ORBOPHONE: A NEW INTERFACE FOR RADIATING SOUND AND IMAGE

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ABSTRACT

The Orbophone is a new interface that radiates rather than projects sound and image. It provides a cohesive platform for audio and visual presentation in situations where both media are transmitted from the same location and localization in both media is perceptually correlated. This paper discusses the advantages of radiation over conventional sound and image projection for certain kinds of interactive public multimedia exhibits and describes the artistic motivation for its development against a historical backdrop of sound systems used in public spaces. An account of an exhibit using the Orbophone is given together with description and critique of the prototype, discussing aspects of its design and construction. The paper concludes with an outline of the Orbophone version 2.

1. INTRODUCTION

The concept was devised and realised by Damien Lock for a collaborative exhibit titled Shades Of Light presented at the "Don't let sleeping androids lie" exhibition, Sculpture Square, 155 Middle Road, Singapore, from June 9th to August 28th 2005, as part of the Singapore Arts Festival 2005. The work presents a selection of readings from Alvin Pang's poetry collection entitled "City of Rain" [2]. These are read by different people to document interpretations that represent a collective response to the text. Themes in the text are developed through accompanying animated images, video, and soundtrack. These elements were sequenced algorithmically in realtime.

1.1. Orbophone - radiation versus projection

Sound radiation refers to a loudspeaker array in which sound emanates from a speaker source or speaker sources positioned in a central location in a room. It differs from standard forms of sound spatialisation where loudspeakers project from the periphery of a room to create an illusion of space. With sound radiation each speaker source within the array emanates from a discrete physical location, in much the same way an acoustic sound radiates from a discrete source. The position of the array within the room determines the overall mix of direct, reflected and reverberant sound experienced by a listener.

Sound radiation offers advantages over the standard cinematic approach to sound spatialisation where surround speaker arrays create an artificial soundfield that surrounds the audience [3]. An artificial soundfield requires careful calibration and control of the acoustics in the room it occupies, and its optimum reception is limited to a region in the center of the speaker array [4]. With sound radiation the speaker array positions sound sources in a centralised location allowing the sound to take on the acoustic characteristics of the room.

Surround speaker arrays operate independently of the screen image, posing limitations on sound spatialisation gestures. Radiating both sound and image from a three dimensional object provides a more unified relationship between the two mediums that naturally interacts with the architectural space the system occupies.

1.2 Sound radiation – historical perspective

Instrument designers have long been producing instruments which either acoustically or electronically radiate amplified sound via speakers which form part of the instrument's body. Luigi Russolo's Intonarumori (noise intoners) constructed between 1913 and 1921 [5] were each fitted with a large metal speaker for this purpose. Ensemble performances in the 1920's of Leon Theremin's early electronic musical instruments [6] is perhaps one of the earliest examples of loudspeakers used for performing music. However, experimental four channel performances by Pierre Schaeffer in the Théâtre de l'Empire in Paris in 1951 signaled the arrival of the use of speaker arrays for spatial sound projection. Whereas Theremin's instruments were each limited to a single speaker, Schaeffer panned signals between the 4 speaker channel. In 1958, Edgar Varese and Iannis Xenakis performed pieces composed for a 425-speaker array installed in the Philips Pavilion at the Brussels Exposition [7]. The first large scale spherical arrangement of speakers was premiered in 1970 at Osaka World's Fair - an arrangement comprising of 50 [8] speakers designed for the performance of Stockhausen works. The Japanese Steel Pavilion in the same year presented Xenakis' Hibiki-hana-ma used "800 speakers situated around the audience, overhead and under the seats". The first permanent installation for acousmatic works was the Gmebaphone' of the Groupe de Musique Expérimentale de Bourges in 1973.

In musical performances, when a performer's instrument is amplified and projected via a soundfield, the sound becomes physically dislocated from the performer. This has posed problems in both performance and the reception of the sound as "the loudspeaker disembodies the actual source" [9]. Performers experience problems maintaining balance in the mix of acoustic and electronic instruments. Audiences also experience difficulty observing the relationship between the physical gestures made by the performers on stage and the resulting dislocated mix of sounds.

Outward bound spherical speaker arrays have a role to play in addressing these problems. Because sound radiation achieves a degree of localisation and naturally dispersed amplification for live signals, they allow electronic instruments to be used in mixed ensembles. Localized in this sense refers to the proximity of:

- the player to the instrument
- the instrument/performer to the other ensemble members

the location of the performer/instrument in the architectural space as perceived by the audience.

