Evolving The Mobile Phone Orchestra

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ABSTRACT

In this paper, we describe the development of the Stanford Mobile Phone Orchestra (MoPhO) since its inception in 2007. As a newly structured ensemble of musicians with iPhones and wearable speakers, MoPhO takes advantage of the ubiquity and mobility of smartphones as well as the unique interaction techniques offered by such devices. MoPhO offers a new platform for research, instrument design, composition, and performance that can be juxtaposed to that of a laptop orchestra. We trace the origins of MoPhO, describe the motivations behind the current hardware and software design in relation to the backdrop of current trends in mobile music making, detail key interaction concepts around new repertoire, and conclude with an analysis on the development of MoPhO thus far.

Keywords

mobile phone orchestra, live performance, iPhone, mobile music

1. INTRODUCTION

The Stanford Mobile Phone Orchestra (MoPhO) provides a platform for research, instrument design, and sound design, as well as new paradigms for composition and performance. The overarching objectives of MoPhO are to explore new possibilities in research, musical performance, and education. Though these are in many ways similar to those of the Stanford Laptop Orchestra (SLOrk) [18], MoPhO uses hardware, software, and interaction techniques that are quite unlike those that have been explored using laptops.

MoPhO has undergone significant development since its inception in 2007 [19]. Beyond a change in mobile device (from the Nokia N95 phones to the Apple iPhone), the Mobile Music (MoMu) Toolkit [1] has been written to facilitate programming mobile musical instruments. With an emphasis on the aesthetics underlying mobile music, this paper summarizes the context of mobile phone usage in the domain of music (§2), describes current cultural trends, hardware, software, and interaction designs (§3), and concludes with an analysis of the MoPhO paradigm with ideas for future directions (§4).

2. ORIGINS

Mobile phones have come to greatly affect the lifestyles of people around the world. With the increasing popularity of smartphones that offer advanced capabilities and user-friendly interfaces, mobile phones have become powerful yet intimate devices that serve a myriad of functions far beyond their original intended usage. Naturally, music is one such domain in which mobile phone users have found new cultural and social trends. This section briefly surveys developments over the past decade in the exploration of the mobile phone as musical instrument, reviews the birth of the mobile phone orchestra within this context, and discusses how the aesthetics of MoPhO as an academic ensemble parallels the evolving societal trends of mobile phone usage in the domain of music.

Mobile phones have been explored primarily as new interfaces for controlling musical parameters and as part of locative performances. For instance, Tanaka controlled streaming audio using accelerometer-based custom augmented PDA (2004) [14], and Geiger designed a touch-screen based interaction paradigm with integrated synthesis on the mobile device (2003, 2006) [6, 7]. Other examples of employing augmented interfaces on mobile phones for music include CaMus [13], which uses the mobile phone camera for tracking visual references for musical interaction.

Beyond taking advantage of sensors, other works leverage the phone's mobility and ubiquity. Levin's *Dial Tones* (2001) is among the first works to explore the concept of using mobile devices as part of the performance by having the audience members be the primary sound sources [9], and Tanaka and Gemeinboeck's installation piece *net d'erive* (2006), through GPS and wireless communication, traced and displayed position information of moving audience in city streets [15].

Gaye, Holmquist, Behrendt, and Tanaka provide a definition of mobile music and describe how it can enable novel forms of musical experience by taking advantage of changes in social and geographical context [5]. Wang, Essl, and Penttinen offer a more complete survey of previous works using mobile phones [20].

In 2008 as part of the *au Design Project X* (which evolved into *au*'s new mobile-product brand *iida* in 2009), Yamaha explored transforming the mobile phone into musical instruments. Based on the concept of "Musical Mobile Phones / Instruments You Can Carry", Yamaha exhibited their vision of future mobile phones through several prototypes. For instance, "Band in my pocket" features five musical interfaces including those reminiscent of a trumpet, trombone, and harmonica; "Sticks in the air" splits the phone into two sticks to hold in each hand; and "Strings for fingers" contains ten strings, in the body of the phone, to pluck.[21] [22]

The founding of the Stanford Mobile Phone Orchestra in

Figure 1: The Stanford Mobile Phone Orchestra

2007, as a repertoire-based ensemble using mobile phones as the primary instrument, was intended to further these concepts as well as explore new possibilities. The increasing computational power of mobile phones has allowed for sound synthesis without the aid of an external computer. In fact, mobile phones have come to be regarded more as "small computers" with PC-like functionality than as simply phones with augmented features. For the purpose of music making, one may even regard the phone as being superior to computers, offering light-weight yet expressive interactive techniques made possible by its various on-board sensors.

