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The Wrist-Conductor

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ABSTRACT

The starting point for this project is the want to produce a music controller that could be employed in such a manner that even lay public could enjoy the possibilities of mobile art. All of the works that are discussed here are in relation to a new GPS-based controller, the Wrist-Conductor. The works are technically based around the synchronizing possibilities using the GPS Time Mark and are aesthetically rooted in works that function in an open public space such as a city or a forest. One of the works intended for the controller, *China Gates*, is discussed here in detail in order to describe how the GPS Wrist-Controller is actually used in a public art context. The other works, *CitySonics*, *The Enchanted Forest* and *Get a Pot & a Spoon* are described briefly in order to demonstrate that even a simple controller can be used to create a body of works. This paper also addresses the breaking of the media bubble via the concept of the "open audience", or how mobile art can engage pedestrians as viewers or listeners within public space and not remain an isolated experience for performers only.

Keywords

Mobile Music, GPS, Controller, Collaborative Performance

1. INTRODUCTION

1.1 Performing in Public Space

Performing art in civic space automatically awakens curiosity and interest in the public because it is lifted out and away from the everyday by the performer's actions. This type of art reaches a diverse audience, people who do not generally make it to modern art events. The resulting social interaction in public space is unique and is an important issue concerning the concept of audience and performing space in general. Although mobile music works are finding their way into civic space, they tend however to isolate the public as a possible audience due to a focused use on headphones or personal display devices that enclose the user within a non-bursting "media bubble". The resulting isolation of the performer from the audience therewith deprives both sides of one of the most important functions of public performance: social interaction. However, the media-bubble can be burst and a new audience be discovered. The Performances of the various works for the Wrist-Conductor have proven this and also that a combination of traditional Instrument with the Wrist-Conductor brings about more visually animated playing experience to the public that extends mobile music into the performative and visual.

2. BASIC CONCEPTS

2.1 SynchPoint and Phasing

GPS satellites transmit signals to GPS receivers, which passively receive them. The signals provide each receiver with coordinates plus a sync signal termed the Time Mark. So that all GPS satellites are able to synchronize operations, the signals are repeatedly transmitted at exactly the same instant. As mentioned, the Wrist-Conductor works are all technically based around the synchronizing possibilities using the GPS Time Mark, and it is used to synch an on-board clock housed on the microcontroller of the Wrist-Conductor. The shifting of this clock pulse algorithmically is the basic idea behind the controller.

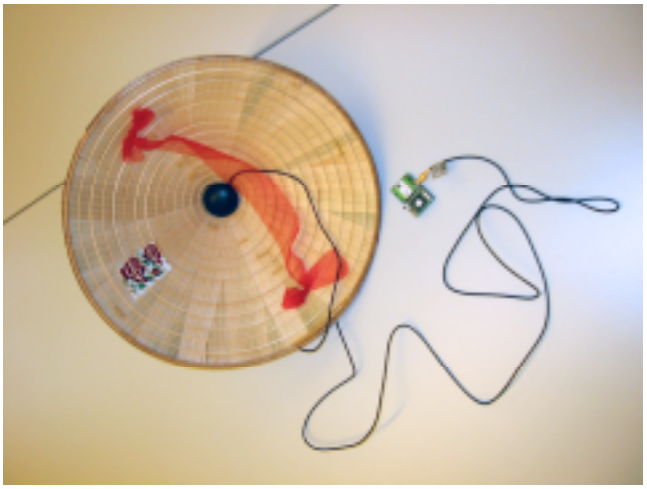

Fig.1 Wrist-Controller with Wearable Antenna

Since the Time Mark arrives at the same moment for all of the performers, having the clock shift algorithmically makes it possible to synchronize and desynchronize events between players. To accomplish this technically and to employ it aesthetically as a compositional mechanism, a single geographic point within the performance space is used as a reference point. This reference point is referred to as the "SynchPoint". It is exploited algorithmically by placing a time delay of a certain amount of milliseconds between the arrival of the Time Mark and the lighting of an array of LEDs. This results musically in a form of rhythmical phasing, which is exploited compositionally by the performers when using the Wrist-Conductor.

