MOBILE MUSIC

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1. INTRODUCTION

Music is ubiquitous in our daily life. The extensive usage of music in entertainment or public locations such as film, clubs, stores, etc. cannot be neglected. It is even been used in medical area as a therapy for mental problems. Furthermore, music is not just for personal entertainment but also a social instrument; by sharing music taste, people can interact with each other. People have a desire to share the music listening experience with others, but current mobile devices don't support this activity well. For example, in 80s people carried their ghetto blaster playing music aloud on the street, while now in Aachen teenagers still do the same thing but use mobile phone loudspeaker (Figure 1.1). Nevertheless, most mobile music devices focus on personal usage. Interaction between people is disappearing because headphones desensitize them to activity in their surrounding.

Figure 1.1: The Different between 80's and now

While listening to music is a passive experience, some people have the desire to create music and perform for others in public. Through making music they are able to express their feeling and self-identity. Mobile devices can also be used to create music, and easily make this activity to be a part of daily life. In this paper we evaluate mobile music devices in two different aspects: devices for music listening and composition. We can see mobile music devices evolve to be social devices, while the privacy of users is still considered, and how mobile technologies help people express their musical ideas and even interact with each other musically.

2. EVOLUTION OF MUSIC DEVICES

Sony Company plays an important role in the evolution of mobile music devices (Figure 2.1). In 1979, Sony makes the first mobile music device with cassette, called ''Walkman". Now this device is out of fashion, because compared with MP3 player, it is bulkier, and incapable of displaying metadata, such as song information. Besides, cassettes are more expensive in comparison with Compact Discs, and physically degrade with time. Therefore, by late 1990s, cassette walkman was generally less popular than emerging digital technologies of CD, DAT, and Mini Disc.

The first CD based Walkman was launched in 1984; it was officially called the "Discman". The Discman makes it easier to select the song on CD, because most Discman have information Display that shows the title number. The Discman featured ESP (Electronic Skip Protection), which pre-read the music from the CD into on-board memory to prevent the CD skipping when the player was moved, which alleviates the interference of playback in mobile circumstance. The newer models can play ATRAC3, ATRAC3plus and MP3 CDs too. However, CD is read-only and pretty fragile, which impedes the extending development of Discman. Therefore, with the coming of newer technologies such as flash memory and hard drive-based digital audio players, CD- and MD-based Walkman are gradually going out of use.

Initially the MiniDisc was comparable to be a miniaturised CD, which can store up to 74 minutes of CD-quality audio, or up to 4 times the amount of music to be stored on one MiniDisc, at the sacrifice of some sound quality. The MD Walkmann was able to play and record MiniDiscs from digital sources and microphones. The newer MD Walkman called NetMD (Network MD). This allowed uses to convert music from CDs or MP3s to the MiniDisc, so it can also functions as MP3 player. However, MD is still not a popular choice of portable music device, because the file conversion requires extra software and hence is a troubling and time-consuming process. Comparative high price is also a cause of its small market.

Figure 2.1: The evolution of mobile music devices

Some other mobile devices, such as Mobile phones, PDA, PSP also gradually integrate musical functionalities. In general their battery life is not as durable as the specialized mobile music device. Some new models can playback MP3 files and the user can use that song for ring tone. With their

versatile nature, there are many possibilities for playing music.

In the following sections, we will see how these conventional devices turn to be social instruments, or even machines to make music.

3. MOBILE MUSIC FOR MUSIC LISTENER

3.1. Sharing Music for Mobile Devices

3.1.1. TunA

TunA [1] is a mobile wireless application that allows users to share their music locally through handheld devices. This project connects people on a local scale via music, through the use of handheld devices and creation of dynamic and ad hoc wireless networks. TunA focuses on a mobile fruition of music and on the social dynamics fostered by an ad hoc shared music experience. Moreover, it is based on handheld devices instead of desktop computers, which makes it a very convenient application. TunA is ideally meant to work on any handheld device that supports 802.11 technology (ad hoc mode). TunA has a full screen skinnable interface (Figure 3.1). It can be used as a standard MP3 player for personal music and at the same time it visualizes all the other TunA users who are in range in one single screen. All the users in the same range are able to share playlists, access personal profiles of other users, and sync to the song they are currently listening to, which realizes the mobile ‘‘shared music experience”. TunA gives the possibility to bookmark a specific song or user in order to keep track of encountered information. With the support of networking, TunA users can send instant messages to each other, such as SMS, as long as they are in range or tune in.

