The Liminal Surface: An Interactive Table-top Environment for Hybridized Music - Theater Performance

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Abstract

This paper documents the development of a new instrument for the creation of experimental music theater. This environment, known as the *liminal surface*, uses a portable "table-top" design to integrate audio, video, analog and digital sensors, and computer-based control of external media (i.e. musical robotics). This environment will enable the composition of a series of new works exploring interactive computer music, intermodal relationships, and collaborative performance on a visually stimulating and technologically sophisticated platform.

Introduction

The *liminal surface* is a new instrument for the creation of experimental music theater. It is an interactive table-top environment that allows for new forms of expression through the combination of contemporary music and theater, performative sculpture, percussive musical practice, and interactive software-enhanced performance building on an existing collaborative practice between the authors. These table-top miniature stages are outfitted with sensors and actuators as well as sound and video hardware. The tables are designed to accommodate a wide range of sensors that provide our specialized real-time audio/visual software with information about our physical gestures.

Similarly, the tables allow connectivity with a wide range of actuators (i.e. electromechanical components like motors and solenoids that are integrated into small moving sculptures). These actuators are controlled by software according to precomposed rules as well as through interactive translations of our gestures. Concurrently, contact microphones attached to the table and small pin-hole cameras that can be positioned around the table allow the performers to present a rich and immersive audio/visual perspective on this miniature stage.

Liminal surface draws inspiration from the Freudian concept of *the uncanny*[1]*.* Beginning with a disection of the german word (*Unheimliche*--literally, *"un-home-ly"),* Freud exposes to the unique psychological power of objects that simultaneously exhibit a contradictory dual character (familiar and unfamiliar; animate and in-animate). He takes as an example the automata ("a mechanical figure or contrivance constructed to act as if by its own motive power"[2]) and analyzes the uncanny power of a lifeless object that exhibits animate behavior. Freud's analysis of one's experience of such uncanny objects points to the concept later coined by Festinger as the state of cognitive dissonance[3]: the realization of contradictions in one's own attitudes, feelings, perceptions or behavior. Similarly, in his essay on marionette theater, through a discussion that is very much derived from the concept of *the uncanny,* Kleist points to "the advantages" of a puppet over a living dancer: a puppet emulates human behavior while maintaining immunity from the forces that weigh down humans (i.e. affectation, uncertainty, gravity, etc.).[4]

With the *liminal surface* we use tightly choreographed and computer controlled movement, video and sound to evoke the *uncanny.* We not only use robotic automata in similar ways to the mechanical automata and marionette figures that were the topics of Freud's analysis, we also use sensor technologies to remotely affect our automata with musical precision. The strength of the *liminal surface* as a performance instrument

therefore lies in its combination of physical objects that autonomously take on musical and theatrical roles, and the power of the performers to theatrically intervene into this autonomy. Another important performative strength is our ability to use audio and video amplification and perspective to instill musical and theatrical meaning into the actions performed by the table's machinations. In this regard, the works for this environment engage with the emergent genre of Live Cinema, where performers play the role musician and visual artist, as well as actor and cinematographer.

