Audio-Only Augmented Reality System for Social Interaction

Tom Gurion[1] and Nori Jacoby[1,2]

[1] Bar-Ilan University, Ramat Gan, Israel
{nagasaki45,nori.viola}@gmail.com
[2] Hebrew University, Jerusalem, Israel

Abstract. We explore new possibilities for interactive music consumption by proposing an audio-only augmented reality system for social interaction.

We designed and built an Android application that measures the relative position of the device from freely moveable Bluetooth beacons. Based on this information, an algorithm dynamically changes the music that the users hear in their earphones.

We assessed the interactive component of the system in the context of a silent rave party in a controlled experiment by comparing the system positioning readings in interactive and non-interactive control segments. We also directly assessed the user experience using self-report pre/post surveys. Our results suggest that the system facilitated higher levels of user movement in space and enhanced social interactions, thereby displaying the potential of using audio-only augmented reality in future mobile applications.

Keywords: Interactive Music System, Social Interaction, Augmented Reality, Indoor positioning system.

1 Introduction and Framework

In the past 60 years the development of new technology has fundamentally transformed music creation and consumption [1]. Today, interactive music systems are used in many different contexts ranging from instrument design [2] to socially interactive installations [3]. With the emergence of modern mobile devices, interactive music systems have become accessible to non-musicians (for example AutoRap by Smule [4], and RjDj [5]) as well as facilitating a shared process of music creation between different users in social context [6-7].

Meanwhile, the emergence of location-based services for mobile devices led to new demands for indoor positioning technologies [8]. Most indoor positioning systems for mobile devices today use Wi-Fi or Bluetooth communication and require external infrastructure [9]. In order to eliminate the need for external infrastructure, researchers have suggested relative indoor positioning systems using Bluetooth technology [10] or a device's built-in accelerometer and compass [11].

The main goal of our research is to propose an audio-only augmented reality system for social interaction based on relative indoor positioning Bluetooth technology. We implemented and evaluated the proposed system in the context of a

C. Stephanidis (Ed.): Posters, Part I, HCII 2013, CCIS 373, pp. 322–326, 2013.

silent rave party [12]. More generally, our work explores the potential for a new way of music consumption through mobile devices, considering their effect on social behavior, location-based services and augmented reality concepts.

2 System Description

Figure 1 shows a schematic diagram of our system, which consists of a mobile application developed for Android OS [13] and six specially designed Bluetooth beacons [14]. Participants can freely move the beacons that are installed on physical objects, thereby changing the structure of the music in the virtual space. The Android application repeatedly searches for nearby Bluetooth beacons (see figure 1, BB_1-BB_6). Received signal strength indication (RSSI) is used as an estimation of the distance between the user and the beacon. This is then sent to a Pure Data (Pd) patch [15] through the libpd API [16]. The Pd patch plays an audio loop corresponding to the nearby beacon. Every audio loop, played by the sound zone players SZP_1-SZP_6, is identified by a distinct musical style, and uses the RSSI value differently; for example by controlling volume, filter and granularity of the sound zone. In addition, the different sound zones are modules which can be rhythmically and harmonically synchronized with each other in almost endless combinations.[1]

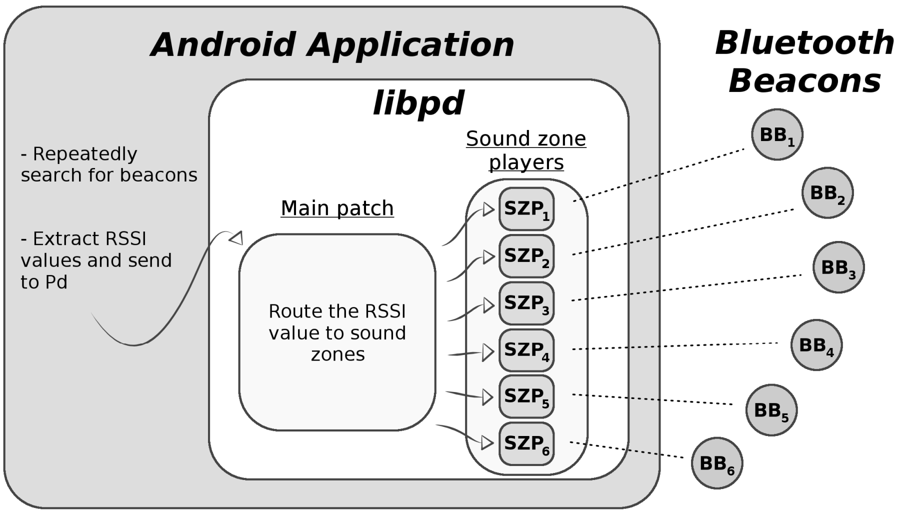


Fig. 1. System architecture

3 Experiment

According to Azuma, one of the main motivations for augmented reality (AR) systems is to enhance the user's interaction with the real world [17]. However, most of