Figure 3.1: TunA Interface

3.1.2. BluetunA

BluetunA [2] represents a follow-up project of the TunA [1] Sharing Method. This application can be run on mobile phones with Bluetooth-enabled function. Other than TunA, with BluetunA users are able to find and meet people who have similar music tastes. BluetunA allow users to listen to their own MP3s, create a personal profile and browse the list of the users in Bluetooth range, just like TunA. But since it is based on Bluetooth, therefore it can only work in proximity about 10-50 m. What makes BluetunA much more interesting than TunA is the Music Profile Matching System. Every MP3 Files have ID3 tags information, and within BluetunA it’s possible to use such profiles to compute similarity metrics either by using the audio content or by relying on the ID3 tags, which includes the information about the artist, album, song, and genre. And that’s why as BluetunA user you have the choice to browse others users music which available in range and to adopt it in an active or passive attitude. Through these profiles matching system people with similar music tastes can easily find each other.
Supported with Bluetooth BluetunA users are also able to send messages. And they have also the ability to see how many users are connected to each other at any given time. BluetunA users can also buy songs via their mobile phone.

3.1.3. Sound Pryer

How to share music when someone is driving a car? The only way we know so far is playing it loud so the cars next to us can hear the music we’re listening to. But the new fashion has come due to Sound Pryer application. Sound Pryer is a wireless peer-to-peer shared system for listening to music in automobiles. It is similar to TunA, which works basically on handheld ad-hoc networking radio device like PDA. With Sound Pryer it is possible to share music with other drivers when driving a car, and of course it will make driving much more fun. This project uses handheld devices with WLAN function, and so that in the future the use of this sharing method will become more enjoyable due to the widespread area network. The function of Sound Pryer depends of the number of co-located peers. And if co-located, all receivers depend of the number of users, who are active providing music. It will be suggested that users assemble a playlist before they activate the playback mechanism, so that the possibility to the choices of the music can be listened is maximum. The playback mechanism in Sound Pryer will be split in two models, manual and automatic, and has four combinations of mode and music source, they are:

1. Manual/local: user can select manually the music and the remote peers
2. Manual/remote: the application receives and plays the broadcast stream from a remote peer. If there is no connection, the application will be switched back to manual/local
3. Automatic/local: if a remote peer appears, the playback and boardcasting of a local file will be stopped. The application will be changed automatically to automatic/remote
4. Automatic/remote: If the connectivity is lost, a new peer remote will be selected automatically and at present there should be minimal 2 remote peers. The remote peers will be selected randomly. If there is no remote peers present, application will be changed to automatic/local.

Sound Pryer interface is designed in the range of the user’s attention and should not bother the situation at hand. A sensitive touch screen as well as large interface controls makes finger-based interaction easier. And to display

effectively the status, SoundPryer interface use large control icon with high-contrast. The user information will be presented in three properties, like: nickname, silhouette of vehicle (car, pick-up truck, bike, motorcycle etc), and its colour (Figure 3.2).

Figure 3.2: User information on Sound Pryer interface

3.1.4. Push!Music

Imagine that you have a mobile device that can store and play back music files like PDA (Figure 3.3). On the street you come across someone and suddenly your mobile devices connect to each other wirelessly and the media agents from other devices nearby providing the status of your media collection. Based on what you have been listening to in the past and which files you have owned already, new music might spontaneously and autonomously "jump" from other device to yours. Later, when you listen to your songs, your Push!Music [4] player also plays some newly obtained tunes that you have not heard before.