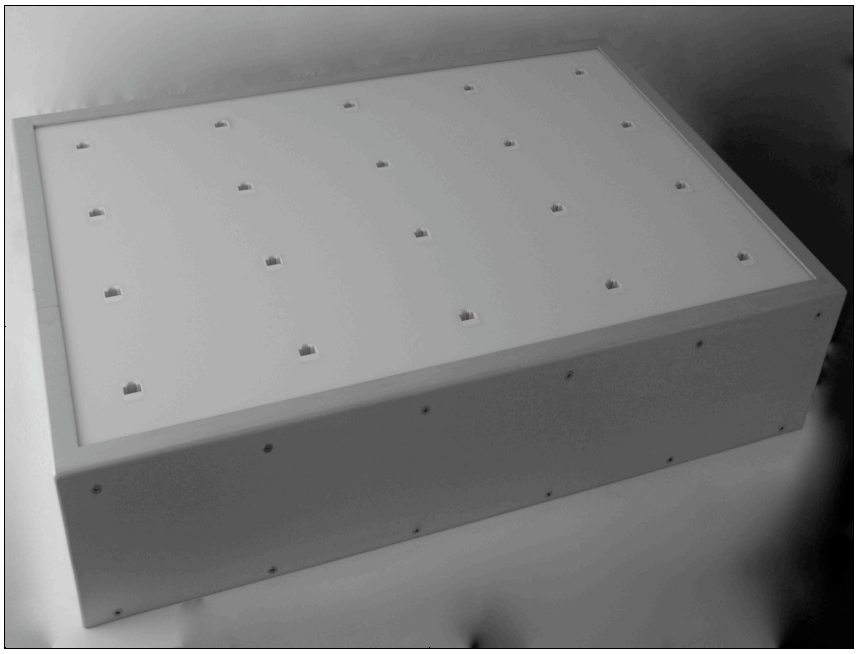

Figure 1. The *liminal surface*.

Live Cinema and Table Top Performance

Table Top Performance

Table top environments have been used by a small number of artists over the last 50 years as a vehicle for non-traditional performances of a music-theater nature. The use of the table is indicative of several things – 1) that the performance falls outside of conventional musical norms, 2) that the theatrical space is focused on the surface area of the table and the performers around it, and 3) that the presence or presentation of objects on or onto the surface is a major component of the theatricality of the work.

A number of precedents, including previous works of our own, have been influential in developing a table-top performance practice for the *liminal surface*. A significant body of composer John Cage's work utilized the theatrical presentation of materials in this fashion. To highlight just one example, the first performance of *0'00"* ("in a situation provided with maximum amplification (no feedback), perform a disciplined action"[5]) consisted of Cage writing out the performance score on an amplified table - the sounds of the pen strokes crafting the musical landscape. A subsequent performance of this piece, dating from 1968 and renamed "*Reunion*", found Cage and Marcel Duchamp playing a game of chess on a specially prepared chess board designed by Lowell Cross. The location

of chess pieces acted as a switchboard for electronic sounds created by David Tudor, Gordon Mumma, and David Behrman. [6]

More recent influences include:

- Mark Applebaum's "Mousetrap Music" – idiosyncratic Rube Goldberg-esque table-top environment for electroacoustic music performance.
- Rick Burkhardt, Andy Gricevich, and Ryan Higgins' "The Nonsense Company" – music theater composers/performers whose works combine political narrative with percussive instrumentation often derived from everyday objects.
- Kanta Horio's "Particle" – performance shaped by the electromagnetic manipulation and choreography of paperclips with amplification of the resulting sounds.

Current trends in Human Computer Interfaces (HCI) and musical instrument design are also developing technologies pertinent to the creation of new works in this field. The *reacTable*[7] tangible computer music interface developed at the Music Technology Group of Pompeu Fabra University in Spain and the *Audiopad*[8] electronic music controller developed by the MIT Media Lab's Tangible Media Group are two such notable examples.

Live Cinema

The work of the *liminal surface* also connects with the emerging field of "live cinema". As a term, live cinema usually refers to performance practices that combine real-time generation of audio-visual content that is projected onto a screen and out of loudspeakers[9]. Often, but not always, the performer's body is included as a theatrical agent - visually active in the manipulation of sonic and/or visual materials. Furthermore, our utilization of specialized software that generates audio and video in real-time opens the doors to non-linear forms of cinematic experience referred to by new media theorist Lev Manovich as "soft cinema"[10].

One influential precedent is Bob Ostertag and Pierre Hebert's ongoing project "Living Cinema". This series of performances is based on real-time audio and video manipulation of everyday objects (chosen in part for their potential for socio-political commentary) and often employs digital stop motion techniques developed by cinematographer Hebert.[11] Another prominent example is David Stout and Cory Metcalf's "Noisefold" - a duo whose work uses interactive sensor based input to control immersive environments of computer generated abstract imagery and sound.