Spherical speakers are now commercially available [10]. Acoustic instruments have been shown to have unique frequency dependent radiation patterns [11]. By emulating this characteristic of musical instruments in loudspeaker design it seems possible to integrate sound played on electronic instruments in concert performances with acoustic ensembles. Such an approach has already been adopted by Trueman, Bahn and Cook [12].

2. ORBOPHONE – MACH 1

2.1. Structure

Panning rapidly across the surfaces of a three dimensional object seems an appropriate gesture for audio spatialisation. Such a gesture may describe radiation patterns that are omni-directional or highly directional. The icosahedron form - one of five polyhedrons defined by their congruent regular polygon surfaces and polyhedral angles - was chosen as an enclosure as it can produce a good omnidirectional radiation pattern of sound energy [13]. The dodecahedron with twelve sides is the particular variant of the icosahedron used. Though it roughly approximates a spherical surface, it is economical and capable of delivering a variety of soundfields via individually driven speakers symmetrically mounted on ten of its faces. The top and bottom faces are reserved for image projection and display.

Figure 1 *shows the dodecahedral structure of the Orbophone. A loudspeaker is mounted in ten of the twelve pentagonal faces*

2.2. Sound

Two modes of sound radiation are possible with the Orbophone: isotropic and anisotropic. Isotropic is when the magnitude of the sound is uniform in all directions (omnidirectional). Anistropic sound radiation occurs when the magnitude of the sound varies in direction. The radiation modes may be described as:

- a monophonic sound through all speakers (isotropic)
- sound through discrete speakers (anisotropic)
- sound through groups of 2 – 10 speakers (anisotropic)
- sound moving through groups of 2 – 10 speakers (anisotropic)

This configuration of independent directional speakers can produce a variety of spatialisation gestures including circular panning around the asimuth, as well as elevation panning.

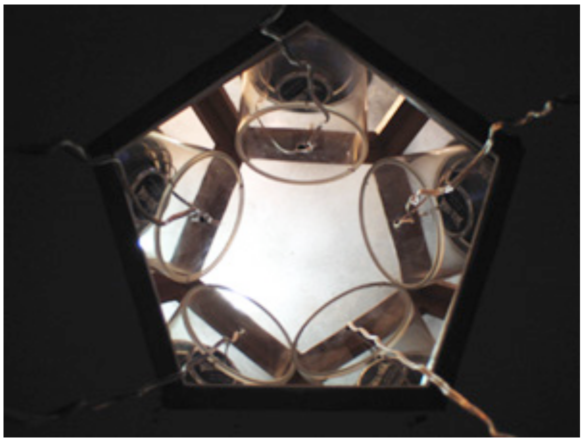

Figure 2 *shows five of the ten loudspeakers each positioned in the centre of one of the pentagons on the side of the structure. An image projector is mounted in the plinth and projects through the pentagon at the base of the structure onto the pentagon at the top.*

2.3. Image projection

Images are radiated via a high resolution projector connected to a computer's video card. The projector is positioned underneath the Orbophone and points upwards through its base. Images reflect off and through translucent surfaces on all faces of the dodecahedron except the bottom. The top face has no speaker so has a clear display area where images can be viewed distinctly. The translucent surface also allows light to disperse and influence the visual ambience of the space around the Orbophone. Image is also projected onto the ten pentagonal faces of the dodecahedron. Here, image is limited to the surface area surrounding the loudspeaker on each face.

Figure 3 *shows a close up of bleached mulberry fibres which enhance light absorption properties of the surface*

Each pentagonal face is made of transparent acrylic material. This was treated to make it translucent in order to catch images projected from the rear projection system. This was achieved by thinly and evenly coating each surface using 3M Spray Mount™ Artist's Adhesive. This transparent aerosol spray loosely simulates the effect of sand blasting on the acrylic surface to prevent light from going straight through the transparent panels. This then enabled each surface to be thinly coated with bleached mulberry fibre to further enhance light absorption.

The Orbophone projects light in a variety of ways:

- at close proximity (up to 3 metres) distinct images can be viewed on any surface
- further away (from 3-25 metres) patterns and colours appear to radiate from the Orbophone
- light is dispersed through translucent surfaces onto surrounding walls and ceiling

2.4. Media design

Media designed for the Orbophone was algorithmically organized and comprised of both pre-recorded and synthesized elements. Parameter mapping between sound and image systems heightened the relationship between these mediums. Abstract images worked well as they were able to be prepared without the need to accommodate geometrical aspects of the screen surface. Supercollider [14] was used to sequence the sound events and to communicate event information via Open Sound Control [15] with the image projection engine running on Max/MSP/Jitter [16]. Improvements for Orbophone media design include:

- Integration of non-abstract visual material that is oriented in a way so it may be projected as a coherent image on the 3-dimensional projection surface
- dynamic organization of the material so that it is partial to viewer interaction and the influence of control parameters originating from user interference.
- Automatic calibration of the audio/light levels to suit a variety of installation scenarios.

