Smartphone-based Music Conducting

Yang Kyu Lim, Woon Seung Yeo
Audio & Interactive Media Lab
Graduate School of Culture Technology, KAIST
291 Daehak-ro, Yuseong-gu, Daejeon
lim0386@kaist.ac.kr, woony@kaist.edu

ABSTRACT

This study introduces *vMaestro*, a smartphone interface for music conducting. Powered by the device's gyroscope, *vMaestro* analyzes conducting motions, allowing the user to not only control the *tempo* but also to simulate cueing for different instruments. The results of user tests show that, despite certain ergonomic problems, conducting practice with *vMaestro* is more satisfactory than traditional methods and has a strong potential as a conducting practice tool.

Keywords

smartphone, conducting, practice, orchestra

1. INTRODUCTION

It takes a considerable amount of practice to play music well. In particular, to become masters of music, conductors require sufficient practice time. However, it is impossible to gather more than 200 orchestra members for daily practice. Therefore, a conducting major generally has only few chances to conduct a real orchestra. Conducting majors usually practice with music whose speed is unchangeable, such as CDs or MP3s. Further, students study with pianos as much as possible to make up for what they lack in live music practice. They quickly translate the full score of the orchestra to piano music. This practice helps them to learn about *tempo*, instrumentation, and melody line. Yet, there remains a significant lack of necessary practice. Therefore, the conductor cannot expect to have a good interaction with an orchestra in a short duration, as he would with an individual musical instrument. Significant experience can help someone master the technique of conducting.

vMaestro is a handheld digital musical interface that can be used by students majoring in music in order to practice orchestral conducting. *vMaestro* gathers several scattered conducting practices –*tempo* and cueing- into one realistic practice, using smartphone gyroscopes and computers to help students practice conducting. Students can learn about *tempo*, instrumentation, and melody line through conducting gestures and cueing directions.

2. RELATED WORK

Many research studies on virtual music conducting programs have been carried out in the past. The first was *Radio-Baton*, which was invented by Max Mathews. It is a system that allows conductors and composers to play orchestral scores through electronic methods, and it is still in use today [2]. Its computer-generated MIDI player controlling concept is similar to that of *vMaestro*. Using both hands to control the dynamics and other musical signals is very similar to real conducting. Using just one hand is a handicap when it comes to recognizing all gestures involved in conducting. However, using *Radio-Baton* is not a similar way to practice real conducting. Conductor's cueing must have a directional information to command more than 200 orchestra members. Our study uses directional informations with gyroscope to make a realistic situation of practice.

Pinocchio is a virtual symphony orchestra system that enables the user to experience conducting using a baton with a computer camera. It also develops and applies multiple beats, orchestration setups, and audio effect setups. Orchestration practice is the focus of our study. *Pinocchio* has an administration mode that can move each user anywhere on the screen. Adding a face recognition conducting system was suggested as a future task [3]. However, until now, studies have considered only conducting gestures, not cueing. It is similar to our study using as a learning tool for children. However, our study is focused on conducting practice for musicians.

The Nintendo Company in Japan recently developed a program called *Wii Music*. It is a virtual game that enables the user to play various instruments using the motion plus system, which has three accelerometer axes from the Wii remote controller, as well as two more axes from the Wii Fit Balance Board. The orchestra-conducting category uses the Wii remote controller as a baton, which allows the user to conduct a virtual orchestra on the monitor by following the beat.

One program that is similar to *Wii Music*'s orchestra conducting game is the *UBS Virtual Maestro*: *An Interactive Conducting System*. This also uses the Wii remote controller as a baton to conduct a virtual orchestra, and uses a method that changes the music *tempo*. Using a motion sensor to change *tempo* is a similar to the method used in our study [4].

These Wii-based conducting systems include visual information to recognize and sense the presence of a live orchestra. They are considerably similar to the *vMaestro* program used in our study, but we have added a cueing system in order to identify and develop conducting practice. Both the Wii remote control and smartphones have gyroscope-based downbeat detection.