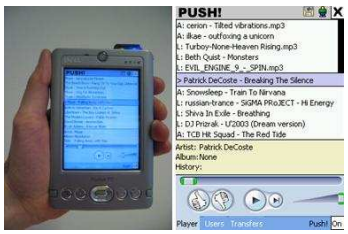

Figure 3.3: Push!Music playlist

Push!Music is a mobile application, which gives users options to listen to and share music for a limited period of time via peer-to-peer scheme. This application runs on handheld devices with Wi-Fi function. It is then possible to recommend music to other users around by pushing them via ad-hoc network. In Push!Music, all MP3 files are media agents [5] that observe the behaviour of the user and other people in the vicinity (Media agents are intelligent systems that are able to automatically collect and build personalized semantic indices of multimedia data on behalf of the user whenever and wherever he/she accesses/uses these multimedia data). Between the connected devices in a wireless network the songs can freely move from one player to another. Push!Music has functions as a source of inspiration. It is a way of discovering new music as we move around in public and open a new dimension of sharing music. But it raises also many issues regarding security and intellectual property. One way to make Push!Music more viable is with a better robust payment model, either as a subscription service or using one of several emerging peer-to-peer payment systems.

Similary to Push!music is FolkMusic [6], it was a mobile peer-to-peer file sharing system
that allowed people to select music from nearby users using an interface based on set theory.

3.1.5. Spy & Buy

It is very frustrating if we hear a song, but can't come up with any information about this song such as title, artist or album. The Shazam Entertainment [7] in London helps us to solve this problem. With Song Identity we are able to get all these information once we hear the music. The O2 mobile phone provider [8] uses the same method to sell their music product. You can use this service for free and can always listen to the music for 30 seconds to know whether it is the right song. In order to use this service from O2 we need a mobile phone with GPRS/UMTS connection as well as WAP function.

How does it work actually? First of all users have to download this Song Identity application and install it to their mobile phones. If users need some information about music, they can launch the application that has been installed into their mobile phones (Figure 3.4 left). The applet will record the music about 10 seconds, generate a small signature file and send these audio file to Shazam Server. The central server accepts and saves these signatures files, performs a searching function and provides the matching metadata like title, artist, and album, and sends all these information back to the applet via SMS (Figure 3.4 right).

Figure 3.4: Left: Applet recording the song, Right: Song Information via SMS

The users receive the song information and can also check out the cover art and track details right away by following the link to the Shazam WAP Portal showed on the message. It is also possible to buy and to download these songs.

There are some issues that should be considered for this system, such as:

- Noise: Noisy background sound (for example: at cafes or traffic) can interfere the transmission of music via mobile phone. It might decrease the matching rate of central server.
- Distortion: The system should be able to deal with distortion, which can be caused from variety of sources, for example: audio samples made by the mobile phones reduce the frequency response to about 300Hz-3,400Hz, or it can also be caused

from the audio sample due to low bit-rate voice compression.

- Database management: In order to offer instant service to a huge number of concurrent user queries, the system should be able to search millions of songs on its online database in high speed without making the server overloaded. The addition of millions of songs into the database can slow down the process to get the correct information and that's why the system should scale statistically.

3.1.6. Public Sharing Music

For people who are sitting in a cafe, it might be interesting to be able to choose music to be played, find out who has the same music taste, or even vote for the song to be played next. Musicology and Jukola make it possible. The main idea of these projects is to bring music expression into public places and enable music from personal to be social experience. The Musicology system brings personal musical taste into a public space and creates a relationship between users' private world, which is represented by personal music devices and the public jukebox. Similar to Musicology, Jukola is interactive MP3 Jukebox equipment, which gives users the possibilities to choose the next song from database.

Musicology

The primary motivation of musicology project is offering applicable interaction mode under different circumstances. 3 different interface modalities are in this system available, such as:

1. Public; which means that the users are visible without any other information details (e.g. name or email address).
2. Anonymous; here users could interact anonymously from their mobile device with server.
3. Registered; in this case, only user who establish their own digital profile could interact with the server from their mobile device.

