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An Interactive and Generative Framework towards Enhancing User Experiences in Interactive Music Performance Systems

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Musicians and engineers tend to develop new applications based on new interfaces, which introduce new user experiences and interactions to products or systems. Yet, this overlooks the need to extend the intelligence and creativity concerning music-making. To enhance user experiences and extend the engagement of music performance systems to a deeper cognitive and creative level, this research explicates a theoretical framework that incorporates generative and interactive techniques between users and the music performance system. The study suggests an adaptable solution through an adjustable mechanism in terms of interactive and generative intensity whereby musicians or dancers can cooperate with the system and contribute their knowledge in the creative and collective process of generating new music with strong features online. This research integrates generative design into interactive music performance applications as well as new digital multimedia techniques for ethnic minority people remotely connected to the outside world, whose culture presents a challenge to embracing new ideas and new techniques in their music and dancing tradition.

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An Interactive and Generative Framework towards Enhancing User Experiences in Interactive Music Performance Systems

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Certificate of originality

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Abstract

This thesis presents a theoretical framework which incorporates generative and interactive techniques in order to enhance interactivity and user experiences through interaction and collaboration between users and the system. It proposes an adaptable solution to supporting music performance through a mechanism of adjusting the interactive and generative intensity through the implementation of an interactive music performance system. In addition, it provides sharable components so that musicians or dancers can cooperate with the system and contribute knowledge in the creative process of a collaborative and dynamic generation of new music inheriting strong features of the music recorded online.

In recent decade, there is a strong tendency for musicians and engineers to develop new applications based on new interfaces. Music applications equipped with innovative interactive features can easily attract attention. However, it is unavoidable for these applications to be replaced in a short period of time owing to the rapid development of technology. This makes them rather short-lived and re-writing of program code is necessary. Although this tendency can introduce new user experiences interacting with products or systems, it overlooks the need to extend the intelligence and creativity with regard to music making. While generative techniques can provide creative solutions and generative systems give rise to sophisticated generative and transformative outcomes, they are underused by existing interactive music performance systems. In view of this, a balance should be made on one hand to enhance interactive experience and to explore creativity on the other hand.

On theoretical basis, the studies of Human-Computer-Interaction address issues relating to interaction, usability of interfaces, cognition and modalities when designing an interactive music performance system. However, it overlooks design issues regarding emotion, creativity and aesthetics which are critical to the design of contemporary interactive systems. There is also lack of theoretical framework

towards bridging the gap between designing user interactions with the system on one hand, and designing highly algorithmic and generative systems on the other hand. New theoretical framework will be proposed to introduce new user experiences which can be further enhanced and suggest solutions for a more engaging system or product.

This research proposes a theoretical framework aiming to increase interactivity between users and the system by incorporating interactive and generative techniques. It also intends to enhance user experiences and extend the engagement of the system into a deeper cognitive and creative level. Yunnan Yi Minority music performances are taken as a case study. It makes attempt to experiment new paradigm of collaboration between human performers and the system while retaining the traditional practices and techniques of performing ethnic Yi Minority music. This avails exchange of musical knowledge through interaction in the creative process.

During the literature review stage, a real public media performance was conducted in Hong Kong in 2009. I was one of the team performers responsible for keyboard playing and application development which brought out interactive features and contents to interact with the audience. Participant observation was adopted to understand the interaction with the audience and collaboration among performers in real life situation. In order to study the traditional practice and culture of performing dances and music of a group of people in depth, case study is selected as a method to have a closer examination of the music and dance performances of Yi minority group of Yunnan Province in China. Ethnographic field trip is initiated to visit a village where AXi people of Yi Minority live, called Ke Yi Village, in the east of Kunming which is the capital of Yunnan Province. Observation, field notes, video and sound recordings of the performances are major tools to understand the ethnic musical culture. A number of system prototypes are implemented with interactive and generative techniques based on the guidelines suggested by the design models. The music resulted from the systems bears some resemblance to the Yi music with its ethnic elements. These systems are used in the experiments conducted with the

villagers to collect data and feedback. Results are discussed and evaluated in the thesis.