Lijuan Peng's study used an infrared camera installed in a Wii remote controller to read users' hand movements. This made the conducting of 2/4, 3/4, and 4/4 time possible [5].

That study focused on detecting various time signatures. The focus of our study was different; however, we did use conducting gestures as a controlling method in our study.

NIME'14, June 30 – July 03, 2014, Goldsmiths, University of London, UK.

3. DOWNBEAT AND CUEING

Figure 1. Four-beat and six-beat conducting styles.

To measure conducting motions, we have to know about conducting. Every conducting motion has an up-and-down direction. We call this the upbeat and the downbeat. The downbeat is a particularly important factor in calculating the music's *tempo*. In one bar, the relative strength of each beat is "①Strong-②Weak-③Middle Strong-④Weak" in 4/4 time, while in fast 6/8 time—in which one downbeat is counted per three beats—the strength of each beat changes as follows: "①Strong-② Weak- ③ Weak- ④ Middle Strong- ⑤ Weak- ⑥ Weak" to "① Strong-②Middle Strong" (see Figure 1) [6].

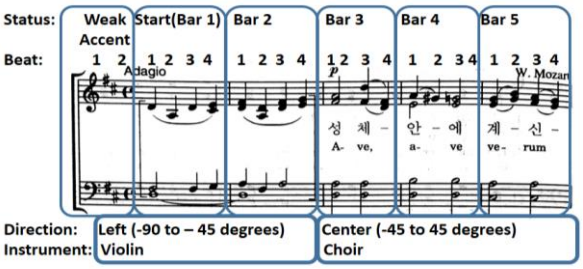

Figure 2. Example of 4/4 time conducting analysis [7].

Before the music starts, the conductor makes a weak accent to demonstrate the *tempo* and cue the start of the music. Usually, a weak accent is a half or full conducting gesture. While conducting, conductors change the direction of their gestures to make signs. The indication of entries—when a performer should begin playing—is called cueing. There is no special method for cueing: a conductor can use a hand gesture, a facial expression, and so on. The most important thing is the direction in which the conductor is facing. For example, if the violin section, located on the left side of the orchestra, has to start the main melody, the conductor must stand to the left and give a cue to that section immediately. An incorrect direction could cause a mistake to be played in a classical orchestra concert (see Figure 2).

4. DESIGN AND IMPLEMENTATION

Some details of *vMaestro* are as follows. First, the user inputs an IP address and a port number in order to connect with the server computer. Then, the user presses Start button to activate the sensor on the smartphone. Then, he/she begins the conducting practice. The user's current position will be shown as a bar number and a directional angle slider (see Figure 3).

The conducting procedure is similar to a natural conducting method. The user starts with a weak accent to set the *tempo* and then makes conducting gestures and cueing directions to control the music smoothly.

Further, the user can enter the number of the bar in which he/she wants to start, or reset a directional angle to fix an incorrect direction.

Figure 3. Screen shot of *vMaestro* iOS app.

The sensor gathers the information on *tempo* and direction. This information is tied to an *Open Sound Control (OSC)* message, which is transformed within the computer, which generates a musical and graphical order. Music is generated from a sequencer program and played through the speakers. The current direction of the conductor is displayed on a screen to guide the direction of each instrument in the orchestra (see Figure 4).

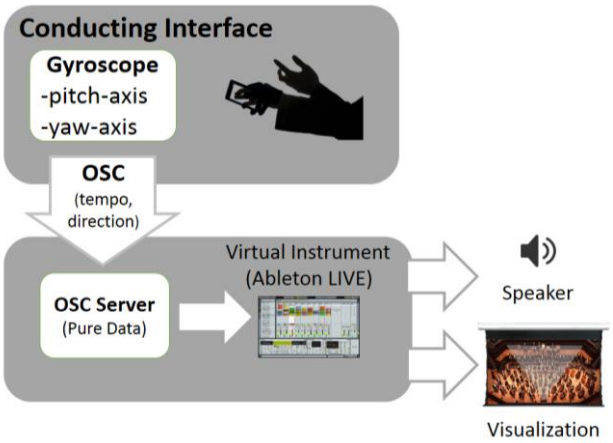

Figure 4. *vMaestro* operation process.

