Evaluation of the Mobile Orchestra Explorer Paradigm

Donald Glowinski, Maurizio Mancini, and Alberto Massari

InfoMus Lab, DIST, University of Genova, Italy
{donald,maurizio}@infomus.org, alby@infomus.dist.unige.it
http://www.infomus.org

Abstract. The Mobile Orchestra Explorer paradigm enables active experience of prerecorded music: users can navigate and express themselves in a shared (physical or virtual) orchestra space, populated by the sections of a prerecorded music. The user moves in a room with his/her mobile phone in his/her hand: the music performed by the orchestra sections is rendered according to the user position and movement. In this paper we present an evaluation study conducted during the Festival of Science 2010 in Genova, Italy. Forty participants interacted with the Mobile Orchestra Explorer and filled questionnaires about their active music listening experience.

Keywords: mobile, orchestra, paradigm, evaluation, explore, active listening.

1 Introduction

Active listening is a new concept in Human-Computer Interaction in which novel paradigms for expressive multimodal interfaces have been developed [2], empowering users to interact with and shape the audio content by intervening actively into the experience. Active listening applications are implemented using non-invasive technology and are based on natural gesture interaction [4].

The goal of this paper is to present the implementation and evaluation results of the Mobile Orchestra Explorer paradigm, developed in the framework of the EU Projects SAME [10] and MIROR [8].

The Mobile Orchestra Explorer paradigm entails the user to set up the position of a virtual orchestra instruments/sections and then to explore the resulting virtual ensemble by walking through the orchestra space.

This paradigm was tested during during the Festival of Science, a public event hold annually in Genova, Italy. Evaluation was carried out to study system usability and to produce an in-depth description of the user experience.

Section 2 introduces related work; in Section 3 we illustrate the Mobile Orchestra paradigm; finally in Section 4 we resume our evaluation study.

A. Camurri, C. Costa, and G. Volpe (Eds.): INTETAIN 2011, LNICST 78, pp. 93–102, 2012.

2 Related Work

Previous work *Orchestra Explorer* by Camurri et al. [3] allows users to physically navigate inside a virtual orchestra space, to actively explore the music piece the orchestra is playing, to modify and mold in real-time the music performance through expressive full-body movement and gesture. By walking and moving on a surface, the user discovers each single instrument and can operate through his/her expressive gestures on the music piece the instrument is playing.

Camurri et al. also propose a more sophisticated active listening concept, called *Mappe per Affetti Erranti* [2], where multiple users can physically navigate a polyphonic music piece, actively exploring it; further, they can intervene on the music performance modifying and molding its expressive content in real-time through non verbal full-body movement and expressive gesture.

Goto proposed a GUI-based system for intervening on prerecorded music with some original real-time signal processing techniques to select, skip and navigate sections of the recording [7].

Some projects addressed mobile music performances: *SonicCity* uses multimodal sensors allowing a single user at creating music and manipulate sounds by using the physical urban environment as interface; information about the environment and the user's actions are captured and mapped onto real-time processing of urban sounds [6]. *SoundPryer* is a peer-to-peer application of mobile wireless ad hoc networking for PDAs, enabling users to share and listen to the music of people in vehicles in the immediate surrounding [9]. The *SonicPulse* system is an application designed to discover in a physical environment other mobile music users and engage with them sharing and co-listening to music [1].

3 Mobile Orchestra Explorer Evaluation Scenario

We present now the Mobile Orchestra Explorer scenario we evaluated during the Festival of Science in Genova, Italy, November 2010. In the scenario the user interacts with the system in two consecutive phases: (i) on the first phase, he/she walks in a sensitive empty space (a theater stage) holding he/she mobile phone in his/her hand and selects orchestra instruments/sections name on the mobile phone screen; when he/she reaches the point of the space in which he/she wants to place an instrument/section he/she press a button on the mobile phone to record its position; (ii) on the second phase he/she is allowed to move in the sensitive space and, as soon as he/she approaches an instrument/section position the corresponding pre-recorded audio track is played back. During both phases the user position is tracked by a fixed infrared camera.