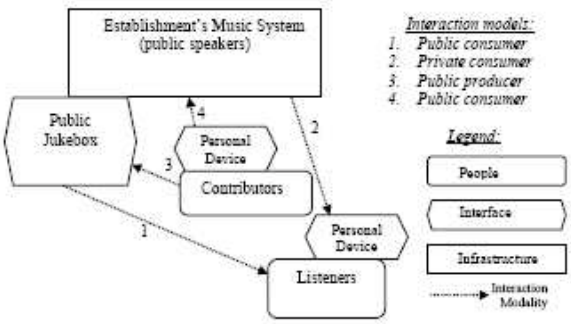

Figure 3.5: The Musicology System Architecture

The Musicology System Architecture shown in figure 3.5 reflects the underlying social structure implicit in general interaction. The fundamental of this system is contributor/ listener (producer/consumer) and device/kiosk (private/public). Contributors provide content and intent. It manages the actual song to play and a preference about which song to play. In a normal cafe the owner or staff takes on the role of contributors. By allowing individuals to contribute to a locale, the Musicology system changes this dynamic. In this case every user can be a contributor. Listener is the most important aspect of this ecosystem. Listener interacts with an available content of contributors, either by listening, voting, collecting songs information or browsing other guests' playlists. The Musicology system comprises two main pieces of technology: a mobile device, which is carried by the user, and the public infrastructure, which is installed in the equipment. The mobile device has two main functions: enabling users to bring their personal music into the system and interact with the system, like voting the song, browsing song information, etc. Jukebox is the central of the system. It allows people to interact with the system without providing their personal identity. The public Jukebox consists of the audio equipment to play audio in the public, which is linked with other jukeboxes, and connected to personal mobile device via Bluetooth or WiFi.

After several field trials there are two kinds of results: baseline results and interface results. Based on the baseline result, there is an important link between the private life perspective of a person and its link to the music as a sign of self-identity. On the other hand, interface results show that private people seem generally more willing to interact with the system. However, they don't like to broadcast their identity in order to vote or know who exactly is playing the song.

Jukola

Same as Musicology, Jukola is made of a number of different components, which all afford different levels of control over the music choice. Music is stored as MP3 files in a database on the central unit. The Jukola central unit is connected to Internet to collect the information about the songs and also update Jukola's web page.

Figure 3.6: Touch screen display songs database and song information

The touch screen display (Figure 3.6) is located in a public bar. By touching the screen the clientele can browse the song collection located in the server, get information about

the song currently playing, view the rank of the recent voting and nominate the song to be played next.
The handheld clients (Figure 3.7) display information about the currently playing song and present the four nominated songs that will be played next. At the end of the voting session, the song with the highest votes will get played. In order to avoid the same song being played repeatedly, the frequently played song will be removed from playlist.
After a field trial conducted in The Watershed cafe bar, the interaction between customers in the public cafe is better than before by using Jukola. Music becomes the common topic for everyone. They discuss which music to nominate, talk about their vote, or learn new genders of music from other customers. Besides, "MusicFx" and "iTunes" also offer similar technology: MusicFX is a system that adjust the selection of music played in a fitness centre to best accommodate the musical preferences of the people working out at any given time, and "iTunes" is used to share music over a local area network.

Figure 3.7: PDA used for voting and showing currently played song information

3.2. Summarized overview of the software

PROGRAM	TunA	BluetunA
Device & Technology	PDA, WLAN	Mobile Phone, Bluetooth
Sharings Level	Interpersonal	Interpersonal
+	+ Big display + Concise interface + Use as normal MP3 Player	+ Songs preview + Users connecting information + Matching profile + Use as normal MP3 Player + Possibility to purchase songs
-	- PDA not ideal device - Missing search function	- Small display - Short bluetooth range - Low bluetooth transfer speed - Incompatibility with Mobile OS

PROGRAM	Sound Pryer	Push!Music
Device & Technology	PDA, WLAN	PDA, WLAN
Sharings Level	Interpersonal	Interpersonal
+	+ Driver not Losing The Concentration + Enjoyable despite only hearing snippets due to the crude awareness	+ Recommend music + Sync automatically to the playlist
-	- Streaming rether than file downloading - Design for awareness - Users information missing - Unsupervised UI allows interaction during mobile work	- Playlist overloaded - Virus risk - Danger for music industrie