The authors feel that this genre allows for a uniquely embodied form of live performance. As in some forms of puppetry, in which the puppet master is in plain view and direct control over the puppets is never questioned, our performerly bodies hover over the actions of the tables, manipulating objects, sensors, and miniature musical instruments. However, through computer automation, the tables can simultaneously embrace processes that run out of the immediate control of the performers allowing for shifting relationships of causality.

Design Considerations

The clean visual aesthetics of *liminal surface*'s physical presence are akin to the minimalism inherent in shadow theater. We draw from what William Kentridge refers to as the paradox of shadows:

"Shadow is all appearance, immateriality, without substance; but at the same time gives a way of avoiding the seduction of surface--often referred to as appearance as opposed to essence."[12]

The table has a purposefully reserved and neutral visual character for the table (white surface, unadorned rectangular metalic chassis, etc.). Many of our plug-in-props refer to shadow theater (i.e. the sillouette of a walking man, as opposed to an animation or figurine of the man). These aesthetic decisions allow us to subvert the seduction of surface, design, ornamentation, and allegory, while attempting to compose with the essential symbolism and musicality of our theatrical components. The reserved visual scenery of the *liminal surface* also creates a backdrop of abstraction that sits in theatrical contrast with real-world stories, objects and performance venues. This contrast creates a distance between our performance persona and the performance context (i.e. the hall and the audience as well as the specific subject matter of a composition); by composing *for* this distance/abstraction, we ourselves become shadow figures in a play that privileges substance over surface, gesture over affect, and action over language.

Each *liminal surface* is housed in a 24" x 16" x 5" brushed aluminum case. The top panel is cutout allowing for a 1/4" sheet of translucent acrylic to be mounted inside the casing. The acrylic sheet is populated with 20 female RJ45 (ethernet) connectors arranged in an evenly-spaced grid of 5 columns by 4 rows. These are used to connect "gridpoint gadgets" to the tables. Each gridpoint is designed to simultaneously control a one actuator and one analog sensor.

Along the side panel closest to the performer, there are cutouts for a series of "mega-ports" - RJ45 connectors with a more specialized purpose than the gridpoint connectors. There are two amplified (0-12V) actuator mega-ports each controlling up to seven actuators, two control-level (0-3.3V) actuator mega-ports, and four mixed actuator and sensor ports. Additionally there are three connectors that provide dedicated control over a 64 channel dimmable LED matrix (8 columns by 8 rows).

RJ45 connectors were chosen for both the gridpoint gadgets and the mega-ports due to their convenient form factor, lost cost, and high wiring density (8 wires). They do exhibit some negative characteristics, particularly with regard to current ratings. Most RJ45 cabling and connectors are only rated up to 1 amp. If electromechanical devices, such as motors and solenoids, need to perform a lot of work (e.g. moving a heavy object) current needs can quickly rise above that level - potentially melting cable housing and leading to an electrical short. Distributing heavy loads over more than one cable can reduce this risk.