[1] The interactive music composed for the system by the author T.G.

the research in AR nowadays does not describe a formal user evaluation of the interactive elements of the system [18].

In order to evaluate our system we invited eighteen volunteers to participate in an interactive silent rave party. Each participant installed the Android application on his or her phone and filled pre/post party surveys that included questions regarding their musical background and preferences as well as system evaluation feedback. The participants could freely move the six Bluetooth beacons which were installed on colored balloons. The party consisted of four alternating interactive/control blocks of duration 5:40 minutes each (see figure 2). The participants were randomly assigned to two groups: A and B, comprising the interactive and control blocks respectively.[2] They were generally informed that the experiment consists of interactive and control segments, however they were not informed about the exact schedule and timing of the blocks or the group assignments. Both groups started the experiment together. In the interactive blocks, the application generated music as described above, whereas in the control blocks the participants heard recorded non-interactive music created in advance using the musical material of the interactive system.[3]

Interaction with the system's components was assessed by counting the number of Bluetooth device discoveries made by each participant's phone during both the interactive and the control blocks. In order to eliminate edge effects, we analyzed only the two middle blocks of the experiment.

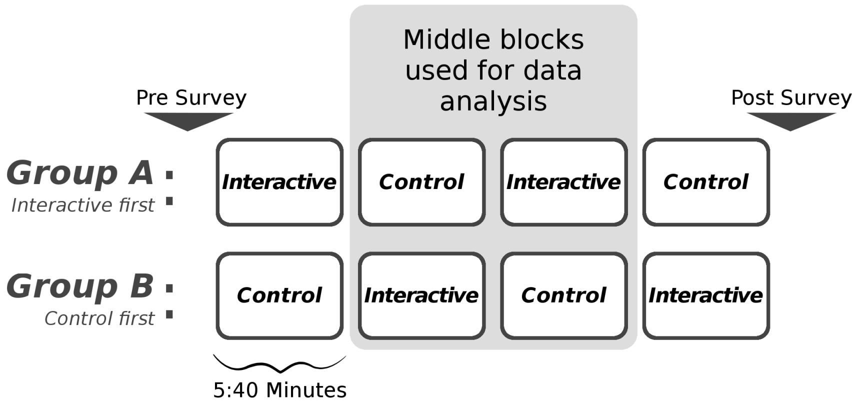


Fig. 2. Experiment design

4 Results and Conclusions

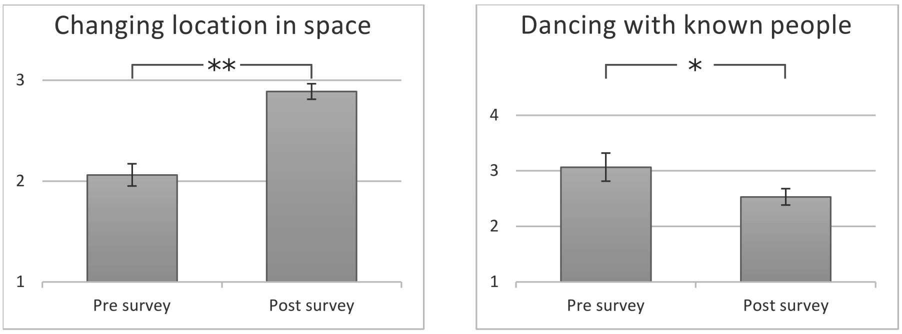
In the post-party survey, participants self-reported significantly higher levels of movement (paired t-test, $t(15)=3.9$, $p<0.01$) using the system, compared with their

---

[2] Group A (interactive first) consists of 8 participants (4 females and 4 males) with mean age of 36.7 (s.d=12.3); group B (control first) consists of 10 participants (3 females and 7 males) with mean age of 29.6 (s.d=10.2). Participants had a diverse musical background with 4.7 mean years of musical training (s.d=5.2).