The aesthetics behind MoPhO design considerations embrace the new culture of "mobile music" enjoyed by mobile phone users. MoPhO aims to improve the process of instrument development and performance experience — not only for students and researchers in computer music, but also for the broader population — thereby exploring new technological and artistic opportunities for music making. The next section describes the present status of the ensemble against the social backdrop of increasing mobile application usage.

3. PRESENT

The proliferation of smartphones and other mobile platforms — such as Nintendo DS or the PSP — along with their corresponding SDKs and APIs have encouraged developers to create applications for these devices. The sheer number of mobile instruments that have been developed recently illustrates the increasing interest in mobile music applications. These applications cover a wide range of musical interactions and sounds, from basic sample-based and touch-triggered instruments[2] to more advanced accelerometer and multitouch based synthesizers[12].

The availability of such instruments has encouraged both their developers and application consumers to explore their use in a number of creative ways. For instance, the idea of a "mobile instrument mashup"[8], where a single or multiple performers play a variety of mobile instruments simultaneously in a jam session, is an interesting concept as it shows an increasing interest in collaborative mobile music making and means to generate musical expressions in a social setting. Examples covering a wide spectrum of sounds and interaction techniques can be found on the web. A short reference list can be found in Appendix A.

In this context, mobile music ensembles have found their place in universities and other institutions. Aside from Stanford MoPhO, other ensembles have emerged, such as The Michigan Mobile Phone Ensemble[10], the Helsinki MoPho[11] and the Yamaha Mobile Orchestra[23].

3.1 Hardware

Over the past year, MoPhO has seen a considerable change in the physical hardware used for performance and instrument design. Originally, MoPho developed and performed on un-amplified Nokia N95 smartphones generously donated by Jyri Huopaniemi of Nokia. While these first generation phones served well, the Apple iPhone is currently the ensemble's platform of choice due to its superior computing power, numerous on-board sensors, and convenient development environment.

To provide additional amplification and boost bass frequencies, wearable speaker designs were tested and evaluated. Three initial designs were prototyped in the following form factors: necklace, jacket, and gloves.

Each prototype was based on commodity hardware and

Figure 2: Building the Speaker Gloves

employed minimal tools. The prototype designs were quite basic, but nonetheless allowed testing on usability and interaction experience (Figs. 3, 4). While the necklace and jacket designs served the basic purpose of amplification, they felt bulky and difficult to control, especially the directionality of sound. On the other hand, the close proximity and controllability of the gloves in relationship to the phone seemed to provide a much more satisfying, immediate, and transparent user experience.

Using the glove speakers, the natural position of holding the mobile phone with one hand and controlling the on screen user interface elements with the other hand results in the sound projecting both above and below with respect to the surface of the mobile device. Performers can easily change the directionality of the amplified sound by making simple hand or arm gestures.

Moreover, the close distance between the speaker and phone can be seen to more closely approximate an acoustic instrument. As mentioned in [16, 18], strongly associating sound sources to their respective instruments aids in the emulation of a traditional orchestral settings and provides a closer association between instrument and performer. This is an essential aesthetic of MoPhO and has been apparent through all aspects of past and current performances.

Figure 3: Prototype Designs: Speaker necklace and speaker jacket

3.2 Software and OS

The change in hardware consequently led to changes in the software environment. The previously used Nokia N95 smartphones run Symbian OS, use C++ and Python programming languages, and require a somewhat complex initial development setup procedure. Such development environment was perceived to be more formidable for new developers and constrained the resulting musical interaction and performance.

With the change to iPhone hardware, mobile phone software development has been greatly improved. The iPhone SDK provides tremendous development support, largely in

Figure 4: Selected Prototype Design: Speaker gloves

the Objective-C programming language using the XCode development environment. The iPhone SDK provides tools for graphically designing and testing user interfaces (Interface Builder), and projects can include C or C++ code. To streamline instrument development, an additional layer of abstraction has been created on top of the iPhone SDK through the MoMu Toolkit, greatly simplifying audio input/output, synthesis, and on-board sensing among other things [1].

3.3 Instruments, Interactions and Performances

Figure 5: Stanford Mobile Phone Orchestra Concert: December 3, 2009

A concert in December 2009 gave MoPhO an opportunity to explore capabilities provided by these new hardware and software platforms. The instruments and pieces presented in this performance were built using the Mobile Music Toolkit [1], and focused on achieving a tight coupling of sound and physical interaction. In all but one piece, performers amplified sound using the glove speakers. In *Wind Chimes* described below, however, an 8-channel surround sound audio system was used.