PROGRAM	Shazam, O2 Music	Musicology, Jukola
Device & Technology	Mobile Phone	PDA, Jukebox, Bluetooth, WLAN
Sharings Level	None	Public
+	+ Legal + Comformable price + Easy to use + Free songs preview (O2)	+ Legal + Get to know a new music
-	- Noise, Distortion, Database management Problems - Not working on live, classicalmusic	- Virus risk - Same music playsrepeatedly - Device damage frequently (PDA on Table)

4. MOBILE DEVICES FOR MUSIC MAKING

4.1. GameBoy Rock

Gameboy (Figure 4.1) is a portable games machine; however, it has also been applied to music making. Instead of using sample-based synthesis, the sounds are synthesized in real-time using a sound chip. It requires less memory but the resulting sounds are limited because no sample can be used. The Gameboy sound is very lo-fi and nostalgic, which offers an alternative way of making music. However, Gameboy is not an open platform; releasing of software on Gameboy requires the grant permission from Nintendo. The

unit can only communicate with other Gameboys and offers very low extensibility (such as customization of sounds, which would be very appealing), and with the small scene of Gameboy music, there is not much attention drawn to this field. The main two pieces of Gameboy music software are Nanoloop and Little Sound DJ.

Figure 4.1: Nintendo Gameboy

In the field of electronic music, tracker and sequencer are extensively used for making music. Tracker allows users to arrange their samples stepwise on a time line while sequence allows users furthermore to edit MIDI data. Many pieces of music making software as follows are in either form. (MIDI = musical instrument digital interface, the universal control standard for all electronic instruments)

4.2. Nanoloop

Nanoloop [15] is a synthesizer / sequencer for Nintendo Game Boy systems, which lets users generate various electronic sounds, and record, play, and edit digital music. Stored on a normal game cartridge, it allows producing electronic music without further hardware, using either headphones or an external amplifier (home stereo, active speakers, etc) for sound output.

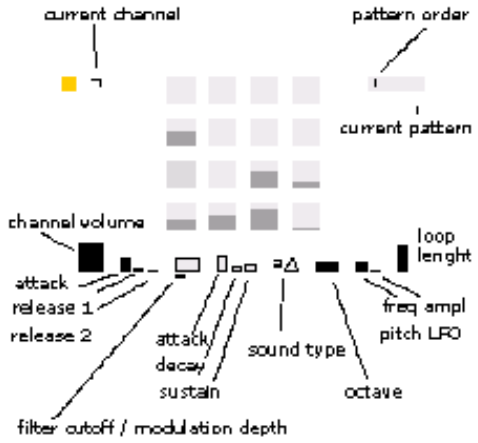

Figure 4.2: Nanoloop, view of Instrument Editor

Nanoloop has no menu control, so users have to memorize all the short cuts for reaching different modes. Because of the limitation of the number of input keys, the same key is reused and combined with other keys to map to different modes. For example, Start, Start long, and Start + select will result different effects; this is not systematic and makes the learning curve of this software pretty steep. Furthermore, functions and effects are represented only by graphics (Figure 4.2). Context is hard to comprehend with the over-simplified graphic, which again increases users' learning load.

4.3. Litte Sound DJ

LSDJ is a sequencer based on the achievement of Nanoloop, which has an easier learning curve than its predecessor. For example, combined with button A, users can change to different modes with direction pad (Figure 4.3). It doesn't require so many different key combinations to map to different modes. Different functions are labelled with text, which makes it much easier for the user to master the software. However, there are still some flaws in the UI design. For example, the linking between different modes is not well-designed: some modes can only be reached when in a specific mode; if user wants to reach mode A, wherever they are, they have to first switch to mode B, and then the user can switch again to mode A, which means the only entrance to mode A is from mode B. Also, a part of the numbering system in LSDJ is hexadecimal, which also adds the learning load for many of the users.

