION DESIGNS

Although many interaction methods were explored over the Jam-O-Drum's development cycle at Interval Research, only a few examples will be discussed herein. (See [2] for more detailed information).

Freeform Improvisation

Using BlissPaint's color animated drawing program, the team explored a freeform approach to collaborative improvisation. Players caused color, hue saturation and brightness changes in a kaleidoscopic atmosphere [4]. Greg Jalbert customized the BlissPaint code to respond to a set of scripted MIDI commands that launched graphic events. Individual sounds were layered over a pre-composed backing track intended to provide an atmospheric and rhythmic musical reference. Due to the high level of visual intrigue, people were generally less attentive to the act of playing

music together. While this scheme provided the opportunity for spontaneous musical interaction, the overall sonic blend quickly degenerated into chaos for players more focused on their individual solo efforts than the group's musical output. Offering players this level of freedom proved to be a trade-off; despite the lack of musical direction, the BlissPaint schemes were perceived as the most visually impressive prototypes and held user interest for extended periods of time.

Call and Response

The Call and Response interaction pattern was developed to create an orchestrated approach for novice interplay as an ensemble. The interface used a pulsing graphic image with audio accompaniment in the center of the table to represent a "virtual caller". The “caller” conducts a four-minute MIDI score of rhythmic patterns and alternating response cues, with each call pattern followed by space for players to repeat the pattern or perform their own form of rhythmic improvisation. "Your Turn" indicators directed everyone at the table to play altogether, to split into subgroups, or play as a soloist (See Figure 1).

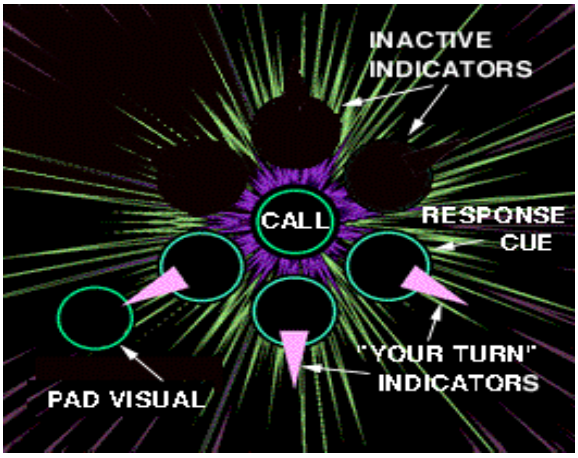

Figure 1: Call and Response Interaction Scheme

Although the call and response rhythmic patterns present a sociable method of phrase recognition and imitation particularly geared toward novice interaction, players are not "locked" into a predetermined cycle of events. Once the players caught on to the alternating play and listen modes, opportunities would emerge for more experienced players to improvise within the compositional form. While some players found the rhythmic learning experience too structured to be entertaining, others enjoyed the game-like "Simon Says" aspect of this prototype. Several videogames with a similar interaction technique have recently proved commercially successful, including Konami’s Dance Dance Revolution [5] and 989 Studios’ Parappa the Rapper [6]. Ultimately, the team found that these highly directed call and response patterns with short learning curves were the most successful in bringing novice and expert players together for musical collaboration. These findings fit with Jan Borcher's work designing and building the World Beat Interactive Music Exhibit at Ars Electronica [7]. Near the end of the Jam-O-Drum project cycle, a number of card game prototypes were developed that reinforced the team's belief that goal-oriented game experiences would be successful on this platform.

HARDWARE IMPLEMENTATION

The seven-foot diameter Jam-O-Drum table was built with 10” drum pads mounted directly onto the steel frame and speakers positioned in front of each station. The entire tabletop was covered with foam padding and encased with a custom-fitted cover to feel like a drumhead. While the cover provided one seamless surface for projections, players were at times unsure which areas of the table were "active" when testing different interaction prototypes. Initially, the Jam-O-Drum's basic system architecture consisted of two Macintosh computers that received MIDI messages from the embedded drum pads (See Figure 2). An LCD video projector projected images from the graphic Macintosh onto the table. In the final phase of the project, the Call and Response music and graphics software were streamlined to run on a single computer for the Experience Music Project Exhibit.