The LED Array lights up in series to signal the performer to execute an event in precise manner and at an exact moment. The moment of execution stands in geographical relationship to the performance area, because the delay amount is dependent on GPS coordinates. The amount of delay at the SynchPoint is 0 milliseconds and at the edge of the performance area the delay is 1000 ms. The delay time is mapped linearly over the performance area regardless of the area's size. Performers move freely with in the space and as they relocate, i.e. move to and away from the SynchPoint, the delay time modulates. The more dispersed the performers are as a group the more the rhythmic phasing increases.

3. ZONES AND TEMPO MODULATION

The distance between the SynchPoint and the parameter of the performance space divides into three "Zones". The performer's present position is assigned to one of the three Zones. They act as gears and function as follows: The performance area is divided up into three Zones by the program. The Zones form concentric circles around the SynchPoint with the distance 500 meters (for example) from the center to the areas edge. The Zones divide the entire range of the performance area evenly and follow a simple gearing rule. If the performer is in Zone 1 every GPS Clock Pulse is used to trigger the light array, if the performer is in Zone 2 every other GPS Clock Pulse is used to trigger the light array, and if the performer is in Zone 3 every third GPS Clock Pulse is used to trigger the light array. Therefore, as the players move away from SynchPoint the banging on the gongs is diminished until it has been reduced to 1/3 of what it was at the SynchPoint. A further interesting rhythmic effect results as players come and go from one zone to the other and events and pauses get flipped and are heard as ping-pong type syncopations between performers.

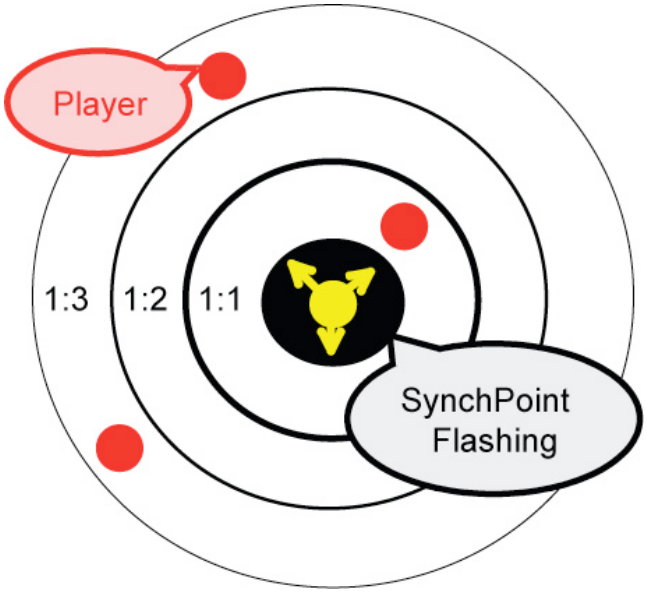

Fig. 2: Zones in relationship to the SynchPoint.

4. SOFTWARE

4.1 China Gates

This section explains the software in detail in relationship to the *China Gates* work. One obtains here a better impression of how the controller is actually employed in public space and how the software for *China Gates* functions in comparison to the other works mentioned later. The diagram in Fig. 2 should help the reader follow the process that takes place between the arrival of the GPS Time Mark from the GPS-Satellites and the flashing of the LED light array on the Wrist-Conductor. The delay function is key to a whole principle of "harmolodic-movement" inherent in the *China Gates* work. For example, when the delay amount is the same between any number of players, the LED light array on all the devices are synchronized and thus are all of the gongs hits they signal to take place. This results in a single sounding chord, whose constituent tones have a common attack point and whose number is in proportion to the number of players having the same GPS coordinates. In the opposite situation where players are scattered within the performance area, a melodic line made up of the constituent tones of chord is heard as melody.