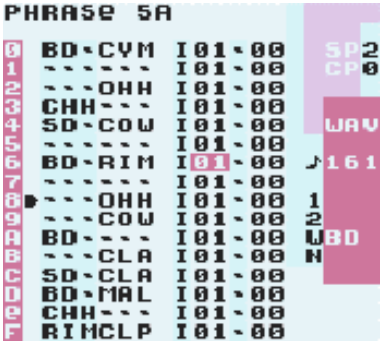

Figure 4.3: LittleDJ, Phase Editor

4.4. Nintendo DS

Nintendo DS is a handheld games machine developed by Nintendo. DS [25] has two LCD screens- one of which is touch sensitive, which makes DS a better device for making music in that it greatly reduces the pain of using the limited input devices, such as direction pad on the left side and four buttons on the right side of the panel (Figure 4.4).

Figure 4.4: Nintendo DS

Users can directly manipulate functions by touching the screen. Compared with Nanoloop on Gameboy, which uses direction pad extensively for changing mode and value, software on DS system is much easier to control. Also, by mapping the value of x and / or y-axis to the desired effect, the two-dimensioned touch screen can also be used like some conventional hardware, such as Kaoss Pad [16]. The software on these devices is much closer to the conventional synthesizer software on a PC. Nitro tracker [17] (Figure 4.5) is a music making program for DS.

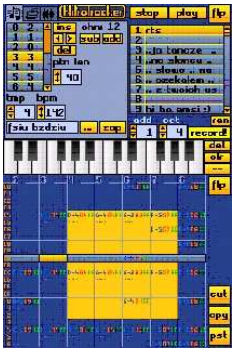

Figure 4.5: DS, Nitro tracker

Users can compose melodies using a keyboard shown on the touch-screen. The built-in microphone on DS also enables users to make their own samples and record them into the software. But the unfriendly price of DS keeps it away from being a popular mobile device.

4.5. GP2X, GP32

GP2X, GP32 are open source, Linux-based handheld video game consoles and media players created by GamePark Holdings of South Korea. GP2X, and GP32 are ideal for homebrew because of their Linux platform, which enables the freedom to make software for them without the effort of hacking the devices. One interesting advantage of GP2X is that it supports all USB peripherals: for example, it can have one or more sound-cards plugged into it, which brings many possibilities for music applications. LittleGPTracker is a sample-based tracker for GP32, GP2X. Its interface is based on that of Little Sound DJ.

4.6. Mobile Phone

The Mobile phone (Figure 4.6) is regarded as a promising device for mobile music, because of the much higher popularity and relatively low cost of the device.

Figure 4.6: Remote controlling software via mobile phone

It is also easier to extend functions and to integrate with other devices. Jason R. Kramer has written a script for remote controlling Ableton Live via mobile phone [18]. Ableton Live is a loop-based software music sequencer for Macintosh and Windows. It is designed for remixing music in real-time. In order to enhance the real time use, the user interface is more compact than most sequencers. Therefore it is feasible to remote control Ableton Live via very confined device, such as mobile phone. This script contains 15 user assignable functions and play/stop toggles, which enables the ability to have quick access to performance buttons without the need for a separate MIDI controller.

4.7. CaMus

Introduction

This system uses mobile camera phone, as a motion oriented handheld musical performance device. A camera-equipped mobile phone is used to generate various numerical values according to the relative distance between the mobile phone and one or more targets in the real environment. The black-dotted paper shown on Figure 4.7 represents a virtual plane. By placing the mobile phone over the visual marker (the coded paper) [20], the codes will be caught by camera. The system then converts the codes to a virtual plane, and shows the related virtual plane on the display of the mobile phone (Figure 4.8).

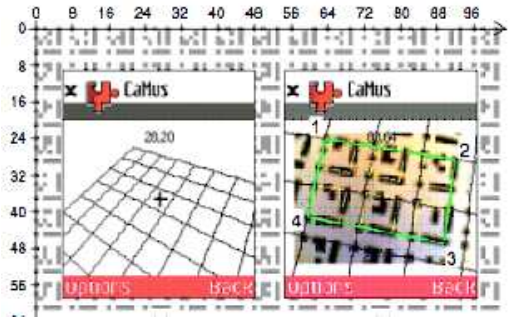

Figure 4.7: CaMus: interface shown on user's display

The system on the mobile phone does not generate sound itself. Instead the mobile phone sends the generated values to a remote machine via Bluetooth, and then the remote machine converts them to MIDI messages and maps the messages to distinct parameters of sound generating software or hardware. By assigning the movement parameters, it is possible to dynamically create melody or change timbre.