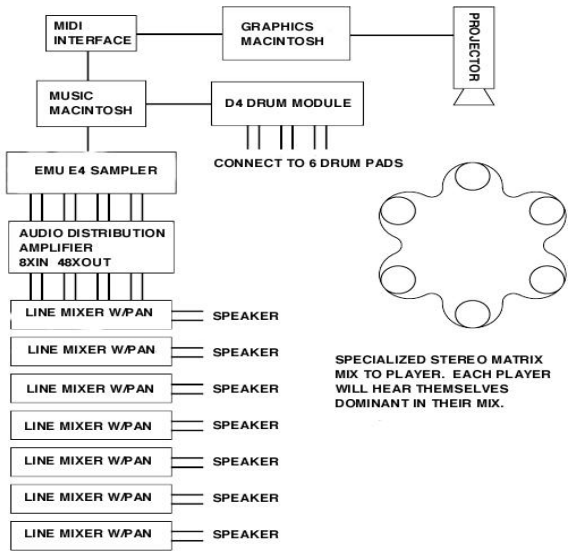

Figure 2: Jam-O-Drum System Design Overview

SOFTWARE ENVIRONMENT

Over the Jam-O-Drum's seven-month development cycle, many different interaction schemes were explored with a variety of software packages. In early schemes designed to enhance the musical responses of unskilled players, Opcode’s MAX was used to process real-time MIDI information from the drum pads, control playback of backing tracks, and forward control information to the graphical subsystem [2]. Emagic Logic was used to play back scripted MIDI sequences that initiated audio and graphic events. Metrowerks CodeWarrior was used for C development and Opcode's OMS developers kit was integrated for the call

and response and BlissPaint prototypes. Bias Peak, Steinberg's ReCycle and ReBirth were used to edit the custom library of samples.

FACILITATING GROUP INTERACTION

Future Potential of the Jam-O-Drum

Observations of novice musical behavior on the Jam-O-Drum led to the following conclusions about promising areas of future research toward facilitating group interaction in a public environment:

- To introduce more game-like interaction
- To create goal-oriented or directed activities that would encourage more communication and social interaction between the players
- To develop a basic software framework to support the rapid development of new prototypes.
- To explore an orchestrated approach to the music and visuals in order to avoid chaotic interaction
- To integrate controllers/input devices that might disassociate player's expectations regarding responsiveness.
- To make the active areas/input devices on the table more discrete.
- To design interactions with direct relationship to player's actions.

Most of these findings would be put into effect in the next iterative phase of development for the controller device that would become known as the Jam-O-Whirl.

JAM-O-WORLD

Building a 3D Musical Gaming Environment

An invitation to develop an exhibit for Zeum, a Youth Art and Technology museum in San Francisco, offered the opportunity to create two site-specific musical gaming experiences. The installation would be in a dedicated conical shaped exhibit space approximately thirty feet in diameter with thirty-foot high ceilings. A series of balconies around the perimeter of the cone provided scenic overlooks for bystanders and also placed constraints on the size and dimension of the room's wall projections. The games developed for this environment would have to be visually and aurally appealing, accessible to players of varying ages and abilities, and support extended replay value in a public space.

Jam-O-Drum's Redesign into Jam-O-Whirl

The authors, in collaboration with a team of graduate students from the Entertainment Technology Center at Carnegie Mellon University, set out to augment the Jam-O-Drum controller device with new inputs and implement a set of musically enhanced games. The Jam-O-Drum's original hardware design was enhanced by integrating two input devices: a MIDI drum pad embedded inside a turntable disk. Integrating both the drum pad and turntable as inputs enabled additional control of projections and sound via the movement of the turntable. Another important element of the Jam-O-Drum's redesign included making the four player stations more distinctive and conducive for team interplay. The desire to clarify the interaction areas was in part inspired by Toshio Iwai and his Composition on the Table [8] mixed reality installations. In Iwai's exhibit, which shared many of the same goals as Jam-O-World, players controlled the visual and aural aspects of the experience with trackballs, mice, dials, or switches: input mechanisms that players immediately knew how to interact with and instinctively gravitated toward. A trio of lazy-Susan disks used to prototype the CircleMaze game inspired the Jam-O-Whirl's crossover into a combination gaming interface and musical controller.