The scenario architecture is represented in Figure 1. A fixed camera grabs frames of the theater stage at 25 frames per second and sends them to the SAME platform on which EyesWeb XMI is running. EyesWeb extracts the user silhouette from the frame background and computes the user barycenter position, relative to the orchestra space. The user, by touching buttons on the screen of his/her mobile phone, sends the following commands to SAME platform:

command name	**possible value**	**description**
mode	*0,1*	indicates wether the interaction mode is either *setup* (0) or *explore* (1): the user either moves in the orchestra space to arrange the position of instruments/sections or is exploring the orchestra space and listens to the instrument/sections that are close to his/her current position.
instrument	*name*	(works only in setup mode): the user select the instrument (or section) indicated by the parameter *name*.
set	*x,y*	the user sets the currently selected instrument (or section) position to the current user's position obtained by the camera frame.

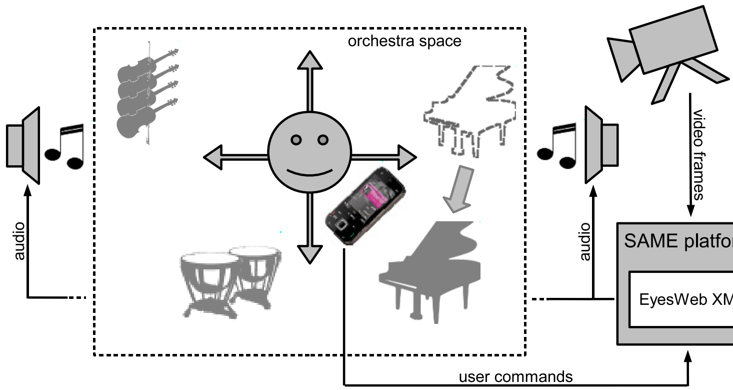

Fig. 1. The Mobile Orchestra Explorer evaluation scenario architecture

4 Evaluation

The evaluation of the scenario presented in Section 3 was conducted during the Festival of Science at Casa Paganini (Genova, Italy) in November 2010. Questionnaires were submitted to visitors. The first part of the questionnaire was the mobile user profile (i): it addresses how the visitor uses his/her mobile in daily life (see Table 1); it also investigates his/her musical background (expert, music lover, etc.) and identifies the type and frequency of his/her physical activities (sport, dance, etc.). The second part focused on the evaluation of the Mobile Orchestra Explorer app (ii).

Table 1. Items related to the use of the Mobile Phone including standard call and sms functions plus multimedia applications (music listening, picture and video recording). Items were defined following the most recent standards [5,11].

	Never	Less than once a month	Once a month	Once a week	Several times a week	Once a day	Several times a day
1.1 MAKING CALL							
1.2 SENDING/RECEIVING SMS MESSAGES							
1.3 TAKING PICTURES □0 don'h have this function							
1.4 RECORDING VIDEOS □0 don'h have this function							
1.5 LISTENING TO MUSIC □0 don'h have this function							
1.6 PLAYING GAMES □0 don'h have this function							
1.7 OTHER MUSICAL APPLICATIONS Please specify:							

4.1 Mobile User Profile

Participants. 40 participants tested the applications (m=30.5, std 19.9), age ranged between 8 and 84 years old. It is worth mentioning that 50% of the population had less than 20 years old. All but one participant had a mobile (the 8-year-old child did not have one). Authorization to consent for the evaluation of the data was requested for any minor.