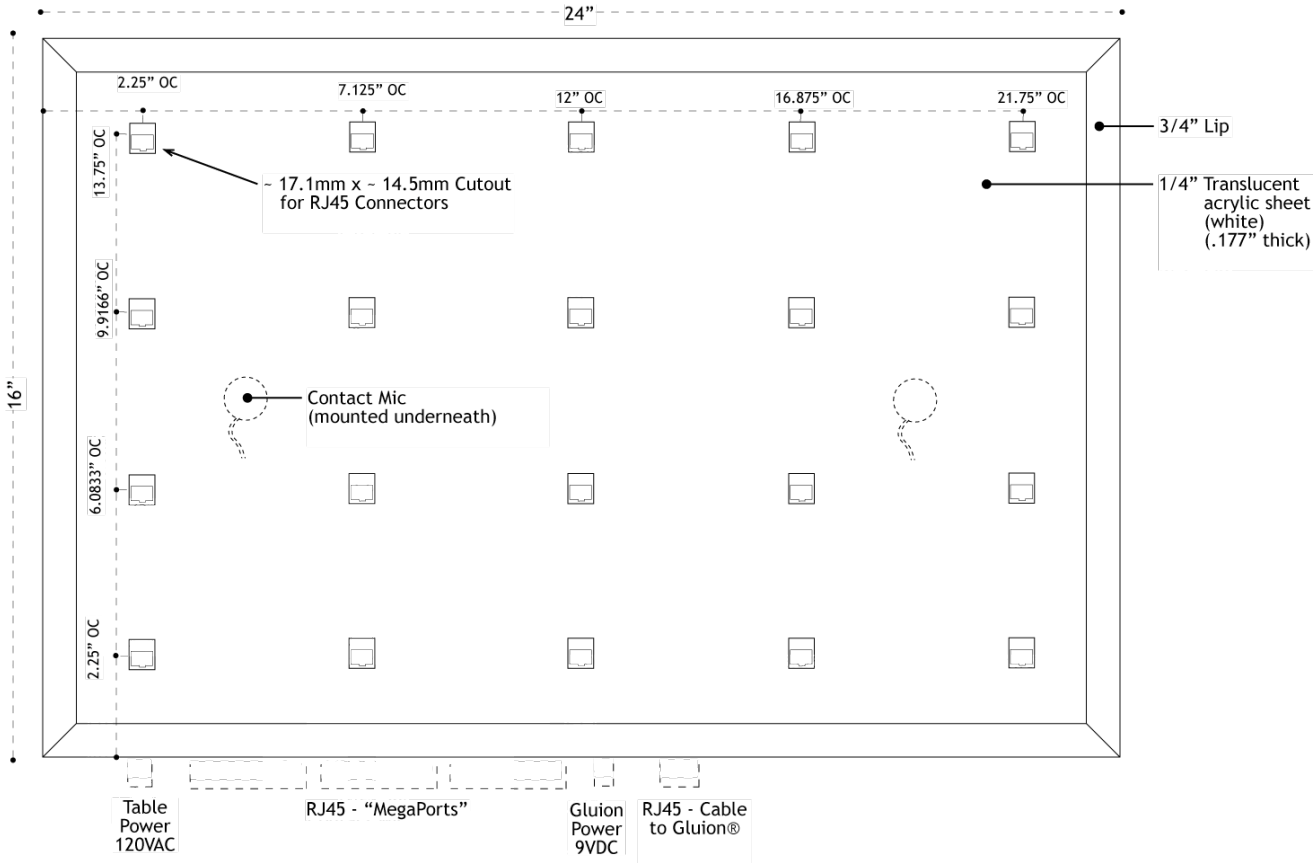

Figure 2. Top view of the table top layout of the *liminal surface*.

Internal Hardware

Gluion Interface As an interface between the computer software environments described below and the hardware world of sensors and actuators, we have chosen to work with an FPGA-based sensor interface known as the Gluion[13]. The Gluion is designed and commercially available from Sukandar Kartadinata, a German-based musician and electrical engineer. For our purposes, the Gluion offers several distinct advantages:

- Easy and fast communication protocol. The Gluion utilizes the Open Sound Control (OSC)[14] messaging system over ethernet and can be controlled via a wide variety of software environments. This protocol also makes it possible to run both Liminal Surfaces from a single computer or to easily share data between computers each running a Liminal Surface independently.
- Speed. The Gluion updates at a rate of up to 1000hz. This results in sensor data with percussion-level timing accuracy.
- High resolution. The Gluion has 16bit resolution allowing for a range of sensor and actuator values between 0 and 65536 (the popular Arduino microcontroller, by contrast, is a 10bit interface with values between 0 and 1023).
- Large number of configurable channels. The Gluion has up to 68 configurable digital pins (input, output, switch matrix, etc.) and 32 analog input pins.

For our purposes, we have configured the Gluion with 32 analog inputs (20 in the grid, 12 in the mega-ports), 44 digital outputs (for the gridpoints and mega-ports), 6 digital outputs for internal lighting, and 16 digital outputs for an external dimmable LED matrix.