GAME DESIGN FOR THE JAM-O-WHIRL

CircleMaze

Forlines conceived of the CircleMaze game as an example of a control device mapping position and movement of a circular disk to a corresponding circular ring projected on the tabletop. Each one of four color-coded turntables controls one of four matching colored virtual rings. Players work together to align the rings' pathways, allowing virtual balls to travel from the outer ring into the center of the concentric maze (See Figure 3). The game starts with one ball and sixty seconds for the players to devise a group strategy. Once players get the first ball into the center, they advance to the next level of game play, the number of balls increases exponentially and a new set of musical backing tracks and sound effects are introduced. Zeum visitors of all ages quickly learn that progressing to higher levels of the game cannot be achieved without communication and teamwork.

CircleMaze employs a consistent user interface: the same actions at every level of game play produce the same results. This "unity of design" principle makes for an intuitive and easy-to-learn game. By not requiring the players to memorize a series of actions and establishing an obvious correlation between simple disk movement and its impact on the table's projections, CircleMaze promotes a state psychologist Donald Norman refers to as "knowledge in the world" [9]. Essentially, players have two options, to hit the drum pad or turn the disk. Inexperienced players can quickly examine all possible options and even if other players don't assist them, the worst possible outcome is that the game resets at the same level. Over time, their experiences will result in "knowledge in the head"[9] as using the controls becomes second nature. Players are then free to concentrate on more efficient game play (i.e. advanced strategies, and self-imposed goals), and social interaction.

Mapping Sound

The implementation of a device that could be used in a public installation for gaming and expressive musical control with a turntable disk and drum pad posed a series of potentially conflicting design challenges. First and foremost, the

Jam-O-Whirl's graphical user interface would be the most obvious focal point of the exhibit. Designing a simple, easy to use interface would be necessary to present a low barrier to access the game, particularly for young people. As a result of this focus, the music-making aspect of the ensuing games became lesser in importance. Ultimately, the trade-off of providing greater musical expressivity and functionality was forfeited in favor of providing overall sonic cohesiveness as an integral element of gameplay. Most importantly, the Jam-O-Whirl's disks and drum pads had to be designed for maximum durability to withstand hundreds of young visitors' turning and hitting them each day.

Figure 3: CircleMaze on the Jam-O-Whirl

Mapping the audio to create a direct correlation between player's actions and still provide driving musical accompaniment in an overall sonic blend, also proved challenging due to the fast rate at which the disks were turned. The underlying compositional method for this level of interaction ended up being somewhat comparable to the modular composition approach that Gideon D'Arcangelo used in his "Currents of Creativity" soundtrack for the Pope John Paul II Cultural Center [10]. In this regard, the team faced a similar design challenge as D'Arcangelo; the need to create a framework for visitors that would trigger musical loops that would be perceived as an integrated whole regardless of their initiation point, but with synchronization between tracks.

Minimizing Chaos with Modular Composition

In an effort to avoid total chaos, one method that proved fairly successful in terms of sonic cohesiveness and variation was to compose four different audio tracks for each individual station at all five levels of game play. Unlike D'Arcangelo's infinite collage approach [10], CircleMaze's musical elements exist in two and four bar phrases designed to be recombinant in 256 interlocking configurations. Players turning their disks in 90-degree rotations would set one of four tracks per station in motion at the next incidence of the downbeat. The collective positioning of all the players' disks at any given time would determine the overall selection of musical backing tracks during each level of the game, thus giving players control of subtle changes in the collage of musical accompaniment. Auxiliary samples triggered by hitting the drum pads provided players with immediate audio feedback and clear identification of their musical contribution. Generally, visitors were more attuned to their audio contributions from the drum pads and not as aware of their impact on the musical accompaniment once the backing tracks were engaged. Because the drum pads mainly provide complementary sonic contributions and are not as integrated into gameplay as the disks, it sometimes took awhile for visitors to discover that they could play the drum pads to launch sound effects and individual percussion sounds. As with earlier findings user-testing the BlissPaint prototype, the visual impact on aural perception was significant. The drum pads also served as the projection surface for an egg timer-like clock displaying the time remaining in a diminishing circle.