This research is an attempt to integrate generative design into interactive music performance applications with ethnic minority people who are remotely connected to outside world and new digital multimedia techniques, and whose culture presents a challenge to embracing new ideas and new techniques in their music and dancing tradition. However, the field trips provided excellent opportunities for the author to know the complexity in real interactive music and dancing. They also revealed the limitations of the implemented systems in terms of its real time responses to users who are completely new to any new digital devices and interfaces. The evaluation of the implemented prototype systems provided good insights on how the integrated generative and interactive framework proposed in this research can be further enriched and improved in future research.

Acknowledgement

I would like to express my sincere thanks to my thesis supervisor Professor Tang Ming-Xi for his continuous guidance, patience, encouragement and support in the research.

In this research, two field trips were conducted in the Ke Yi Village of Yunnan Province. Special thanks to Professor Pang for her arrangement and guidance of the field trips. Her post-graduate students also spent a lot of time and effort in helping with the visits, experiments and interviews conducted in the village.

During the stay in the village, accommodation was provided by the villagers. It was a precious opportunity to learn about their folk songs and dances which enriched the content of the research. Without their help in songs recording and dance performances, the music CD of "AXi Dancing Under The Moon" will not be published and the research cannot be completed.

Final thanks go to my parents for their understandings and support.

Publications

Elaine L. Wong, Wilson Y. F. Yuen, Clifford S. T. Choy. (2008) “Designing Wii Controller As A Powerful Musical Instrument In An Interactive Music Performance System”, 6th International Conference on Advances in Mobile Computing & Multimedia (MoMM2008), Linz, Austria, 24-26 November 2008.

Elaine L. Wong. (2009) “Augmenting Media Performance with Interactive Technology”, 12th Generative Art Conference GA2009.

Elaine L. Wong & Ming-Xi Tang. (2011) “An Interactive and Generative Framework for Enhancing User Experiences in Music Performances”, International Conference on Interaction Design 2011.

Yunnan Music CD Publication. “AXi Dancing Under The Moon” music CD jointly published by Hong Kong Polytechnic University and Yunnan University, 2011

Elaine L. Wong & Ming-Xi Tang. (2012). “A Generative and Interactive Framework Enhancing Music Performances Based on a Cognitive and Computational Model of Interaction”. Fifth International Conference on Design Computing and Cognition, 7-9 June 2012, Texas A&M University, College Station, Texas USA.

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Part 1 Introduction

Chapter 1

1. Introduction

Music performance is interactive in the sense that it is reacting expressively and emotionally to the performer. It exhibits strong cohesion when musicians are interacting with each other to synchronize with the flow of the music. When the computer came into play, music performance is interactive in the way people perform with a system and in the manner the system creates music. In the context of an interactive music performance, interaction with the humans, computer listening, manipulation of transformed signals and presentation of musical output are the areas that musicians and interaction designers are working on. Given a real-time environment, the system is able to communicate with the human performer seamlessly to generate and compose music and sound in audio as well as visual formats. According to Rowe, he defined interactive music systems as:

> *"Interactive computer music systems are those whose behavior changes in response to musical input. Such responsiveness allows these systems to participate in live performances, of both notated and improvised music."* (Rowe, 1993)

Interactive music systems are distinguished from algorithmic composition systems for having a human performer interacting with the system. Algorithmic composition, on the other hand, is the method to compose music by formal procedures and logical sequences with minimal or without human intervention. The techniques being used range from mathematical models or formulas to biological evolutionary methods. When a human performer is involved, it provokes a lot of studies regarding interface design for interpreting signals from the human players efficiently and interactivity issues for effective communication between humans and the mediated system.

Rafaeli classified different types of interaction according to the communication responses and their effects. For interaction to take place, communicants need to respond to each other in a coherent way. Quasi-interactive or reactive communication requires later messages refer to the earlier ones. On the other hand, full interactivity "differs from reaction in the incorporation of reference to the content, nature, form, or just the presence of earlier reference." He made a view point on it: "Interactivity, on the other hand, is an active quality; it is incorporated purposively. In information theory terms, interactivity is all but noise; it relates to all the other components of the information transfer model—sender, receiver, channel, and message." (Rafaeli, 1988)

"Interactive" here, means not only the responsive or reactive communication between the system and the user, but also the continuous dialogs between them. Since music performance is a dynamic and on-going process between the player and the musical instrument in which adjustment and adaptability are required. The same principle applies to music performance systems, which further entail manipulation and transformation functions in order to achieve the desired results. The degree of interactivity is empowered by the processing power of the computer. With high performance of computers today, music systems are able to interpret inputs, manipulate them, execute composition algorithms and provide feedback to the users in live setup.