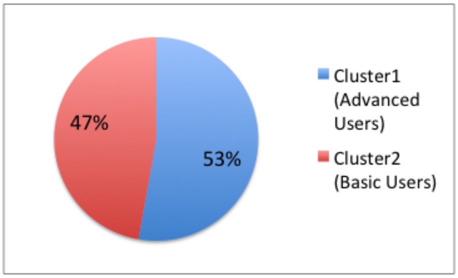

Fig. 2. Cluster Sizes

Mobile User Profile of the Participants: Advanced vs Basic Users. To identify user profiles among the visitors, the two-steps clustering technique, an unsupervised learning method implemented in spss (www.spss.com), were applied on the ratings related to the use of the mobile phone (Table 1). Results showed that two clusters emerged which divided the population of participants in nearly two half-parts: Cluster1 and Cluster2 contained respectively 53 % and 47 % of the total sum of participants. The analysis of each cluster composition presented in the following sections showed that Cluster1 and Cluster2 refer respectively to group of Advanced and Basic users of mobile phone.

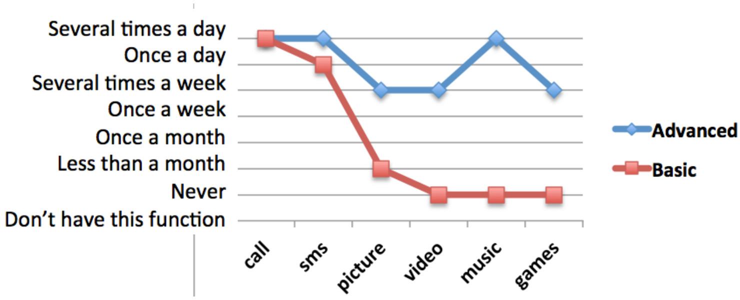

Fig. 3. Median plot of Advanced (Cluster1) vs Basic (Cluster2) Users frequencies by Items.z

Cluster Profile. The original ratings were ranked ordered and a Mann-Whitney U test was used to compare the ranks of the n=19 participants of Cluster1 (Advanced users) and n=17 participants of Cluster2 (Basic users) for all items. To control the inflation of type I error probability due to multiple comparisons, the Bonferroni correction was applied to p-values (the levels of statistical significance). The results indicate a significant difference between the ranks obtained by Cluster1's participants versus the ranks of Cluster2's participants for all items except for the ones corresponding to call and sms functions (see Table 2). For all other items, the mean rank of Cluster1 are higher than Cluster2's one. The participants of Cluster1 tended using much more the other multimedia functions, with a particular interest for music listening (see Figure 3).

Table 2. Mean ranks are higher for Cluster1 with respect to Cluster2's ones for items related to the multimedia functions of the mobile phone

	Picture	Video	Music	Games
z	4.57	4.93	4.76	3.51
Exact Sig.	$p < .05$	$p < .05$	$p < .05$	$p < .05$

Cluster Composition. To better understand the composition of each cluster, analysis of cross-classifications with respect to age and music expertise characteristics were conducted.

Analysis revealed that young participants (less than 20 years old) are more likely to be part of Cluster1 (Advanced users) (83.3%) than when being older (22.2%), η^2 (1. N=36) = 13.486 ($p < .001$), odds ratio = 17.54. The participants