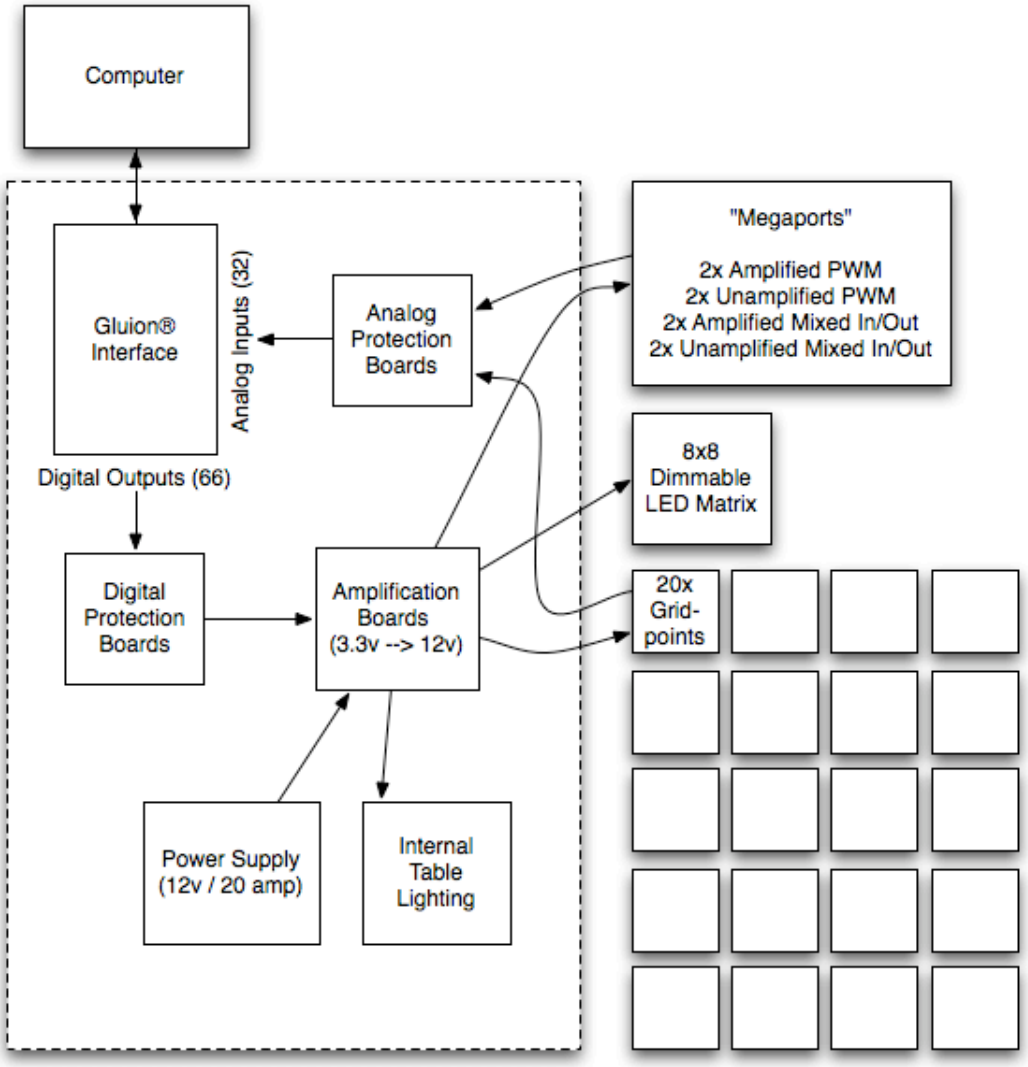

Figure 3. Internal block diagram for the *liminal surface*.