For interaction to take place, there must be a good stimulus that causes people to be interested in some people or something of very dissimilar background and nature. If interaction is about communication, exchange of ideas and experiences, interaction design should facilitate and enhance interaction among human beings or between humans and the mediated system. New user experiences are believed to be created with innovative technology through interacting with the products and the systems. Sharp defined interaction design as:

> *"Designing interactive products to support the way people communicate and interact in their everyday and working lives. Put another way, it is about creating user experiences that enhance and augment the way people work, communicate, and interact."* (Sharp, 2007).

Experience is initiated when attention is attracted. It is the job of the interaction designers to hold the user's attention so that the experience can be continued. In order to enhance the experience, there should be an extension and that extension can be achieved through digging into greater depth or stretching out to a newer kind of experience.

1.1. Music and Technology

When the music programming language "MUSIC I" was developed by Max Mathews in 1950s, algorithms could be implemented to compose simple notes. At that time, inputting methods relied mainly on legacy devices such as punch cards. The invention of MIDI(Musical Instrument Digital Interface) in 80s standardized communication of musical signals such as pitch, volume, timbre, etc. within digital interfaces. The popularity of personal computer with keyboard and mouse gave birth to the music composition applications. During that period, applications were mainly algorithmic in nature due to the restricted choice of input devices and inability of the computing power to respond fast enough in real time. Software sequencers were successful in music production for recording, editing, mixing and rendering. They are currently widely used for commercial production in the industry. From 1990s and 2000s onwards, the emergence of new technologies such as virtual reality, robotics, multimodal interfaces, augmented reality and multi-touch allowed applications to have attractive features and offer exciting experiences that people have never encountered.

Reviewing the development of computing technology in relation to music making, generation of music was rather automatic using algorithms with simple screen

interface with no or minimal human intervention. With increasing power of the computers and innovation of new interfaces, music applications were able to respond to users in real time and interactive in nature. There is a strong tendency in recent decade for musicians and engineers to build expressive interfaces. New interfaces for music performance of diverse interactive techniques and designs approach the market. However, the heavy reliance of such digital musical instruments on new interface can yield some problems. First, owing to the rapid development of technology, it is likely for new interfaces to be substituted in a short period of time. Thus, re-writing of applications is unavoidable in order to adapt to the new platforms. It is very difficult for products and applications of this kind to be sustainable through time. Second, the strong tendency to build on sophisticated new interfaces overlooks the need to extend the intelligence and experience of music making in cognitive level within the computer-based musical systems.

Rowe also made a comment about this situation when he was defining and classifying interactive music performance systems:

> *"Many of the programs developed to date have been realized in relative isolation from one another, with little scope for building on the work of earlier efforts. Now, several fundamental tools of the trade have become standardized and are no longer so subject to ad hoc solutions."* (Rowe, 1993)

1.2. Review on Theoretical Framework

On theoretical basis, Rowe made a classification of interactive music systems summarizing their genres in three dimensions. It distinguished those systems which are driven by stored scores or not; it differentiated methods for generating musical responses; it identified human players using digital instruments and the artificial players. Wanderley proposed a number of guidelines to evaluate musical controllers

in the perspective of human computer interface by looking into products' usability and accuracy. Bongers proposed a number of interaction models studying the relationship between human performers, audience and the music system. Interaction loop takes place and travels through modalities of seeing, hearing or touching with the intent to reach memory and cognition operations of the system and the human brain.

The early stage of HCI research focused on the study of usability, ergonomics and functionality of the products or systems. It overlooked design issues of emotion, cognition, creativity and aesthetics which are critical to the design of the contemporary interactive music systems. Bongers proposed some interaction models to study interaction through sensory perception and cognition in the context of music performance system. However, they did not tackle the issues relating to music making, performance and creativity incurred during interaction.