Visual Tracking System

In order to generate signals, the mobile phone user has to set up an interaction target. While the target is set, a ring is created with the target as the centre. In the centre of the display, there is a cursor that indicates the interaction centre from user's view. If user's cursor is outside the target's range of influence, which makes the perimeter of the target turn from red (see the red ring on Figure 4.8) to yellow, no interaction will take place between the cursor and the target. While the cursor is inside the range of influence, signals relative to the target will be generated and sent to the remote machine. By using the joystick on the mobile phone, the user can easily add, delete or move the position of the target. For example, pressing the joystick in south direction will create a new target while north will delete an unwanted one. This interface makes the device very easy to use: with the same hand user can adjust the spatial position of the

mobile phone, and use their thumb to allocate the location of the virtual target. Furthermore, multiple targets can be set up to generate complex signals. For example, if two targets are put close, there will be some overlapping of their range of influence. When cursor is inside the overlapping area, signals will be generated with respect to both targets. Therefore effects can be manipulated jointly or individually. In such way, we get greater variety of sound generated in the remote machine.

Camera to 3D Space

According to the virtual plane, the camera phone computes the coordinates of the cross hair, the distance from the grid surface, and the amount of rotation and tilting with respect to the marker panel. While interacting with targets, if cursor is inside the influence area, the strength of the effect is inversely proportional to the distance from the centre. This concept is very easily acquired by listening to the generated sound whilst moving the cursor around.

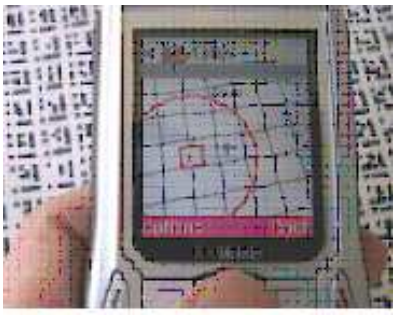

Figure 4.8: CaMus: user's cursor is inside the range of influence, so the ring is red

Overview

There are several pros in this system. Firstly, three colours to indicate different interaction modes can be learnt quickly in the first few attempts. Secondly, targets are easily modifiable by pressing joystick in different directions. However, this might also easily cause mistakes, such as deleting a target when the user intended to add a new one. For the simplicity and joy of the design, this system can also be used as a game for kids to experiment on sound, while professional musicians can also use it as a live performance device.

4.8. Mobile Music Making

Introduction

This is a project by Atau Tanaka [21]. This system uses a PDA (Figure 4.9) as a musical instrument and takes advantage of WiFi to enable the ability of collaborations with other users of the same system. User's input is managed by two different methods. Firstly, the touchscreen captures the user's voluntary input to graphical user interface, which contains user login mechanism, and some musical functions such as sliders. Secondly, a subsystem is attached to the PDA for catching user's involuntary input to the system.

Figure 4.9: PDA as mobile terminal with sensor subsystem

For example, a force sensing resister (FSR) captures grip pressure, and accelerometers sense gestures and motion in three-dimensional space, so expression more typically associated with musical instruments can also be captured. However, there is no direct link between operation and effect. Compared with another video enabled project CaMus [19], which only converts the generated values to MIDI messages and maps them to sound generation software or hardware, this system manipulates inputs altogether in a sound generation engine, made by using MAX/MSP, to produce several parallel music channels.

Trust Strategy & Collaboration

Since WiFi technology enables cooperation with other users, security issues must be considered. The accesses permissions are limited to four levels and personal information is stored in the device. According to different access levels users can actively collaborate with each other, or are only allowed to listen to the result from others, and so on (Figure 4.10).

Figure 4.10: Onscreen graphical interface

Gestural input from the group of connected users arrives via XML or OSC (Open Sound Control) messages [22] (these are optimized networking protocols). Time stretching is used to reconcile any differences in tempo. Filtering and time domain re-ordering improve the flexibility of the collaboration activity. Instead of the conventional collaboration mode, which receives the MIDI input from each user and simply merges them together; this system enables the activity to be real-time flexible.

