Interactive Mobile Music Performance with Digital Compass

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ABSTRACT

In this paper we introduce an interactive mobile music performance system using the digital compass of mobile phones. Compass-based interface can detect the aiming orientation of performers on stage, allowing us to obtain information on interactions between performers and use it for both musical mappings and visualizations on screen for the audience. We document and discuss the result of a compass-based mobile music performance, *Where Are You Standing*, and present an algorithm for a new app to track down the performers' positions in real-time.

Keywords

Mobile music, mobile phone, smartphone, compass, magnetometer, aiming gesture, musical mapping, musical sonification

1. INTRODUCTION

Modern mobile phones, especially smartphones (i.e., high-end mobile phones with advanced features and computing power) have affected our life tremendously in a number of areas, including music. With sensors such as multi-touch screen, accelerometer, microphone, camera, GPS sensor, proximity sensor, and magnetometer, a mobile phone has a huge potential as a new musical instrument (or, more generally, a music-making device). Also, mobile music instruments can be networked virtually anywhere without being tethered: this true "mobility" allows the performers to move around the stage (sometimes totally off the stage) freely while playing their instruments, thereby leading to more creative and profound interaction design not only with the audience but also between performers.

Innovative music performances with creative mobile instruments have been suggested by many artists and researchers, as reviewed in [4, 5]. Examples include the *Stanford Mobile Phone Orchestra* (MoPhO) [6, 11], *Michigan Mobile Phone Ensemble* [10], and the *Helsinki Mobile Phone Orchestra* [8]. At the *Mobile Concert* at NIME 2010, Stanford MoPhO presented pieces with several instruments based on different interaction concepts, including *Colors* (multi-touch interface), *interV* (accelerometer), *Wind Chimes* (compass and microphone) [4], and *Sound Bounce* (accelerometer and compass) [3].

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In this paper, we suggest an interactive mobile music performance using the digital compass on mobile phones. This collaborative performance features multiple performers that make sound by taking aim at other performers: compass-measured orientation of each aiming gesture is mapped to a specific musical note depending on which player is aimed at. While this compass-based interaction method is partly similar to those examples mentioned above, we suggest a new method to "track down" the position of a moving performer without any extra device (e.g., optical sensors, webcams, etc.): this enables us to utilize the information on the on-stage formation of performers for musical purpose in real time, making digital compass an intuitive, interactive mobile musical instrument.

2. SYSTEM DESIGN AND IMPLEMENTATION

Figure 1 illustrates the system for our compass-based mobile music performance, which consists of multiple mobile phones (i.e., Apple's iPhones) as performers' instruments and a server computer for sound generation and visualization. Sound is projected through powered speakers connected to the computer, and current status of the performers is displayed on a big screen for the purpose of "sharing" the music-making process with the audience.

2.1 Apps

Mobile apps for this compass-based performance should be able to measure the pointing direction of the iPhone (and send the information to the server, if required). We first used the *KAMPO App*, an OSC controller for mobile music which can measure the iPhone's sensor data (e.g., discrete/continuous touchscreen input, microphone, accelerometer, and compass) and transmit them via Wi-Fi [7].

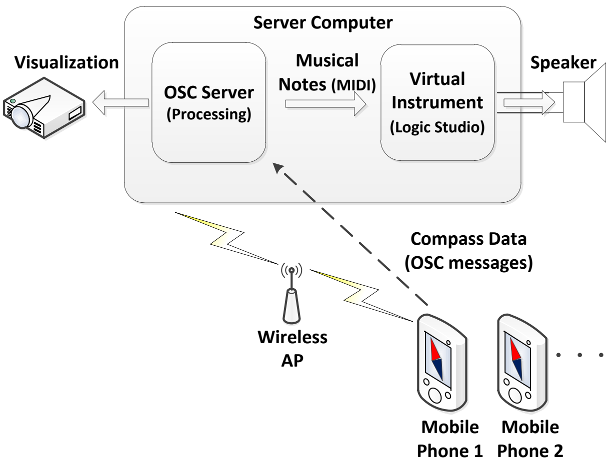

Figure 1. System for compass-based mobile music performance.