1.3. Motivation

The motive for me to do this research rooted in the research project conducted during the master study in 2008. It was an orchestra conductor application using a Nintendo Wii Controller as the baton. It is a new and exciting research area that there is still a huge potential for extending the research areas of usability, adoptability, creativity and affection. At that time, I made use of the existing interface, the Wii Controller and there were a great number of people before and after me doing the same thing. Until the occurrences of iPhone and Macbook, there were streams of people chasing the new products and used them as interfaces or platforms to develop their own applications. There is a difficulty to have an essential and fundamental ground to build upon or evolve from.

Performing and appreciating music is a complex matter. The fast advancement of computing technologies and its impact on the development of new media possess

many challenges to the designers as to how new systems and changing environments can enhance the design of musical instruments to deliver newer and more emotional experiences to the audiences. In such systems, interfaces may have several meanings, and the interactions may take place at different levels of cognitive, emotional and creative activities. A balance needs to be reached in such a system to allow mental and computing powers to be utilized in the maximization of creativity and entertainment experiences. The current fast explosion of various multimedia systems overestimated the cognitive processes of music performance and music enjoyment. As such they turn to over rely on technology which delivers technological oriented contents that are often short lived. The ultimate motivation of this research is to develop a music performance system which is interactive, generative, emotional and creative. In order to define, develop and evaluate such a system, the study in this thesis will focus on how to relocate the system, performers, and audience in an open system in which interactive features and generative features of the system as a whole can be adjusted, tested, and evaluated.

I learnt and composed music when I was young. Playing music and composition have always been my interest and I am passionate in integrating state-of-start technology with music and art. I enjoyed the processes of background research, composition, programming and continuous modification to the system in order to enhance the quality of the music created and performed. I sometimes got difficulties in implementing the system, but had great satisfaction for solving them eventually. Interactive music falls into a category of contemporary music. It is still at an early stage of development and experimentation. In view of the current problems as identified in the previous section, there is a lack of theoretic framework for designing systems to be sustainable and evolving through the rapid change of technology. Therefore, this study is motivated both from an academic context in which the development of methods and frameworks will contribute to the field of knowledge, and a personal context in which my skills and experiences will play an important role in verifying the systems and techniques to be developed and tested.

1.4. Aim and Objectives

The aim of this research is to propose a theoretical framework with an adaptive design to enhance user experiences with an interactive music performance. There are a number of objectives to be achieved:

- Improving interactivity and enabling exchange of musical knowledge between the system and the users who interact with it;
- Enhancing user experiences and extending engagement of the system to a deeper cognitive and creative level by incorporation of generative and interactive techniques;
- Enabling collaboration between the system and the human performers in the creative process.

These objectives are to be achieved through the implementation of several system prototypes with experiments conducted in the field that they can be evaluated with the performers and the audience.

1.5. Methodology

In view of the current situation, a theoretical interactive and generative framework is proposed to understand the evolutionary development of interactive music performance systems and their nature. With the purposes to extend the understanding and enhance user experiences, a flexible and configurable framework is proposed to maintain interest in interactivity on one hand, and explore the beauty of intelligence and creativity in composition done by the computer on the other hand. It should be able to adapt to the changing needs of the performances.

In order to study the way people make music and perform art in depth, ethnography is adopted. Ethnic music of Yi minority group of Yunnan Province in China is selected

as a case study to have a closer examination of its culture. Ethnographic field trip is initiated to have a visit to a village belonging to AXi people of Yi minority. A number of systems are implemented with some ethnic elements based on the guidelines suggested by the design models. These systems are being used in the experiments conducted with the villagers to collect data and feedback. Results will be discussed and evaluated in the thesis.

1.6. Contribution

Although computers have been used in music performance for more than five decades, there are still a lot of criticisms towards their usefulness, affectivity, effectiveness and value. No question, software sequencers are widely used in music industry for making scores for films, advertisement and short videos while Ableton Live is frequently used by musicians for live performances. Algorithmic composition is by no means a power technique to compose music in a unique way. The generative techniques being used can hardly be done by humans and they provide valuable and unlimited source of inspirations and contributions.