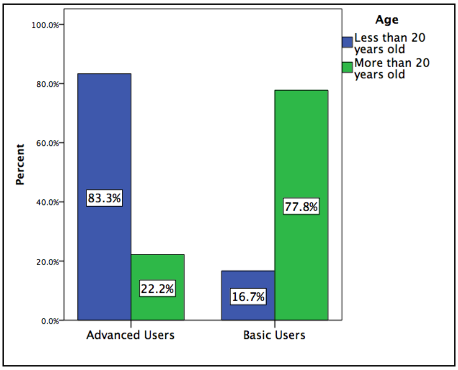

Fig. 4. Age distribution over the two clusters of participants

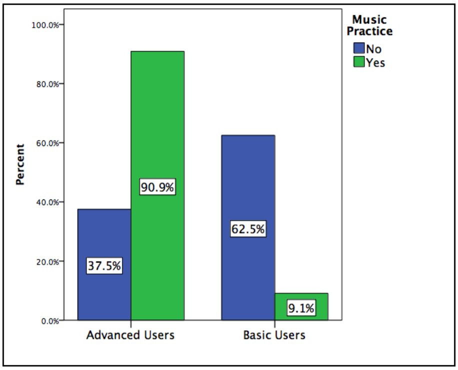

Fig. 5. Music expertise distribution over the two clusters of participants

playing a music instrument also seemed more likely to be part of Cluster1 (Advanced users) (90.9%) than when having no music practice experience (37.5%), η^2 (1. N=35) = 8.67 (p = .003), odds ratio = 16.7. We wondered whether Advanced users felt predominantly at ease when testing the application. Point-biserial correlation coefficient between cluster membership and this extravert capacity revealed significantly high $r_{pb} = .414$, ($p < 0.05$).

Briefly said, Cluster1 members, i.e., Advanced users who take the most of the multimedia functionalities of their mobile phone were young, practice music and had no problem at testing applications among other people. However, as a whole, the population of participants have regular physical activities (67.5%), and listen to the music regularly, at least several times a week (94.2%), no significant differences were found between the two clusters for these characteristics.

4.2 Evaluation of the Mobile Orchestra Explorer Paradigm

The assessment questionnaire consisted of 6 items. First items were formulated to gain information about the usability of the application (e.g., level of understanding, of control) and user satisfaction in using it. Last items specifically addressed the music embodiment and active listening experience instantiated in the EU-ICT Project SAME (`www.sameproject.eu`), e.g., "Were you aware that you action modify the musical content?". Each response was rated on an eleven-point scale, with 11 as the most favorable response and 1 the least favorable response. Results (median) are shown in Figure 6. Ratings confirmed that overall evaluation was positive (m= 8.7, std=0.7). The participants enjoyed testing the Mobile Orchestra explorer (m=9.3), found this application an interesting (m=9.4) and engaging one (m=9). Understanding and playfulness respectively received lower values but remain high (respectively m=8.2 and m=8.7).

A 2 (group) x 6 (item) mixed analysis of variance was run in order to investigate the effects of Group (Advanced vs Basic users), items and their interaction on participants answers. The Greenhouse-Geisser correction was used when necessary to mitigate violations of the sphericity assumption in repeated measures. To control the inflation of type I error probability due to multiple comparisons, the Bonferroni correction was applied to P-values (the levels of statistical significance). The mixed ANOVA identified a significant main effect of Item, F(3.165,104.44)=3.703, $p < .05, \eta^2 = 0.9$, and of the Item x Group interaction, F(3.17, 104.44)=3.77, $p < .05, \eta^2 = 0.9$. Bonferroni-corrected post-hoc analyses were performed to assess specific difference among the Items and the Items x Group interaction effects. Item 6 (*if the mobile orchestra application was installed on their mobile, would they use it*) received significantly lower ratings than item 3 (*If they enjoyed using the application*) and 4 (*Interest of the application*). These results revealed that whereas this application may be enjoyed, and could capture the participant interest, it may not be considered as an application to use with their mobile phone. This effect is particularly high in the Basic User Group which already tend to under-use the multimedia functions.