3. ORBOPHONE – MACH 2

The Orbophone was deployed as an installation in an art gallery situated on the Singapore tourism roadmap, and open to the general public. Audience reaction suggested several improvements. The image projection area needed to be increased as structural beams and opaque speakers tended to obstruct the visual content. The content on display could be more effective if the audience could interact with it rather instead of watching something controlled by an algorithm.

3.1. Transparent sound interface

The Orbophone offers new possibilities for collaborative interaction. The quality of human interaction in any display system is increasingly recognized as a key element in relating to the content on display [17]. Its spherical shape and moderate size allow groups of people to assemble around it, offering a comfortable and practical setting for discussion about the projected material. The addition of an interactive interface suitable for group interaction would further maximize the flexibility of the system to present information, be it artistic or informative.
The planned user interface will detect proximity of a body to each surface of the dodecahedron via an array of non-contact sensors. This allows hand gestures made above the surface of the Orbophone to influence or interfere with the projected media content. These would suit a wide range of intuitive control gestures for the audio visual content on display. Various composers and performers who work with sound spatialisation report difficulties using 3-dimensional gestures to control sound trajectories [18]. An interface using an array of proximity sensors will address that problem. A hand hovering over a particular surface could direct sound to that speaker surface. This provides intuitive direct control over the spatial position of the sound. The gesture would be further reinforced if the image display system tracked the relocated sound.

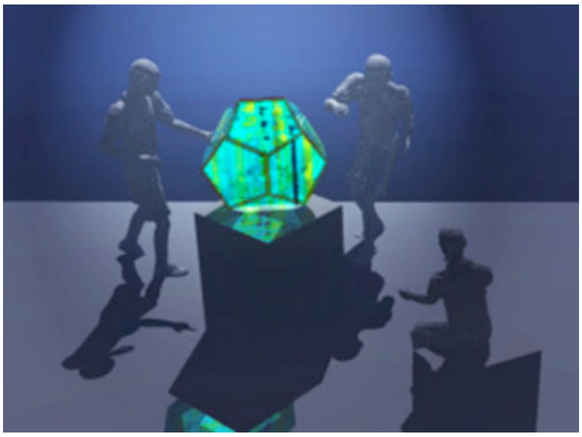

Fig 4: *Mock up of group interaction with Orbophone. Thin film speaker technology enables spherical sound projection together with uninterrupted image projection*

3.2. Uninterrupted sound and image radiation

One obstacle for the full realization of this display system is to project uninterrupted images from all faces except the bottom face where the projector is positioned. The author has identified a thin film speaker technology built from a durable polarised polyvinylidene fluoride, material which has piezoelectric properties [19]. It is comparable to traditional speaker technologies in both performance and durability [20]. It can be translucent, and cut to many sizes and shapes.

In order to achieve higher image fidelity and uniformity of light diffusion on projection surfaces, tests are being conducted using various light management vinyl films made by 3M. These films are designed for application to flat acrylic or polycarbonate surfaces [21]. Normally used by sign makers in internally illuminated signs, incorporating light management film can help to diffuse light and eliminate "hot spots" or glare on projection surfaces. As these films are uniformly white and allow different levels of light transmission, they are suitable for use as back projection surfaces. At an average thickness of 0.1mm, the adhesive films are flexible can easily be applied to each facet of the Orbophone to complement the polarised polyvinylidene fluoride used for sound projection.

3.3. Interface development

The interface is an array of E-Field sensors, made using the Freescale Semiconductor MC33794 E-Field IC. External electrodes allow this IC to detect objects in an electromagnetic field and register their movement in the field as a change in voltage [22]. Electrodes on each surface create a constant interference field around the Orbophone. Communication with the MC33794 will use a microcontroller SPI port. This allows for expanded configurations of multiple sensors where more than 9 electrodes are required. Design challenges include calibration of range and sensitivity, minimizing interference, and eliminating crosstalk between the sensors.

4. CONCLUSION

The Orbophone instrument described above marries sound and image radiation into an adaptable instrument suitable for composing works that investigate the relationship between the two mediums. Future realizations of the instrument will overcome some of it's limitations by enabling the uninterrupted radiation of audio/visual content controllable via an intuitive interactive interface.

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