In this study, well-known pieces were selected according to the method used by music colleges in Germany. In general, each selected piece has a different style and *tempo*. The samples used in this study were *Ave Verum Corpus* by W.A. Mozart—slow choral music in 4/4 time—and *Jazz Suite, Waltz No. 2* by D. Shostakovich—fast orchestral music in 6/8 time.

4.1 Conducting Interface

The *vMaestro* conducting system is an iOS7-based application that can be used on the iPhone. The basic concept of this application is created using MOMU [8] and KAMPO [9] [10].

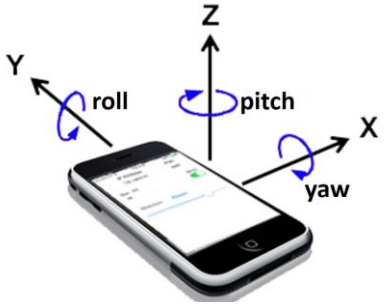

Figure 5. Rotation degrees for each of the three axes.

The gyroscope is the main sensor that detects conducting motions. We used *Apple CMAttitude* to access this data, which includes the rotation degrees for each of the three axes in Figure 5. The conducting movement can be calculated via the pitch-axis of the gyroscope.

The smartphone motion sensor makes a random noise at the downbeat point. This noise causes the music to have an abnormal *tempo*. Slow, small conducting movements create considerable irregular noise. We therefore set the sensor's rotation rate at two rad/s for activation.

Filtering can identify abnormal data in order to create a suitable conducting method for practice. In the situation shown in Figure 6 the hand movement have to show stop at the lowest point from around 0.4 s to 0.7 s. A raw sensor shows unstable movement, but filtered sensor stop detecting at the moment.

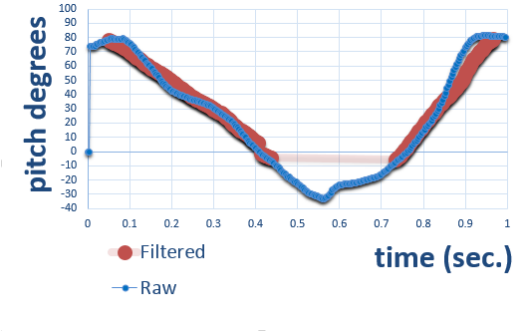

Figure 6. Comparison of raw and filtered sensor data.

We set up very strong beats to play the music. A bar-divided MIDI file plays on the strong beats. Further, there is a weak accent before the music starts or restarts. Two beats are set for both 4/4 and 6/8 time, similar to a real conducting.

Bars are counted in order to recognize where the user is in the music. The user can skip to any bar in the music by inputting the bar number into the text box in the application.

Cueing systems are made by the smartphone gyroscope's yaw axis, sending direction data via *OSC*. *vMaestro* catches the direction of the conductor's smartphone and compares it with a given moment in the music. The direction ranges from -90 to 90 degrees and the conductor can point to four divided spaces. A wrong direction will result in a volume down signal, allowing the user to recognize the mistake.

4.2 Sound Engine

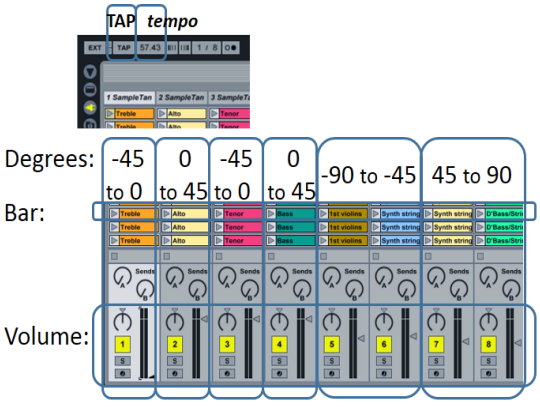

Figure 7. Ableton Live setting [11].