HAM is the other OSC controller app used for prototyping our second performance. While both apps allow the performer to take aim by holding the iPhone horizontally and pointing it in any direction, the latter provides additional feature of "hold-and-move" (hence the name HAM) for tracing the position of the performer on the move: more details on HAM will be discussed in section 3.2. Both KAMPO App and HAM are powered by the Mobile Music (MoMu) Toolkit [2].

2.2 Server

The server computer runs a program (written in Processing) that receives/analyzes compass data from the iPhones to detect any meaningful information, and manages data mappings for sound generation and visual display. Similar to most other sensor measurements, compass data values are lowpass-filtered at this stage for enhanced stability and practical use in music (figure 2). The program can run automatically or be controlled by an operator in order to handle unexpected needs (or emergency situations) of the performers in real-time.

Information on sound/music is then transmitted to Apple's Logic Studio for sound synthesis by virtual instruments.

3. PERFORMANCE IDEAS

We present two cases of compass-based mobile music performance. Both feature 1) multiple performers on stage interacting with each other by taking aims, and 2) musical representation of various inter-performer interactions on stage.

3.1 Case 1: Aiming Directions

In this scenario, performers stand at fixed positions (e.g., at the corner of a rectangle in case of four members) and move their iPhones as if scanning around. Each aiming action of a performer at other is detected as an "event." For N performers, there are $N(N-1)$ distinct unidirectional events, $N(N-1)/2$ bidirectional ones, and numerous combinations of those as well that can be used to trigger sound outputs and visual effects. Figure 3 illustrates possible events in a four-performer case.

Based on this mapping we created *Where Are You Standing*, a piece for the KAIST Mobile Phone Orchestra (KAMPO) [9] with tape sound. It was composed by Bongjun Kim, and premiered on June 16, 2011 at *Sonic Phone-o-graph*, a KAMPO mobile music concert held at Hyundai Capital Auditorium in Seoul, Korea (figure 4) [1] (video excerpt from this performance can be found at [12]). The piece is divided into four sections – introduction, development, turn, and conclusion: each section features different combinations of performers and/or harmonic characteristics. The piece begins with one performer taking aim at various directions to the tape accompaniment in order to "demonstrate" the main gesture of the performance. Then in the second section two other performers join the first one, stand at three corners of a triangle,

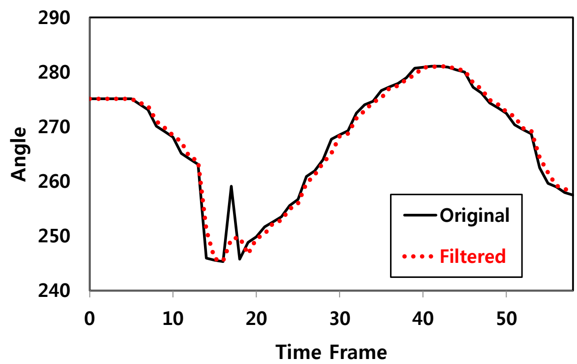

Figure 2. Comparison of raw and filtered compass data.

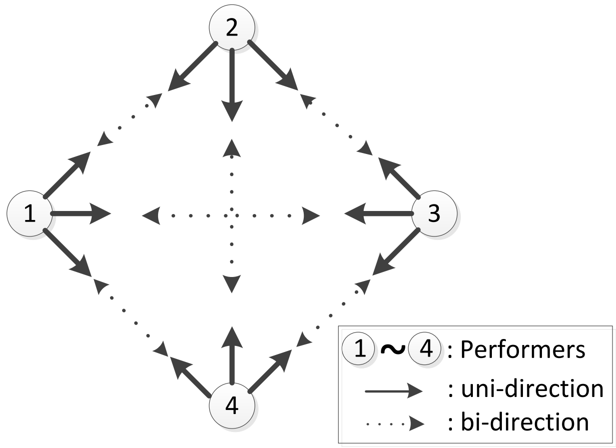

Figure 3. Possible events in a four-player setup.

and start playing piano sound of all "harmonic" notes (in C major scale) by aiming at others. This state of consonance is broken by the introduction of an additional (and the last) performer who represents conflict: the notes played by this performer, as well as the notes played by others when they aim at the performer, are assigned to be dissonant to cause musical tension. Finally the last performer leaves the stage to resolve the tension, and the piece ends with three performers back in congruity.

