Towards Responsive Music Shuffling

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(a) (b) (c)

Figure 1: (a) City space is used as an interface for music shuffling (b) Augmented urban scale model to design music space with superimposed avatar (c) Sensors, such as pacer meter, are adopted to shuffle music

ABSTRACT
This paper presents the concept and structure of a responsive music shuffling system, a popular playing mode but with context-awareness. We investigate current technologies for possible types of music listening applications made by multi-disciplinary design issue. Context-awareness, interactive soundscape, calm and ambient technology, and wearable computing are considered in the design process of mobile music listening. To facilitate cooperative design for different scenarios, we have implemented an augmented reality system which superimposes a 3D avatar and location-aligned information onto an urban scale model. Thus, proximity-triggered music is played while a scenario goes on visualizing on this tangible interface. Moreover, a lab prototype implemented with wearable sensors to automatically alter music playing demonstrates a new type of musical experience and powerful commercial product in the near future.

Keywords
Interactive Music, Context-Awareness, Augmented Reality, Mobile Music, Music Shuffling, Ambience.

1. INTRODUCTION
Music listening is quite often in our daily life, whether in public or private space. People listen to music in so many situations that the personal and the environmental contexts are woven into the impression and interpretation of music. However, the aural contents which may include two categories as complex musical materials considered: recorded music stored on local devices and streamed music from radio programs, do nothing with listeners' contexts at all. Even if a radio program is live broadcasting, still only few rough contexts such as weather and aura in a specific urban are considered by a sensitive DJ. Although good combination of listened music and personal context is thought to be valuable, current applications, more or less, suffer from fixed ordered playing or context insensitivity.

Songs listed in fixed order are usually played on our audio devices, such as mp3 player and CD player. Thus, the more times people repeat the same playing sequence, the less awareness and amazement will they have while listening. We all have the experience that a familiar song played in an unexpected occasion sometimes evoked much more sentiments than the same one played in a well-known order of play list. Moreover, a song led or followed by different songs will give us different feeling and impression because different temporal contexts occur. To realize the variation of a play sequence, many players support alternative playing modes such as random or shuffle.

As we investigate contexts in music listening in more detail, at least three types of contexts are relevant: temporal, spatial and mental contexts. As described above, shuffling music creates variation in temporal contexts so that listeners will be much interested while they can't predict the next song to come out. This uncertainty of temporal contexts in music intermingling with our environmental situations makes "shuffle mode" a good and fascinating alternation. Furthermore, other examples of context and music listening are described as the following scenarios.

User Scenarios:
1. **Bio Shuffle Scenario**

Tom likes to take his personal mp3 player and listen while jogging and walking around the city. The player not only can shuffle music playing, but also can be responsive to his bio-parameters such as heart rate and pacing speed, and automatically select suitable items in database to play. While Tom speeds up his pace, he hears a song which is of strong beat and fast tempo such as rock'n roll or techno genre. On the other hand, when he slows down and takes a walk in the campus, the ambient music becomes a piano solo of new age genre. Since all contents are stored on his personal device, this responsive shuffling scheme creates a chance to listen to one's familiar music according to various personal contexts with reflective mind.

2. **Environmental Shuffle Scenario**
John usually walks in the urban at different time of the day. He also enjoys music listening while walking. He stores a wide range of music genres on his mp3 player so that he can always find appropriate music in any situation. A smart player equipped with light sensors can detect illumination of the surroundings and use it as a shuffle parameter. He often finds music switching to Jazz when the environment becomes darker, and tropical when warmer color.

3. **Hotspot Shuffle Scenari**o
Mary likes to take her work out of her office and changing places really inspires her creativity. Her original and creative idea often comes out at an outdoor location while she reading, composing or listening. Different auras in various places reflect on her personal mp3 player, with wireless networking technology or tagging technology. That is, hotspot in a library informs the player to play a music mixing suitable for reading, and a mixing for street dancing in a field for extreme sports. By receiving a mixing profile from a specific hotspot, Mary can always listens to context sensitive music and catch the aura surrounding her.