Immersion Methods

Three dimensional computer graphics projected on the walls of the exhibit space accentuate the immersive aspects of the game and are collectively influenced by the players' actions. The wall projections surrounding the Jam-O-World environment each represent a different camera angle in a 3D world, creating the illusion of being the ball in the maze suspended in space. Between levels, the rings of the maze animate and extend off the table, rise up the walls of the exhibit space, then land back down onto the table with the appropriate number of balls for the next level of game play. After five levels of successful interaction, a unique three-dimensional animation appears on the table and the walls of the cone accompanied by ten seconds of sound effects. The team was well aware that high quality sound would be critical to the game's success and necessary to enhance the players' sense of immersion. Four directional NHT ceiling speakers were installed into the tabletop, a subwoofer placed below, and additional sound reinforcement was provided by a surround sound system with six distributed speakers mounted in the ceiling and walls of the exhibit space.

Hip Hop

Another musical game experience developed for the Jam-O-Whirl device was Hip Hop. Designed to be a pattern matching game for young people, Hip Hop is facilitated by a 3D robotic rabbit known as "Tokli". Tokli's character promotes interaction by explaining the rules of the game in rhymed verse and encouraging players to work together. With a scripted "rap" narrative designed to facilitate flow-through in a museum environment, Tokli's animations are accompanied by verbal responses based on participants' collective input at different levels of the game. If the players do not assist each other in matching the virtually shuffled cards successfully, Tokli goes into a "flop" animation accompanied by robotic sound effects and his "rap" suggests the players try again. Hip Hop was partially inspired by Dance Dance Revolution (DDR) [5], a game in which players issue and perform dance commands through pattern matching.

Unlike DDR, Hip Hop encourages collaboration instead of competition; players are only rewarded with Tokli's dance if they collectively succeed. If the players are successful in their game interaction by correctly matching all the card images, a combination of Salsa backing tracks are initiated to accompany Tokli's dancing animations and everyone is congratulated. Each player controls four different musical tracks that include keyboard, horns, bass and percussion, that were designed to mix together in 256 possible configurations. Players also trigger percussion samples by hitting their drum pads and have the opportunity to "jam" along with backing tracks during the transitional period between rounds. One of the interaction design challenges the team explored was alternating the focus of game play from the tabletop surface to the dancing animations on the walls. This intentional shift of the players' attention was developed to make extensive use of the exhibit space, create opportunities for improvisational musical interaction and enhance the feeling of immersion.

Tokli's dance and flop animations are observed from three different camera angles; each designed with special lighting and point of view attributes to give visitors the perspective of being at a concert venue. The darkened environment of the exhibit encourages a high level of spontaneous behavior and physicality between the players; even young boys were observed dancing and jumping around. Although the Hip Hop game was designed primarily for young people 8-12 years old, teenagers have also been discovered making up their own games and choreography from the balconies above. The goal of integrating this ubiquitous approach to interface design with elements of animated motion, music and light was intended make visitors to the Jam-O-World environment more aware of their social surroundings and encourage group interaction with each other and Tokli's character. The desire to encourage full body participation was in part inspired by MIT's interactive computer vision project PingPongPlus [11]. While this project was not focused on collaborative music making, the authors recognized their use of sensors, sound, and projection technologies as powerful techniques to encourage full body motion during game play.

Software Redesign

One of the primary objectives of the Jam-O-Whirl's design phase was to create a software library that could support extensibility and standardize the implementation of new interaction schemes. To minimize development time, the team built a simple API that abstracted the hardware interface, allowing all of the Jam-O-World experiences to share a single code base for handling user input and sound output (See Figure 4). CircleMaze and Hip Hop were implemented using Alice2, an interactive 3D authoring tool for rapid application development and interactive experimentation. A JNI wrapper provided communication with DirectX for 3D graphics and surround sound output. 3D Studio Max and DeepPaint were used to generate 3D models, and ProTools, Emagic Logic, MetaSynth, and ReBirth were used for sound design, digital editing and original music composition.