In a typical concert setting, performers are on a stage in front of the audience. The possibility of moving around, however, is greatly facilitated by the use of portable and untethered devices. To take advantage of this fact, MoPhO decided to experiment with a different stage setup. The concert was held in an indoor setting and the performers were surrounded by the audience. Moreover, performers frequently walked around in the performance space, making various physical gestures from bouncing an imaginary ball to swinging arms. This configuration, with the performers' initial locations shown in shaded gray, enables them to move around the audience, thus giving each member of the audience a different musical experience, depending on their position (Fig. 6).

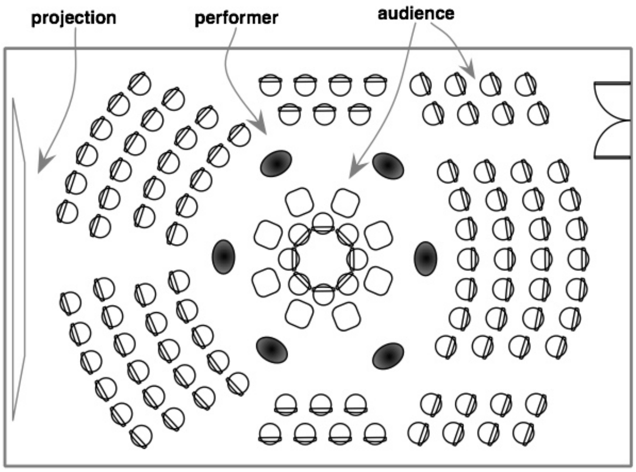

Figure 6: Stage plan.

Colors by Jieun Oh is an instrument with an intuitive multi-touch interface and visualization implemented using OpenGL ES (Fig. 7). The main screen displays black and white horizontal lines to guide the pitch layout of the screen, much like a simplified piano keyboard. Performers trigger polyphonic sounds by touching the screen in up to five locations; moving fingertips in horizontal and vertical directions controls the volume and pitch, respectively, of the triggered sounds. The performers are given a visual feedback of the precise location of touched points through colored rectangular markers. Additionally, a movement preset specific to the piece *"Colorful Gathering"* under settings facilitates changing parameters between movements of the piece. The simple and intuitive interface allows performers to trigger complex polyphonic sounds with subtle variations in pitch and volume without needing to look at the screen. Consequently, it encourages face-to-face interaction between performers, much as in a classical ensemble setting. During the performance, a performer walks up to another performer to carry out a sonic conversation, in which various emotions—from teasing, curiosity, to excitement and discouragement—are conveyed.

interV by Jorge Herrera is a collaborative instrument that uses the iPhone accelerometer as its principal expressive control (Fig. 7). Basically, two axes of acceleration are mapped to the volume of two notes simultaneously played. The performer controls the sound using expressive gestures