The computer runs a program called *Pure Data* that receives *OSC* signals—including direction, *tempo*, play commands, bar numbers, and volume information—from a Wi-Fi-connected smartphone. This musical information is sent to *Ableton Live*, which controls and plays the music with virtual instruments. Every beat signal from the smartphone will trigger a TAP in the control bar on *Ableton Live* in order to calculate *tempo*. Horizontal separation and vertical separation are bar and instrument (see Figure 7).

Directional data is compared with original conducting information, and whether the conductor's direction is right is calculated in *Pure Data*. This decision data will control the volume of the orchestra sections in *Ableton Live* (see the bottom of Figure 7). Visual data are displayed on the screen to indicate the orchestra and directional marks, in order for the conductor to recognize information about cueing. Conductor have to change his direction follow the instructions in the score. If conductor is in the correct direction, music will play normally. If not, main melody will cut off (see Figure 8).

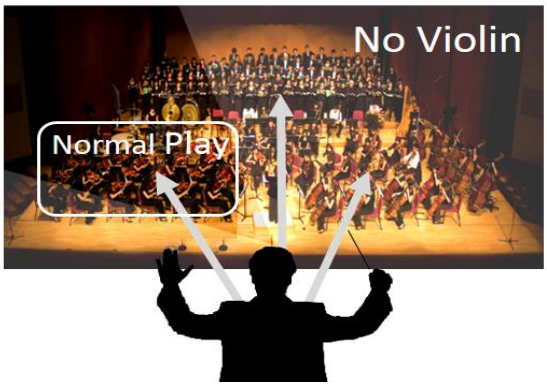

Figure 8. Direction of conductor in 1st bar of *Ave Verum Corpus*

5. EVALUATION

We tested five professional conductors and five professional music players. The reason for this grouping was to evaluate the usability and effects of the program for both conductors and non-conductors. First, both groups were given a short duration to preview the score in order to understand the music. Then, they tried the *vMaestro* program. A short explanation on how to activate *vMaestro* was provided before the practice session. During the session, we let each user have his/her turn. Both sessions performed the same orchestral score. Two tests were conducted, with an interval of one week in between. This was similar to the conditions for a real lesson setting.

The participants were not allowed to use the application except during the two tests because we did not have to measure the application's adaptability, only the relative improvement of the participants' conducting feelings.

After the second practice, the participants were surveyed about *vMaestro*. The survey inquired about their interest and concentration during the *vMaestro* practice. It also measured how similar their *vMaestro* experience was to their existing conducting practice and skill improvement. Each question was answered on a scale of 1 to 5: very negative (1), negative (2), normal (3), positive (4), and very positive (5).

Table 1. Survey items

vMaestro is more interesting than traditional conducting practice.
vMaestro let you concentrate more on conducting practice.
vMaestro practice is similar to real orchestral conducting motion.
vMeastro is an effective way of conducting practice.

We expected that this simple method to practice conducting an orchestra would yield positive feelings. Further, an increased interest in smartphones could enhance the rate of participation in this program.

Table 2. Survey ratings by category

	Conductors	Non-conductors
Interest	3.8	4.0
Concentration	4.2	4.2
Motion	3	3.8
Effect	3.8	2.4

Most participants answered the first question about interest in a positive way, which was the result that we expected before the tests. They also gave both "positive" and "very positive" ratings in the concentration category. This shows that if a program is interesting, users will concentrate more. The professional conductors group was particularly excited about this new learning environment.