An issue is posed in collaboration mode. Since it is a real-time music making device, it should offer users instant

feedback, while the system also has to reflect the latency caused by the distance between participants. How to satisfy these two needs is still not resolved.

4.9. Homebrew Software – PSP

Apart from commercial software, there is also a trend of Homebrew software for the aforementioned devices. They mostly only take the advantage of the ability of WiFi on these devices. This means they use the devices as consoles, and make software for remote controlling music software running on a PC.

PlayStation Portable is a handheld game machine developed by Sony Computer Entertainment. Because the firmware (version 1.00, the first launch) of PSP can execute unsigned code, PSP can run homebrew software. Because of its high processing power and better LCD, PSP is also regarded as a good platform for portable music making devices, especially for composition, which very often eats up the resources of processor. Some examples of homebrew software for PSP are: Rob Kirn creates software for wireless controlling Ableton Live by PSP, and PSP Rhythm is a rapidly growing drum machine on PSP. It has a pretty consistent user interface. Pressing "SELECT" switches to different modes, Up and Down of D-pad is used for selecting different options of a mode, and Left and Right of D-pad for changing the values of the options. Compared with Nanoloop and LSDJ, the PSP offers a much more user-friendly interface.

5. Conclusion and Future Work

For the sharing music applications we can conclude that joint listening (TunA [1], BluetunA [2], Sound Pryer [3]) is an interesting and promising application for the future of mobile music sharing technology and it makes social life more enjoyable. It is also interesting to know the characteristic of a person by the music they listen to (Jukola [10] / Musicology [9]). However it is also annoying if our music devices play music that we actually do not like, or strangers send music to us while we cannot say no. (Push!Music [4]). We don't have any privacy in such situation, because our personal information is exposed in public and can be changed by anonymous.

The problem arises, as Technology pundit Andrew Orlowski said about TunA, "I'm not sure that a device that would allow streaming but wouldn't allow you to copy would be very popular" [14]. It can be a good idea to make music download possible: the system offers only restricted access, but also offers service for users to buy this song from the provider, which also supports music industry.

Besides the software from every project has a potential to be integrated to every devices or public space. Like Sound Pryer could be integrated to concept car, because every new car has an on-board computer, which manages the function from the engine through to music in the car, and Sound Pryer can be a new option of interactive music in the car, or BluetunA in every mobile phone with Bluetooth technology. At present iPod has been intergrated with Car audio system [11]. With a BMW iPod adapter drivers can access the music library and control their music through their existing audio system and the multifunction steering wheel.

While offering shared listening experience, as TunA do, the application can also provide extra flexibility to users. For example, different playback modes for different needs; "sleeping mode" offers a more fluent listening experience. In this case time stretching and equalizer can be used to moderate the difference between two songs, such as the dramatic change from swing music to heavy metal music. "roaming mode" takes advantage of the profile matching technology to help user find the device with high similarity and play the current playing music from the device. Nevertheless, in order to keep fairness and high security, it is better that every user make some registered (in this case it's good for Push!Music project) and we can integrated security engine like anti virus/spam in software.

On the other hand, for music making applications there are also unsolved challenges for the future. For mobile game machines it is apparent that the fluency of using confined inputs still needs to be improved. The software should not follow the conventional model, but seek a way to reduce the frequency of switching between different modes in the confined machines. In Atau Tanka's project [21], in order to satisfy the requirements of remote cooperation, the rendering engine needs to be further developed. The cooperation is enabled via network, and the latency of network represents the existence of the distance between users. However, how to represent the latency, while still showing the immediacy of playing musical instrument to users is a great challenge. In the camera-enabled project, Camus [24], the mapping between motions and affection is still missing. In the future the researchers may try to track everyday types of visuals, such as faces, posters, or specific colors, and map them to characteristic musical output. Besides, with optical flow techniques, phone movement can be captured and mapped to filters, which can both improve the expressiveness of Camus system.

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