4. **Public Shuffle Scenario**
Café and pub are most popular public spaces for social activities, where ambient music is thought to be necessary. At different time of the day, a smart Jukebox automatically plays different mixing of music according to the context in public space. Te enable music shuffling, images from cameras mounted in the space can not only serve as security monitoring but also as input to understand the situation of the space. For example, when customers become fewer or less moved, which can be easily noticed from basic image processing and motion analysis, Jukebox plays soft and smooth ambient music. In the same way, the color combination of dressing in the space also results in different mixed style of music.

2. RELATED WORK

This project is related to some previous researches based on soundscape, mobile music, and context-awareness. Sonic City [3] is an interactive system that creates electronic music in real time by using sensor-quipped wearable devices. Personal and environmental contexts from body-related input and environmental-related input, respectively, are processed and converted to musical composition by a well-designed mapping strategy in which input sound and MIDI are layered. This system invites users to interactively walk in the urban and listen to the real-time synthesized composition. As slow technology considered [4], Sonic City adopts simple materials that are ambient in one's surroundings and processes them by a complex form, a mapping strategy.

Unlike music synthesis by user in Sonic City, many works focus on pre-recorded materials. Jukola [5] is an interactive Jukebox to allow people in a public space to choose music by networked handheld devices. This system demonstrates how a group of people change the public music space. However, the way to alter playing content engages users' attention so that it may not be a design of calm technology proposed by Weiser [9]. Soundwalk [10] produces audio-tours that invite individuals to walk by following the map and guide accompanied with a narrator's voice and mixing of fitting music and sound effects. Within the surrounding aura, one can experience the cultural context vividly from the well-prepared, fixed, and scheduled audio content. On the other hand, Location33 [3], with a nonlinear listening sequence, distributes songs and stories in a specific city space and enables individuals to explore a new type of musical album by movement. Equipped with GPS and wireless devices, listeners experience an interaction of location and listened content without fixed schedule. Thus, physical space is divided and tagged with intended media. With the similar concept and technology, Hear&There [7] enables users to leave audio imprint at a specific outdoor location. However, an imprint provided by an individual is quite different from the complex material prepared by professional composers. Moreover, Location33 and Hear&There are all implemented in a specific augmented space. Thus, ubiquitous listening outside these spaces is impossible.

In stead of appreciating audio content, Ontrack [8] modifies the spatial balance and volume of music to guide listeners to their target destination. In this case, the position of a walker is used to adapt audio balance and volume rather than to determine playing content.

An issue that we address here is the following question. How much attention should a user pay to music listening? Similarly, how much effort is needed for selecting audio content? All systems described above engage one's attention in listening music or making decision. To contrast, our work aims at an ambient interface and listening experience. Fig. 2 shows these location-based audio systems and their design principle.