Table 1 summarizes the event-note mapping pairs used for the piece. Sound Bounce also featured similar direction-to-pitch mappings (in that each of the aiming orientations of performers is assigned to a unique pitch), but it was more like an auditory display for identification of performers.

It is noteworthy that current aiming directions of performers, not to mention every note event, were all visualized in real-time on a big screen as arrows and animated concentric circles (figure 5) in order to help the audience to understand the whole music-making process clearly and intuitively.

3.2 Case 2: Aiming with Movement

The performance mentioned above can be enhanced to be able to identify and utilize the position of each performer: in spite of certain limitations (e.g., directions of movement, number of performers for simultaneous tracking), the same system with HAM app allows us to keep track of performers' positions on stage in real-time.

Figure 6 illustrates the mechanism of position tracking. To move on stage, a performer should first take aim at the

Table 1. Event-note mapping rules.

Unidirectional					
Event	Note	Event	Note	Event	Note
1 → 2	F4	1 → 3	B4	1 → 4	G3
2 → 1	E4	2 → 3	C5	2 → 4	D#4
3 → 1	D5	3 → 2	A4	3 → 4	A#4
4 → 1	F#4	4 → 2	G#4	4 → 3	C#4
Bidirectional					
Event	Note		Event	Note	
1 ↔ 3	FX Sound		2 ↔ 4	FX Sound	

Figure 4. Performance of *Where Are You Standing* by the KAIST Mobile Phone Orchestra (KAMPO).

"reference" performer (i.e., the most adjacent performer on the left), then choose the direction – either horizontal (x) or vertical (y) into which he/she would move – by holding the corresponding button on screen (figure 7) to enter "changing formation" mode. While moving, the performer should continue to point at the reference so that changes in the aiming direction can be measured, from which current position of performer 1 (x_1, y_1) can be obtained by:

$$x_1 = x_2 - (y_2 - y_1) \times \tan\theta_1$$
$$y_1 = y_2 - (x_2 - x_1) \times \tan\theta_1$$

Currently, only one performer can move at a time.

Figure 8 shows an example of change in the formation of performers over time. This variation in positions can also be used for musical mappings. For example, distances between performers can be mapped to interonset interval (IOI). In the initial formation, distances between adjacent performers are all equal and the musical notes assigned to each performer are played at the same interval. As performers start to move, the distances (hence the IOIs of notes) are change accordingly, causing interesting (and complex) rhythmic variations.

The scale and the pitch of notes can be controlled by the position of the performers, too. Figure 9 illustrates an example: depending on the distance from the center of the circle, notes played by the performer get higher pitch (or are in a certain scale).

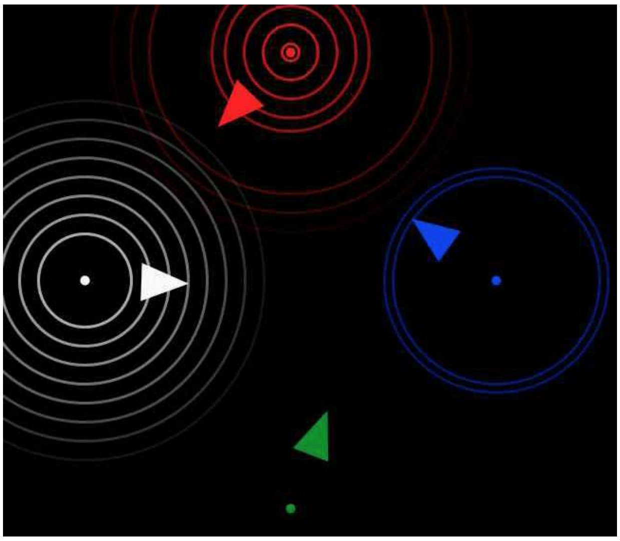

Figure 5. Visualization of performer's aiming directions (arrows) and note events (concentric circles).