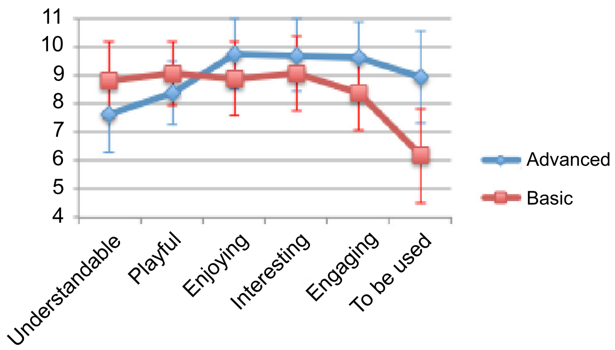

Fig. 6. Interaction plot of Group (Advanced vs Basic Users) by Items

Principal Component Analysis. Data for the 6 items were entered into a principal component analysis. The criterion of examining eigenvalues superior to 1 and elbows in the Screen plot suggested a two factors solution, which cumulatively accounted for 72% of the variance in the data. These factors were subjected to Varimax rotation. Considering the component loadings of the 6 original items (see loading factors in Table 3), and the component plot (see Figure 7), the two rotated factors could be respectively labeled as: Factor 1 (x axis) emotion (e.g., "how engaging and enjoying was the application") Factor 2 (y axis) cognitive loads (e.g., "how easy the application was to understand and to play")

Difference between Advanced and Basic Users with Respect to the Two Principal Components Ratings. Two Independent-samples t-tests were conducted to compare (i) the ratings of the first rotated component (emotion) and (ii) the ratings of the second rotated component (cognition) for the Advanced and the Basic users groups respectively. On average, Advanced and

Table 3. Rotated Component Matrix

Rotated Component Matrix[a]

	Component	
	1	2
Understanding	.097	.831
Playing difficulty	.061	.536
Satisfaction	.942	.152
Interest	.910	.223
Engagement	.885	.172
Future application	.736	-.413

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

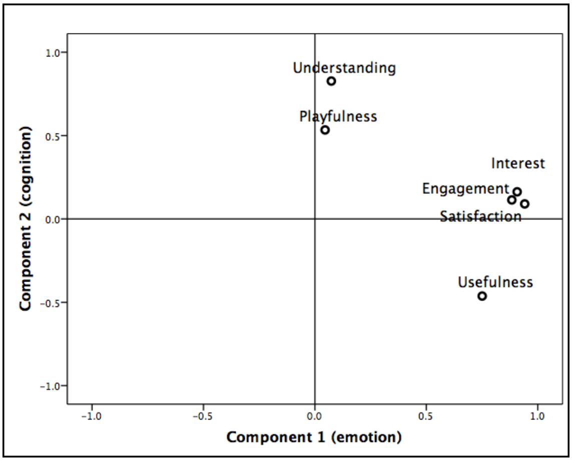

Fig. 7. Component plot in rotated space

Basic users may enjoy the application at a similar level (no significant difference between Group for the ratings of the emotion component, $t(33) = 1.67, p > .05$). However, difference between Group was significant for the ratings related to the cognition component, $t(33)$=-2.04, $p < .05, r = .101$. This result may be a paradox: one would actually expect an advanced user to be more acquainted with new technological devices and applications with respect to a more basic user. This result can otherwise be interpreted in another way: users with more experience in using multimedia functions of their mobiles are more demanding; they can therefore reveal more critics (with lower ratings) when considering the new functions offered by the mobile orchestra app.

Specific Items Related to the Active Listening Concept. Last items of the questionnaire specifically addressed issue related to the Active Listening Concept and its effect in terms of music discovery and learning: "Using this application allowed you to acquire a better knowledge of the instrument timbre?", "The possibility given to explore physical the sound allowed you to memorize better the music piece?". Results (means and confidence intervals) are shown for the Advanced vs Basic Users Groups in Figure 8. Ratings confirmed that overall evaluation was positive ($m = 6.4$). Independent samples t-test was conducted to compare the ratings of the music memorization for the Advanced and the Basic Users groups. Difference in ratings was significant, $t(20)$=3.9, $p < .01, r = .43$.