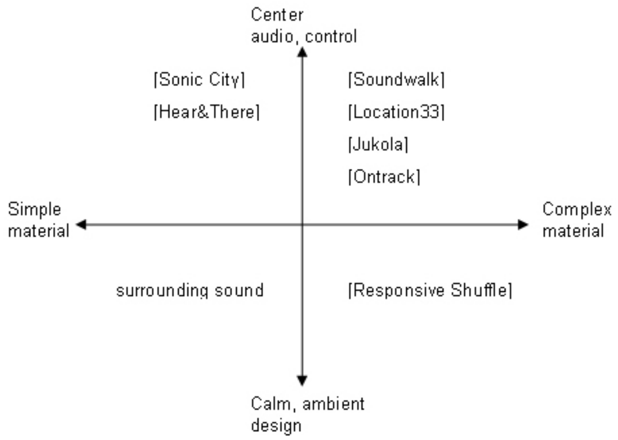


Figure 2. Audio content and attention space

Rather than ambient audio listening, the behaviors of using Sonic City, Hear&There, Soundwalk, and Location33 are much like soundscape exploring, aura matching, or audio-imprint finding. Similarly, users of Jukoka and Ontrack would pay more attention on how they can change or modify played contents. Thus, ambient music listening would not be an issue in the above systems. On the other hand, walkmans and commercial mp3 players are good examples to enable ambient music listening, but are neither location-based nor context-aware. Considering calm and ambient design, audio context surrounding us in our daily life is surely the simplest ambient content. As shown in Fig. 2, Responsive Shuffle focused on context-awareness, ambient design, and complex material.

3. DESIGN

The structure of responsive music shuffle system is illustrated in Fig. 3. A responsive music shuffling system consists of input module and media generator. A general input module can be classified into three types of input: personal bio-data, environmental context, and location data, with different weighting factors W_P, W_E, and W_L, respectively. To acquire different input data, sensors of various types may adopted according to the design requirement of applications. Applying computation and mapping strategy to input data, then, media generator matches or synthesizes proper content to play in public or private space. In this work, input data are processed to perform song mapping or music synthesis.

Different combinations of weighting factors generate different applications. Existing systems or products can be analyzed with their own weighting combination of input module. For example, iPod Shuffle is with the combination of $W_P = W_E = W_L = 0$, and Sonic City [2], W_P ¹ 0, W_E ¹ 0, and $W_L = 0$. Similarly, scenarios described above can be understood as the followings.

Bio Shuffle:	W_P ¹ 0, $W_E = W_L = 0$
Environment Shuffle:	W_E ¹ 0, $W_P = W_L = 0$
Hotspot Shuffle:	W_L ¹ 0, $W_P = W_E = 0$
Public Shuffle:	W_E ¹ 0, $W_P = W_L = 0$

Notice that Environmental Shuffle and Public Shuffle are of the same type of input module, but differ in music playing space. Thus, three typical input modes are listed above, each with only one nonzero weighting factor. Therefore, as input modes considered, there are eight possible modes blended from these three fundamental shuffling modes. For example, Sonic City can be thought as consisting of Bio Shuffle and Environmental Shuffle. In addition, our experimental prototype is similar in input module as Sonic City, and thus, is called Sonic Shuffle.

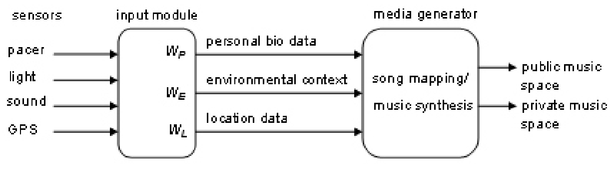
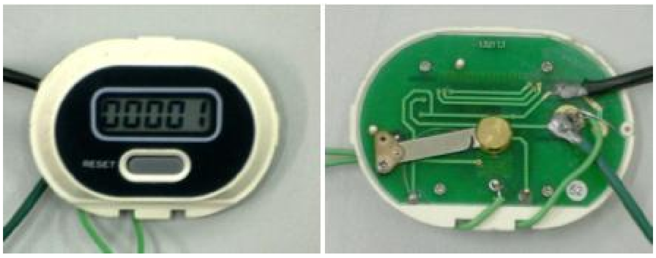


Fig. 3: Responsive Music Shuffle System Structure

Each type of input requires corresponding sensors. Personal bio data may come from pacer, heart rate meter, body thermometer, and so on. In our prototype, a commercial product pacer (Fig. 4) is modified as a pacing sensor connected to a computer. Furthermore, environmental context is basically enabled by sensing technology of vision, audio, temperature, atmospheric pressure, humidity, inertia, etc. For example, ambient brightness and noise can be easily detected by camera and microphone embedded in a handheld device. Finally, location data mainly come from position technology. Ranging from few meters to urban space, possible equipment are electromagnetic 3D trackers, vision-based motion capture system, radio frequency positioning technology, and Global Positioning System (GPS). Considering portability and cost, a handheld device with GPS is a suitable platform than the others.