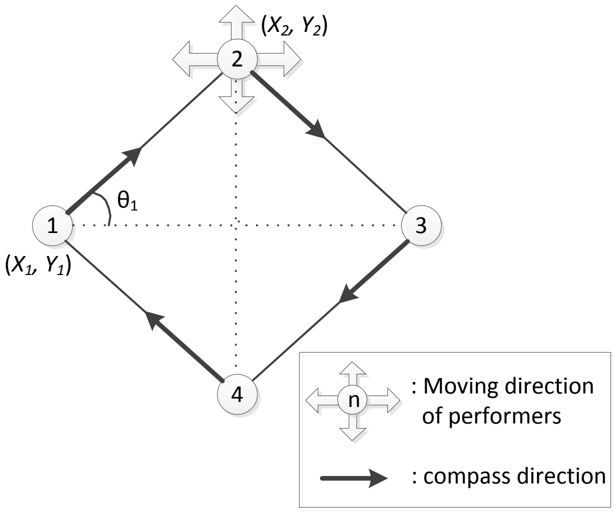

Figure 6. Tracing the location of a moving performer.

Figure 7. Screenshot of HAM iOS app.

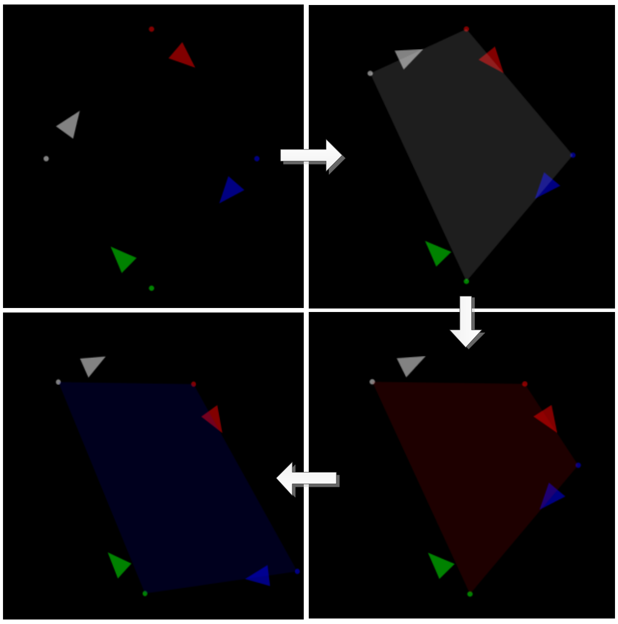

Figure 8. Changes in on-stage formation of performers over time (from top left, clockwise).

4. CONCLUSION

This paper presented an interactive, collaborative mobile music performance system based on the digital compass on mobile phones. The aiming gestures of performers (and their orientations) not only generate musical events, but also allows the audience to appreciate inter-performer interactions more intuitively, especially with real-time visualization of performers' aiming directions on stage to share the "music-making" process. Also, by tracing the positions of moving performers only with compass, we can design a variety of real-time musical mapping strategies with the information on performers' positions.

In addition to the upcoming premier of a new piece using HAM and the "aiming with movement" scenario, we will continue our research on the potential of digital compass for mobile music, focusing on interaction (between performers) and more sophisticated gesture detection.

5. ACKNOWLEDGMENTS

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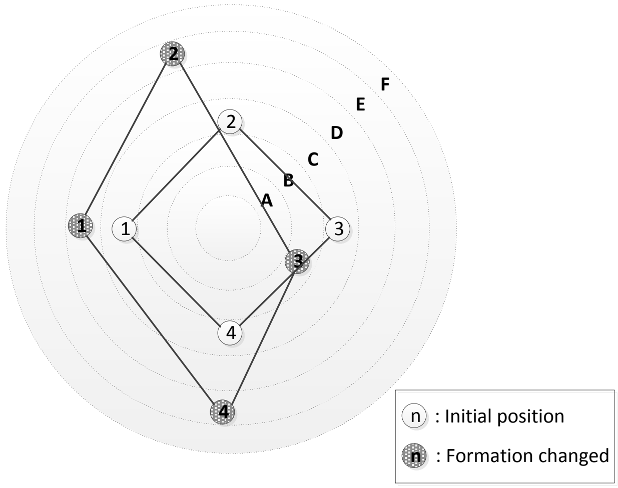

Figure 9. Position-based pitch/scale change.

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