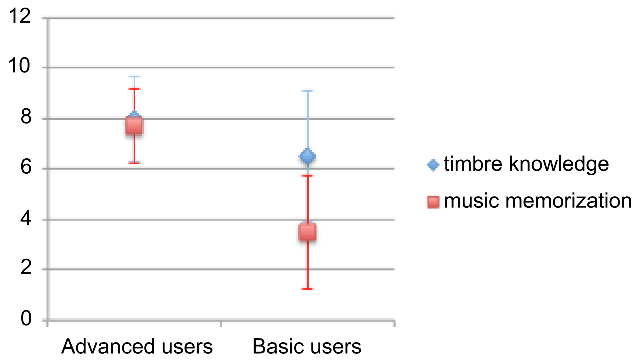

Fig. 8. Means and Confidence Intervals for timbre knowledge and music memorization items for Advanced and Basic Users Groups

These results suggest that using the Mobile Orchestra Explorer may help the participant recognize instrument timbre and memorize music sequences.

5 Conclusion

The Mobile Orchestra Explorer paradigm allows users to navigate and express themselves in a virtual Orchestra Space, populated by the sections of a prerecorded music. We presented an evaluation study conducted during the Festival of Science 2010 in Genova, Italy. Several participants interacted with the Mobile Orchestra Explorer and filled questionnaires about their active music listening experience.

The results confirm that the Mobile Orchestra Explorer paradigm, considered as a proof-of-test of the active listening concept, has the potential to increase the user interest for music and to improve his capacity to distinguish between instrument timbres. Pre-Post tests should be specifically designed to investigate how the real-time temporal and spatial manipulation of a music material allowed by our application may facilitate the acquisition of these musical skills.

As a whole, this study may confirm the suitability of the active listening concept for entertainment and for didactic applications.

Acknowledgements. The work presented in this paper has been partially supported by the EU FP7 ICT Collaborative Project MIROR (Musical Interaction Relying On Reflexion) Grant n°258338, http://www.mirorproject.eu. We thank Carlo Chiorri, Irene de Ferrari and Luca for their support as well as the anonymous reviewers for their useful suggestions.

References

1. Anttila, A.: SonicPulse: Exploring a Shared Music Space. In: 3rd International Workshop on Mobile Music Technology (2006)
2. Camurri, A., Canepa, C., Coletta, P., Mazzarino, B., Volpe, G.: Mappe per Affetti Erranti: a Multimodal System for Social Active Listening and Expressive Performance. In: Proceedings of the 8th International Conference on New Interfaces for Musical Expression (2007)
3. Camurri, A., Canepa, C., Volpe, G.: Active listening to a virtual orchestra through an expressive gestural interface: The Orchestra Explorer. In: Proceedings of the 7th International Conference on New Interfaces for Musical Expression (2007)
4. Camurri, A., Volpe, G., Vinet, H., Bresin, R., Fabiani, M., Dubus, G., Maestre, E., Llop, J., Kleimola, J., Oksanen, S., Välimäki, V., Seppanen, J.: User-Centric Context-Aware Mobile Applications for Embodied Music Listening. In: Daras, P., Ibarra, O.M. (eds.) UCMedia 2009. LNICST, vol. 40, pp. 21–30. Springer, Heidelberg (2010)
5. Foss, R.D., Goodwin, A.H., McCartt, A.T., Hellinga, L.A.: Short-term effects of a teenage driver cell phone restriction. Accident Analysis & Prevention 41(3), 419–424 (2009)
6. Gaye, L., Mazé, R., Holmquist, L.E.: Sonic City: The Urban Environment as a Musical Interface. In: Proceedings of the 3rd International Conference on New Interfaces for Musical Expression (2003)
7. Goto, M.: Active Music Listening Interfaces Based on Signal Processing. In: Proceedings of the 2007 IEEE International Conference on Acoustics, Speech, and Signal Processing (2007)
8. MIROR, http://www.mirorproject.eu
9. Östergren, M., Juhlin, O.: Sound Pryer: Truly Mobile Joint Listening. In: 1st International Workshop on Mobile Music Technology (2004)
10. SAME, http://www.sameproject.eu
11. Samkange-Zeeb, F., Berg, G., Blettner, M.: Validation of self-reported cellular phone use. Journal of Exposure Science and Environmental Epidemiology 14(3), 245–248 (2004)