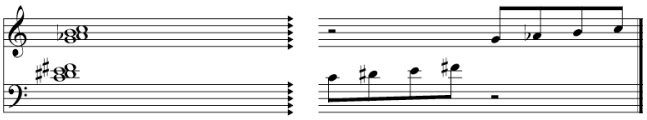

Fig. 3: Unfolding harmolodic movement

China Gates uses a series of tuned gongs whose number is determined by the number of performers. The tone scale (depicted in Fig. 3) is used -either in its entirety or only in part- to give the piece a touch of the orient on the horizontal melodic side and a more western type flavor of dissonance on the vertical chord structure side. The scale, having a mix of minor thirds, minor seconds and major seconds, is unique in that it effortlessly produces both interesting harmonies as well as enchanted melodies Regardless of which gongs are chosen, they must be able to be heard at a distance equal to the diameter of the performance area to be effective. We found that the right choice of beater used, helped greatly in achieving this. In the case of the tuned gongs, the eight-tone scale mentioned above was used. Transpositions, doublings, as well as leaving tones out are all possibilities to adjust the size of the group to the number of tones of the scale. Changing gongs during the performance has proved to be an effective means to create harmonic contrasts during longer performances.

5. PERFORMANCE CONCEPT

To start off a performance of China Gates, all of the players meet at the "SynchPoint". After starting the GPS controller, each player leaves the SynchPoint one by one in a walking tempo. Each of the players has a route that is to be taken through the city by foot. Each route is unique in length and direction. This insures that all the "corners" of the performance area get explored. Each of the players tries to move when the others are not moving. This brings about a type of "choreographic counterpoint" made up of independent movements that are the basis for the rhythmic coloring caused by the vertical to horizontal harmolodic unfolding. All of the routes start and end at the chosen SynchPoint. The performance is not limited to a discreet number of events and regardless of the number of events played, the performance ends for each performer when he or she has returned to the SynchPoint.

6. HARDWARE

6.1 Meeting the Design objectives

A large factor in the design of the Wrist-Conductor was providing a functional device that was small, robust and lightweight enough to be wearable. Also, since it is to be used by amateurs, it was designed to be easily used and to be produced at low cost. The technical demands on the hardware were satisfied by a general purpose microcontroller (Hitachi Renesas H8) with all the necessary communications ports, display drive lines and timing functions. Easy reconfiguration of the device was also important since in the framework of Pedestrian GPS the device would be used in various settings, geographic locations and for various works, all having different demands on the relevant software.

6.2 Getting a Reference

The GPS receiver used in the Wrist-Conductor is the SIRF Star III GPS Chipset. It has a microprocessor with onboard resources. The Hitachi microcontroller is the main one and it calculates where the performer wearing the device is located and what to do with the calculated information. It has a number of tasks to perform and these are: parse the GPS data from the SIRF module, establish the SynchPoint coordinates, calculate each second the radial distance away from the SynchPoint, synchronize a local clock by simple phase lock with the main Time Mark event, set up a 10ms resolution timer where 10ms delay = 1 meter, and finally set up the time queue.

6.3 The LED Array

An LED Array, consisting of four LEDs, is used as a simple display that acts in a similar way to a metronome. The flashing of the LED Array is set to a constant beat of one second, which gets shifted by the delay and geared down by the zone changes. To cue the user as when to strike, the LED train must start in advance of the actual strike time. Here, one needs to know the GPS pulse in advance and since this is impossible, it must be predicted by calculation. To do this, the previous GPS pulse and a time queue delay equal to a fixed delay plus a delay calculated as a function of the SychPoint is used. So, three of the four LEDS flash consecutively at 500ms, 300ms and 100ms before the strike is signaled. Finally, all four LEDs flash to indicate the strike moment.