Analog/Digital Protection Boards The Gluion interface provides no protection circuitry for its input and output pins. If signals of the wrong type go to the wrong pins (e.g. an amplified 12V signal is accidentally connected to an analog input pin or an inductive load like a motor "kicks back" voltage to a digital output pin) the interface can be damaged. Due to the modular nature of the gadgets used with the Liminal Surfaces, we found it necessary to build protection boards to prevent such mishaps. On both the analog input side and digital output side of the Gluion, we have attached circuitry that utilizes a zener diode tied to ground. When a voltage rises above a breakdown threshold (e.g. 5.1v for the analog input pins) it allows current to flow - redirecting the signal directly to the

ground.

Amplification Boards The Gluion outputs control-level (0-3.3V) signals capable of driving only very small loads. In order to drive larger electromechanical loads (or even many small loads like LEDs), the signal needs to be amplified. We have implemented transistor based boards with opto-isolation (for further protection) that adapt the 3.3V signal of the Gluion to a high power 0-12V range drawn from a power supply mounted inside of the tables. These amplification boards are able to power loads with up to 3 amps of current per channel.

Internal Table Lighting Given the translucent properties of the white acrylic top sheet, we are able to illuminate objects on the tables from below - similar to a photographers' light table. We have mounted two high power RGB LEDs on the inside corners enabling full spectrum color lighting. These LEDs are powered by 1 watt driver boards (one per color per LED) and controlled via six of the amplified PWM channels. This allows for independent color control of each half of the table divided along its longest side.

Software

Control over the *liminal surface* is achieved via a combination of commercially available and custom designed software. The boards were originally tested using code written in Max/MSP/Jitter. More recently, the programs have been ported to Max for Live - a feature of Ableton Live that allows Max patches to be embedded within a Live scene. This allows for the flexibility of control allowed by Max while making use of the convenient user interface, sequencing ability, and data storage paradigm of Live.

Individual software modules have been constructed for each type of gadget designed for the tables. In this way, the computer will accurately scale incoming data based on known sensor types and send out actuator appropriate control signals. The values (both sensor and actuator) are freely mappable to any other software parameter.

As an example, one gridpoint gadget (shown in Figure 4) consists of a rotary solenoid with a wooden arm that can strike objects in a percussive fashion. Along the side of this gadget is a slide potentiometer. In software we can map the position of the slide potentiometer to the rate at which the rotary solenoid strikes. We could, just as easily, map this position to the volume of a computer generated sound, the brightness of the internal table lighting, etc. Similarly, input from any source, including computer automated processes, can be mapped to control the rate of the rotary solenoid. When using the OSC protocol between networked computers, mappings between two *liminal surface*s are possible.

Paraguay

The first composition for the *liminal surface*, titled *Paraguay*, was commissioned by the Connecticut College Ammerman Center for Arts and Technology for their 12th Biennial Symposium on Arts and Technology "Revolution: Technology as Change". The title is drawn from a short story of the same name in which the author, Donald Barthelme, details the invented geography (both physical and cultural) of a parallel reality:

> "Thus I found myself in a strange country. This Paraguay is not the Paraguay that exists on our maps. It is not to be found on the continent, South America; it is not a political subdivision of that continent, with a population of 2,161,000 and a capitol city named Asunción. This Paraguay exists elsewhere." [15]

We felt that the miniature stage presented by our tables, acts as a lens that refracts and distorts worldly objects - providing them with surreal "uncanny" attributes. As such, this composition focuses on a dual role of objects - as representational images and abstract actors. The characters created are at once familiar and other-worldly. Similarly, the composition balances narrative elements with scenes of abstract imagery and robotic music.

Figure 4. Detail of the *liminal surface* with objects used in the composition *Paraguay*.

The composition employs a wide variety of sensor and actuator gadgets. These include simple switches, photosensitive resistor boxes, X-Y axis controllers, glow sticks, percussive solenoid strikers, and a wide variety of LED-based lighting.

Conclusions

Liminal Surface is a novel new instrument for interactive musical theater. This instrument draws inspiration from the theatrical power of uncanny objects, and places these objects onto a miniature stage for a table-top performance. This instruments leverages the power of computer controlled automata, gestural control through sensing technologies, and generative audio and video to create tightly choreographed performances that integrate a great variety of media in theatrical ways.

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