[3] The control block music composed by Noam Elron (`http://www.noamelron.com`).

behavior on other parties as reported in the pre-party survey. Figure 3a shows that there was a significant difference (unpaired t-test, $t(33)=6.2$, $p<0.01$) in the mean response to these questions (at a scale of 1-3).



(a) (b)

Fig. 3. Results from experiment surveys

In order to objectively assess if participants moved more in space, we measured the counting of Bluetooth discoveries made by the application's relative positioning system. Our results show slightly higher counts (paired t-test, $t(16)=1.7$, $p=0.06$, n.s) during the interactive blocks of the party compared with the control blocks. This suggests that the interactive components of the system facilitate greater participant movement in space, thereby offering more frequent opportunities for social interactions. Indeed, in the post-party survey participants reported that they danced significantly less with people that they knew in advance, compared with their usual behavior (paired t-test, $t(14)=-2.5$, $p=0.01$). Figure 3b shows that there was also a significant difference in the mean response to these questions in the pre/post surveys. Overall, participants showed a slightly stronger tendency (paired t-test, $t(16)=1.46$, $p=0.08$, n.s) to participate in an interactive party in the post-party survey, compared with their answer to identical questions in the pre survey.

Our preliminary results demonstrate the potential for audio-only augmented reality to significantly enrich the experience of music consumption and its attendant social interaction. We also show that this can be validated in a controlled experiment using both direct reports of subject and indirect objective measurements. In future research we plan to extend the evaluation of the system using live video tracking and accelerometer readings.

References

1. Winkler, T.: Composing Interactive Music: Techniques and Ideas Using Max. The MIT Press, Massachusetts (2001)
2. Jordà, S., Geiger, G., Alonso, M., Kaltenbrunner, M.: The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. In: Proceedings of the 1st International Conference on Tangible and Embedded Interaction, pp. 139–146. ACM, New York (2007)

3. Drummond, J.: Understanding Interactive Systems. Organised Sound 14(2), 124–133 (2009)
4. AutoRap by Smule, http://www.smule.com/autorap
5. Sonic Experiences – RjDj, http://rjdj.me/
6. DistributeDJ: Mobile Group Interaction Toolkit, http://crel.calit2.net/dj.html
7. DistributedDJ, http://ece842.com/S13/projects/S11/S11_ProjectReport_Team1.pdf
8. Zickuhr, K.: Three-Quarters of Smartphone Owners Use Location-Based Services. Technical report, Pew Research Center's Internet & American Life Project (2012)
9. Agrawal, R., Vasalya, A.: Bluetooth Navigation System using Wi-Fi Access Points. International Journal of Distributed and Parallel Systems 3(2), 185–192 (2012)
10. Rao, H., Fu, W.T.: A General Framework for a Collaborative Mobile Indoor Navigation Assistance System. In: Proceedings of the 3rd International Workshop on Location Awareness for Mixed and Dual Reality, pp. 21–24 (2013)
11. Pombinho, P., Afonso, A.P., Carmo, M.B.: Indoor Positioning Using a Mobile Phone with an Integrated Accelerometer and Digital Compass. In: Proceedings of the 2nd INForum Simposio de Informatica, pp. 443–446 (2010)
12. Silent Disco, http://en.wikipedia.org/wiki/Silent_disco
13. Android, http://www.android.com/
14. Bluetooth Technology Website, http://www.bluetooth.com/
15. Puckette, M.: Pure Data: another integrated computer music environment. In: Proceedings of the 2nd Intercollege Computer Music Concerts, pp. 37–41. Kunitachi College of Music, San Diego (1996)
16. Brinkmann, P.: Making Musical Apps. O'Reilly Media, Sebastopol (2012)
17. Azuma, R.T.: A Survey of Augmented Reality. Presence-Teleoperators and Virtual Environments 6(4), 355–385 (1997)
18. Swan, J.E., Gabbard, J.L.: Survey of user-based experimentation in augmented reality. In: Proceedings of 1st International Conference on Virtual Reality, pp. 1–9. Lawrence Erlbaum Associates, Las Vegas (2005)