7. RESULTS IN THE FIELD

After much trial and error a relatively high degree pedestrian accuracy was reached with 5 to 10 meter discrimination being evident. Synchronization Issues and GPS related problems were solved as filter algorithms were implemented and the software was tested in the field to limit settings on the parameters used. The degree of precision and number of satellites will always be an issue that results in some errors. However, when GPS data is poor a mock up clock is implemented that has kept the performers going during a performance without any form of interruption. Antenna Issues and mechanical packaging are difficult to resolve because of the limited development time available to meet such demands.

8. VARIOUS WORKS

8.1 City Sonics

The works described here demonstrate that even a simple controller can be used to create a body of works. *CitySonics* uses the GPS Wrist-Controller to coordinate the playing of a chorus of gongs or horns by multiple participants. Participants excite the instrument as they are scattered through out the performance space. The participants turn or move to a new position and the color of the chord is altered automatically due to the acoustic qualities of the environment. Some of the frequencies making up the natural harmonic recipe get attenuated or amplified by the surrounding materials. Regardless of the size or type of chord played, it will always be an ever-changing sonic metaphor of the public space in which the performance takes place. *CitySonics* also demonstrates a workable solution to performing a piece in a place where the GPS signal tends to fall out. These errors can be understood as a tacit function that re-voices the chord and adds to the structure of the piece rather than subtract from its effectiveness.

Fig. 4: Erratum Ensemble performing China Gates

8.2 Get a Pot & a Spoon

This is a work based around an effective means for public protest: the banging a pot with a spoon. The idea was inspired by the number of homeless that I discovered living in the streets in downtown Victoria, Canada. The city has high housing costs and low vacancy rates with 25% of its population living below the poverty line. The situation was brought about by the Government's disinterest in providing affordable housing, holding the income assistance rate below the poverty line and the shelter rate above reasonable. A performance of *Get a Pot & a Spoon* would therefore be a protest against the politics that create such asocial conditions. For this work, each player is given a pot, a spoon and a Wrist-Controller. This work employs the same algorithm as in *China Gates*, but with divergent SynchPoints for each performer. As a mob of about 50 persons walk through the city banging, clouds of sound are created that modulate in perpetual variation and protest.

8.3 The Enchanted Forest

The work is more complex as the two previous works and in contrast to China Gates, it was conceived for professional players. It is written for a series of Hunting Horns and has an actual score in traditional music notation, which must be precisely followed. Also, the piece has a particular quality of

entcontextualization as the horn players perform within a city setting and not within the expected forest setting.

9. EVALUATION & FUTURE WORK

Difficulties in working with a lay public in contrast to professionals were found in regard to having discipline, which is common among professional musicians but not among the lay. GPS signal quality and availability are certainly less than optimal. Although good results are still achievable by using work-around solutions or by using the deficiency as a central formal aspect of a work, the situation is still far too limiting. At the present time, the Wrist-Conductor uses a Hitachi microprocessor that uses a dedicated operating system geared to running a particular software configuration. The configuration is certainly adequate for a group of works in a minimalist style, which exploit the subtleties of the software implementation in a interesting manner. However, uniqueness in these works is created by the performance situation to a large extent. Although the present configuration provides a good tool for even further works in that style, an actual operating system is desired. With it more complex artworks could be developed, which explore the role of the program in the artwork more.

10. CONCLUSION

Using wearable computing technology within global ubiquitous networks as an art tool allows interacting with society as part of a collective consciousness. This bears significance for the creator of mobile art and also for its recipient participants who likewise realize that personal space endowed with added capabilities and explored as an extension of the self and body points to a global culture of the self in which the individual is not limited to what they are part of globally. The above networking statement was developed over a period of years in which experiments, performances and tool development for mobile works was being done (and still is) daily for mobile works at the ETH Zurich in Switzerland. We have also had the opportunity to prove its truth in the work "Going_Publik"[4] for distributed ensemble and wearable computers and are experimenting further with the Wrist-Conductor and its related works.

11. ACKNOWLEDGMENTS

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