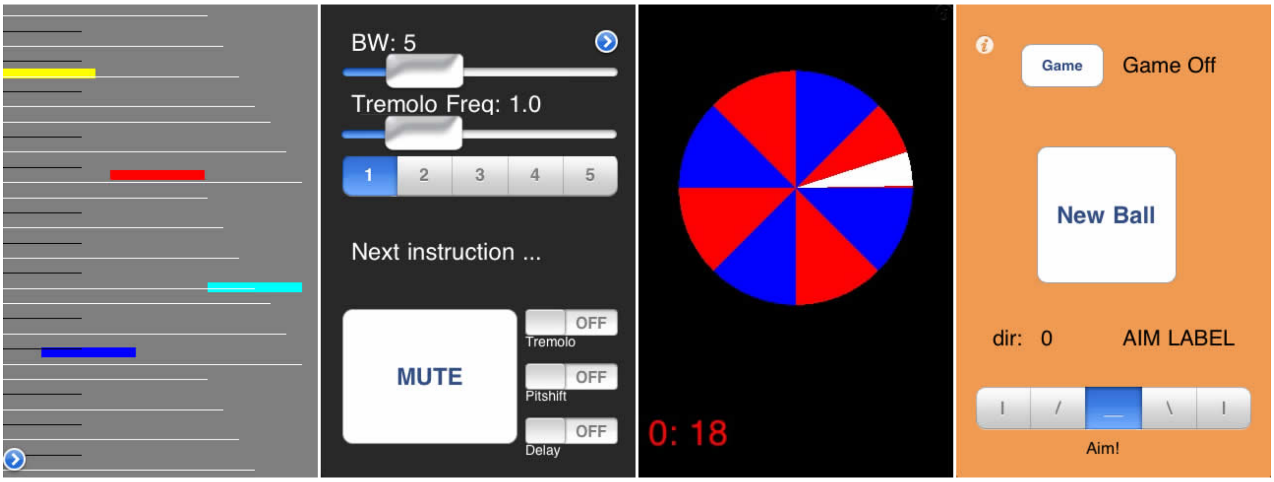

Figure 7: Screenshots of Instruments: (from left to right) Colors, interV, Wind Chimes, SoundBounce.

such as gentle tilts or larger arm movements, allowing the audience to visually map sounds to movements. Also, the instrument is capable of receiving and displaying instructions sent by a central server during the performance. Using this instrument, MoPhO performed *intraV*, a piece that takes advantage of the two main features of the instrument — motion control and network message transmission. Based on the instructions received, performers move around the stage and walk in between the audience, while moving their hands and arms to create a continuously changing soundscape.

Similar to this idea, *Wind Chimes* by Nicholas J. Bryan leverages mobile phones as directional controllers within a 8-channel surround sound audio system (Fig. 7). To do so, the physical metaphor of wind chimes was used to connect "physical" chimes (8-channel system) to a wind force (performer/mobile phone). For performance, one or more players stand in the center of the playback system, orient themselves in a specific direction, and physically blow into the phone microphone to trigger a gradual wash of wind chimes sounds moving across the performance space. While the metaphor is fairly simple in concept, the familiarity and direct interaction proved beneficial and allowed audience members to immediately associate the performers actions to the auditory result, just as in a traditional musical ensemble.

Finally, the piece *SoundBounce* by Luke Dahl is based on the metaphor of a bouncing ball [3]. Virtual balls and their physics are simulated, with the height of the balls controling the sound synthesis. Performers are able to bounce sounds, drop them, take aim at other performers, and throw sounds to them, causing the sound to move spatially from one performer to the other. The instrument is designed to be gesturally interactive, requiring minimal interaction with the GUI. To that aim, all instrument interactions and state changes have audible results which contribute to the sound-field of the piece. The piece ends with a game in which performers try to throw sounds and knock out other players' sounds. As players' sounds are knocked, their sound output becomes progressively more distorted until they are ejected from the game and silenced. The winner is the last player still making sound.

4. ANALYSIS

Since the instantiation of MoPhO in 2007, transforming mobile phones into "meta-instruments" has become an achievable reality. A switch to the iPhone platform, with its powerful capabilities and well-documented SDK, has facilitated the process of repurposing the phone into a musical instrument. The 2008 paper on the birth of MoPhO noted that "there is no user interface that would allow non-programmers to easily set up their own composition yet." While this still remains problematic, the problem has been partly mitigated through the newly written MoMu Toolkit [1]. Developers can now write primarily in C/C++, avoiding Cocoa and the iPhone SDK if they desire. Additionally, Georg Essl has authored an environment that offers abstractions for interaction and interface design on mobile devices [4]. In this manner, many of the technical barriers to creating a mobile phone instrument are being tackled by numerous research groups.

Nonetheless, there are many areas for future development, especially with regards to instrument re-use and performance concepts in light of the burgeoning interest of mobile music making. With the ease of software development comes proliferation of instruments, and consequently these "soft instruments" have become more or less disposable items: often times, an instrument gets written for a specific piece and gets abandoned thereafter. A public repository on existing instruments and documentation may encourage instrument sharing, re-use and further development.

As for exploring mobile music performance paradigms, future work should focus on the social and geographical elements of performance. These types of musical experiences may manifest partly on-device, and partly in back-end "cloud computing" servers, and seeks to connect users through music-making (iPhone's Ocarina is an early experiment [17]). Future directions for the ensemble include experimenting with pieces that involve participation from the audience as well as performers from geographically diverse locations and potentially asynchronous models for collaborative performance. An architecture to facilitate social musical interaction between performers who may be distributed in space should be developed to better understand the phenomenon of mobile music making. Mobile phones' ubiquity, mobility, and accessibility have begun to break down the temporal and spatial limitations of traditional musical performances, and we anticipate blurring of once-distinctive roles of a composer, performer, and audience, as one can now more easily partake in the integrated music making experience.

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APPENDIX

A. EXAMPLES OF MOBILE INSTRUMENT MASHUPS

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