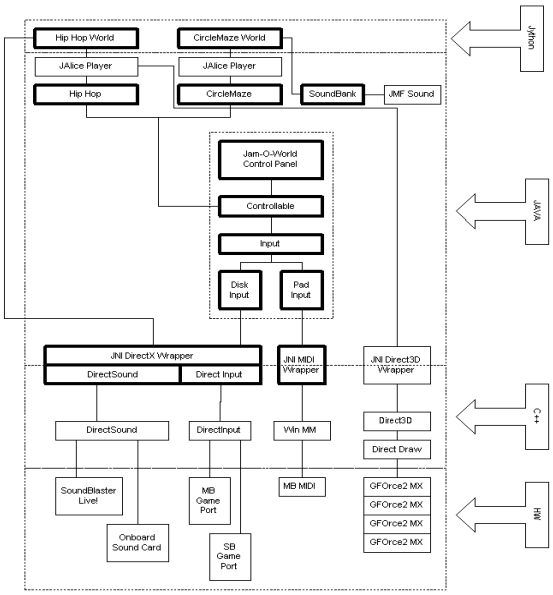

Figure 4: Jam-O-World Software Overview

Hardware Redesign

The Jam-O-Whirl device incorporated a combination of two input devices; a MIDI drum pad mounted inside a turntable ring. As the ring turns, an optical encoder relays its rotational position and speed to the computer. The Jam-O-World includes a Windows-based PC with a 1 GHz Pentium III processor, four NVIDIA GeForce2 video cards, and two Audigy and SoundBlaster Live! sound cards. As one might expect, generating four screens of interactive 3D images and outputting six channels of audio put a huge demand on the system. This burden caused an unacceptable state of instability for a museum environment, where exhibits need to run unattended for hours at a time. Eventually migrating the software and hardware to a dual processor machine helped with the overall stability of the system, but created MIDI incompatibility issues with the sound cards.

OBSERVATIONS & FUTURE WORK

In both the Jam-O-Drum and Jam-O-Whirl installations, one of the most rewarding aspects of this work is the high level of social interaction and engagement among players. Gathering around a shared surface creates a context for bringing people together to play games and create music. Through the design of the aforementioned musical gaming experiences for public spaces, one of the most important elements appears to be the creation of goal-oriented structures that are counterbalanced by opportunities for free form play and improvisation. Regardless of differing objectives towards gaming or music making, both of these installations have demonstrated that goal-oriented interaction makes it easier to communicate and engage with strangers in a public setting. People who might not ordinarily participate in music making activities approach the Jam-O-Whirl because of its game-like attraction and appearance, and also find no musical knowledge is necessary. Not surprisingly, parents often

had more difficulty accessing the games than their children did. Integration of a surround sound system coupled with speakers in the table and a darkened environment created a relaxed club-like atmosphere that inspired physical movement and fostered spontaneous interaction between the visitors. Having the Jam-O-Whirl installation in a fully dedicated space with large-scale wall projections and effective sound levels gave visitors a feeling of audiovisual immersion.

As with earlier research on the Jam-O-Drum, time constraints in the development of Jam-O-Whirl restricted the opportunities to more fully realize the musical capabilities of this system. Although the turntable disks proved to be a highly engaging and intuitive interface for the circular graphic projections, the audio mappings integrated with these continuous controllers were not as obvious to visitors and could be improved. With a development cycle of only four months to complete the hardware and software for the Jam-O-Whirl and projections for the Jam-O-World environment, there were many areas of research and development that could not feasibly be undertaken to investigate opportunities for more expressive musical control. Nevertheless, the modular approach described herein toward the creation of a pre-composed library of audio tracks in combination with individual sounds provided visitors with varying levels of musical interaction. Implementation of this interaction method with two inputs for musical control and expression based on the player's actions was an intentional compromise derived to maintain a cohesiveness to the overall musical arrangement, but still provide visitors the perception of individual control and impact on the system. Perfecting the appropriate levels of musical interaction versus the perceived affordance of musical interaction and complementing sound design, is an area ripe for further research with this development platform. Ultimately, the Jam-O-Whirl platform can be used to develop a new generation of multi-player games with or without the additional projection capabilities in an immersive exhibit space. Because the players' attention has been primarily centered on the visual elements of game play, the music making aspect of the games became a secondary focus. In the future, designing a musical game that specifically leverages the physical characteristics of the disks and spinning, as in a DJ game, would be an engaging area of research.

CONCLUSIONS

The development of the Jam-O-Whirl device was an obvious extension of research and conclusions derived from user testing and experimentation with the Jam-O-Drum. With slight modifications to the original design and intentions of the Jam-O-Drum, a crossover gaming device emerged along with several new approaches to facilitate group interaction in a public environment. The goal-oriented and directed musical game-like activities developed for these platforms enhanced communication and sociability between the players and helped avoid chaotic interaction. Developing a basic software framework to support the rapid development of new game prototypes for multiple audiences was invaluable. Finally, regardless of the focus on music or games, implementing an easy to use, intuitive interface is one of the most important design elements of any interactive experience that invites novices to explore and learn.

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