Another rating category was the recognition of conducting motion in *vMaestro*. Both groups gave it ratings of "normal" and "positive." The reason why the professional conductors group rated their satisfaction as "normal" was that they each have their own conducting motions that do not match perfectly with the textbook method of conducting. On the other hand, the non-conductors group rated it as "positive" because they are only used to making textbook conducting motions.

There was a significant difference between the two groups in the category of effects. The non-conductors group believed in the effects of existing practice methods. They only had complete faith in traditional practice methods and thought neither smartphones nor any other electronic device could replace those methods. In contrast, the professional conductors group expressed the desire to have a more reasonable way of conducting an orchestra. They said that, even if the conducting motions do not exactly match, *vMaestro* can still be a good practice tool for conducting majors.

We will hold a *vMaestro* demo session during a classical concert at the Ai One Arts Center in Seoul, Korea on February 15th.

6. CONCLUSION

vMaestro is a system through which a conductor can freely control *tempo* and supplement cueing—that cannot be carried out in traditional conducting practice—using a smartphone. The results of such practice will allow more conductors to acquire conducting ability through a simple, low-cost method.

Conducting is a major aspect of music performance. This means that conducting is a high-quality musical activity. Basic knowledge of music is not the only qualification for becoming a conductor. Every musician must experience many musical activities. *vMaestro* can make this happen not only via solo training, but also via training with a virtual orchestra.

This study faced two main limits. The first was the weight of the smartphones. When conductors are conducting, they generally use a baton weighing just 10 g, but sometimes they do not use a baton at all. In contrast, a smartphone weights about 137 g, which is 13 times heavier than a conducting baton. During the study, eight users said that they experienced wrist pain after practicing with *vMaestro*.

The second issue is the difference in grip. Since conductors use small batons or their empty hands, the experience of conducting is completely different when using a smartphone. Schmidt used a wristband as his conducting device. An armband may prove to be a solution to the aforementioned wrist pain and difference in grip.

7. ACKNOWLEDGMENTS

We thank GSCT KAIST for allowing us to conduct this study.

8. REFERENCES

[1] Y.K. Lim. Smartphone-based Music Conducting. *Master's Thesis*, Korea Advanced Institute of Science and Technology, Daejeon, Korea, 2012.

[2] M. Mathews and D.L. Barr. The conductor program and mechanical baton. *The Center for Computer Research in Music and Acoustics* (May 1988).

[3] B. Brügge, C. Teschner, P. Lachenmaier, E. Fenzl, D. Schmidt, and S. Bierbaum. Pinocchio: Conducting a virtual symphony orchestra. *In Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE '07)* (Salzburg, Austria, June 15-17, 2007), 294-295.

[4] T.M. Nakra, Y. Ivanov, P. Smaragdis, and C. Ault. The USB Virtual Maestro: An Interactive Conducting System. *In Proceedings of the International Conference on New Interfaces for Musical Expression (NIME '09)* (Pittsburgh, PA, June 4-6, 2009).

[5] L. Peng, and D. Gerhard. A Wii-based Gestural Interface for Computer Conducting Systems. *In Proceedings of the International Conference on New Interfaces for Musical Expression (NIME '09)* (Pittsburgh, PA, June 4-6, 2009).

[6] B.H. Ahn. *Fundamental Conducting Technique*. Samho Music, Korea, 1977.

[7] J.S. Jeong. *Catholic Hymn Book*. Catholic Bishops' Conference of Korea, 1957.

[8] N.J. Bryan, J. Herrera, J. Oh, and G. Wang. Momu: A mobile music toolkit. *In Proceedings of the International Conference on New Interfaces for Musical Expression (NIME '10*) (Sydney, Australia, June 15-18, 2010).

[9] The KAIST Mobile Phone Orchestra. Retrieved February 5, 2014 from http://kampo.kaist.ac.kr.

[10] App Store - KAMPO. Retrieved December 6, 2013 from http://itunes.apple.com/us/app/kampo/id432526049?mt=8.

[11] Gear Lounge. *Ableton 9 Korean Reference Manual*. Gear Lounge, 2013.