Since the content that we concern about is audio, instead of text, image, and video, the media generator simply perform audio mapping. Two possible methods are song mapping and music synthesis, one for pre-recorded music playing and the other for interactive music generation, respectively.

Output space regarded, there are private and public music spaces. Personal mp3 players, cellular phones, and car audio systems are frequently used to form a private music space, while public address systems in cafés, stores, and stations make music space public.



(a) (b)

Figure 4: Modified pacer in our prototype. (a) Front cover (b) Detail inside.

4. PROTOTYPE IMPLEMENTATION

In order to explore more possibilities in the future, we have implemented an augmented reality platform to demonstrate and visualize scenarios described above. Users can easily go through the music shuffling while experiencing the simulated position and movement overlapped on the tangible scale model. Moreover, various sensors with an AD/DA card connected to a PC are adopted in another prototype to experiment the mapping of input parameters and selected music.

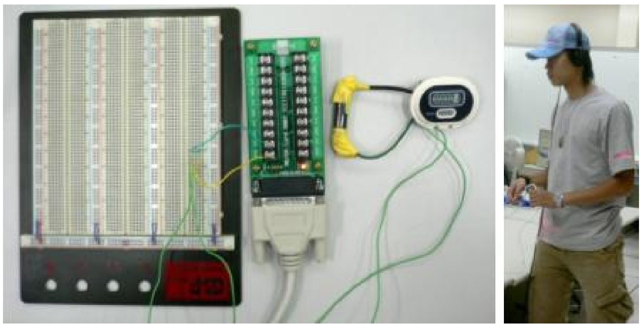
1. Augmented Reality Platform

Fig. 5: Urban scale model with image markers

An augmented reality platform is implemented with an urban scale model tagged with image markers (Fig. 5), which determine the location of hotspot. Users can move a tangible prop and see a pre-defined 3D avatar walking interactively while corresponding music plays according to the proximity of a hotspot. A webcam, a PC, and the software toolkit developed by AMIRE project [11] enable the 3D position alignment and avatar-hotspot interaction. This platform allows multiple users to design and discuss music spaces with tangible interfaces. Moreover, hotspot placing is a flexible feature by changing image marker location physically. Some simple environmental context such as ambient brightness can be easily simulated by altering illuminance on the model. We have successfully implemented two of the three fundamental scenarios on this platform: environmental shuffle and hotspot shuffle.
The other is bio shuffle, and is implemented in the following.

2. Sensor Based Lab Prototype

Pacing speed is one of the most significant information about one's tempo of current state. We modify a pacer to forward electronic pulse generated by a walker to a PC with an AD/DA card. The system calculates number of paces every ten seconds. Tentatively, pacing counts are mapped to three categories of music, slow, medium, and fast. Tempo change will result in music shuffle in a new category, while same tempos keep on playing the unfinished song



(a) (b)

Figure 6: (a) components of our prototype (b) using pacer to shuffle music

5. CONCLUSION AND FUTURE WORK

We have proposed a system structure for responsive music shuffling. Context-aware mobile music is analyzed and designed according to different types of sensors, different application scenarios, and different degrees of sensitivity and engagement. In our investigation, three fundamental music shuffling types are personal bio shuffle, environmental shuffle, and hotspot shuffle. To visualize and facilitate the design of these scenarios, augmented reality and sensing technology are used. An urban scale model is successfully adopted as an augmented reality platform for music space design based on proximity-triggered interaction. Thus, cooperative work on mobile music interaction design as well as urban planning is performed through a tangible interface. On the other hand, lab prototype with a pacer, light dependent resisters, and thermistors performs automatic music-shuffling of pre-classified genres in database. As a concept-proofing work, our lab prototype works very well. However, it still suffers from portability issue. Improving the portability is our next target.

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