This research carries out an extensive study on interactive music, figuring out its benefits and fallbacks. While preserving the goodness of interactive features, the power and intelligence of generative techniques are being studied, tested and incorporated into the study. A theoretical framework incorporating both interactive and generative techniques is formulated to provide design concepts and guidelines for musicians, artists and designers approaching interactive music performance. With the purpose to improve the engagement of the music systems, adaptive and interaction models with the context of music making are introduced within the framework to extend and enhance user experiences. This makes valuable contribution to the areas of cognition, interaction and creativity of interactive music performance systems.

This theoretical framework emerges from the review of historical development of interactive and generative music systems. It attempts to offer a more comprehensive

perspective over the development of existing interactive music systems with an endeavor to strive for a balance between interactivity and creativity in the context of music making. It contributes by suggesting and sharing design viewpoints and guidelines to designers, musicians and artists to create a more interesting, enjoyable, creative and engaging product or system.

Existing conceptual models in interactive music systems pay too much attention on interaction issues and interface usability while cognition models concern sensory perception and mental cognition. The proposed theories and models in this research emphasize on the consideration of performance, collaboration and creativity issues in music making. They contribute by supplementing knowledge on top of the existing interaction and cognition theories and models.

In this research, Yi minority ethnic music of Yunnan Province in China was chosen as the case study in order to study the music making and performance culture of this group of people in depth. It contributes to the knowledge of the field by advancing the research to an unexplored area which yields unanticipated results and valuable insights in different dimensions. Furthermore, the uniqueness and richness of the culture and music making of Yi minority provide valuable resources for expanding cultural elements and knowing in the area of interactive music composition and performance.

1.7. Thesis Outline

Chapter 1 gives an introduction of the interactive music performance system. It presents the background and overview of the research.

Chapter 2 presents a literature review on the interactive music performance systems. Major works are reviewed along the history of development with accounts of interactive and generative techniques.

Chapter 3 presents a literature review on the existing theoretical framework towards interactive and generative music systems.

Chapter 4 reviews a real public media performance held in July 2009 in Hong Kong. This serves as a background study of the mixed media performance augmented by digital musical instruments. Issues regarding interaction design, contents development, musicians' collaboration and audience participation are visited.

Chapter 5 proposes a theoretical framework towards interactive music performance systems with the incorporation of interactive and generative techniques.

Chapter 6 gives an introduction of the cultural elements of folk songs and dances of Yi minority in Yunnan Province. Formations are illustrated and methods are presented to translate the ethnic elements to be understood by the computer system.

Chapter 7 gives an account of the methodology with discussions of various research methods involved in the research process.

Chapter 8 reports the observations and activities occurred during the ethnographic field trip carried out in the Ke Yi Village where Axi people of Yi minority live in Yunnan Province.

Chapter 9 gives the details of the implementation of the experiments being conducted in Ke Yi Village for the adult villagers and the primary school students.

Chapter 10 presents the design of the system architecture. Implementation logic and details of interactive and generative modules are revealed.

Chapter 11 reports and summarizes the results obtained from the experiments and interviews conducted in the Ke Yi Village of Yunnan Province.

Chapter 12 concludes the research with discussion of findings and limitations. It reviews the shortcomings of the first version of the system prototype and attempts to propose an enhanced version including more interactive features with folk dances.

Part 2 Literature Review

Chapter 2

2. Literature Review on Interactive Music Performance Systems

This chapter presents an overview of the development of interactive music performance systems that were greatly influenced by the advance of the computing technology. Major works are examined revealing the changes of interactive experiences and techniques being applied, followed by description of generative techniques that can be used in an interactive music performance system.

2.1. Development of Interactive Music Performance Systems

Electronic Music Before 1945

Before 1945, electronic musical instruments were invented primarily for performance purpose in order to play music live by electronic means. Telharmonium was one of the electro-mechanical instruments invented in 1895. It made use of the telephone system to distribute music and the tone wheel design to produce and modify tones by electronic as well as mechanical means. Theremin was one of the first instruments which used beat frequency technology to produce tone with vacuum tubes. It can be determined as the first gesture driven electronic musical instrument. The relative distance of hands to the antennas can control pitch value and volume level. This technology was patented by Leon Theremin in 1924.

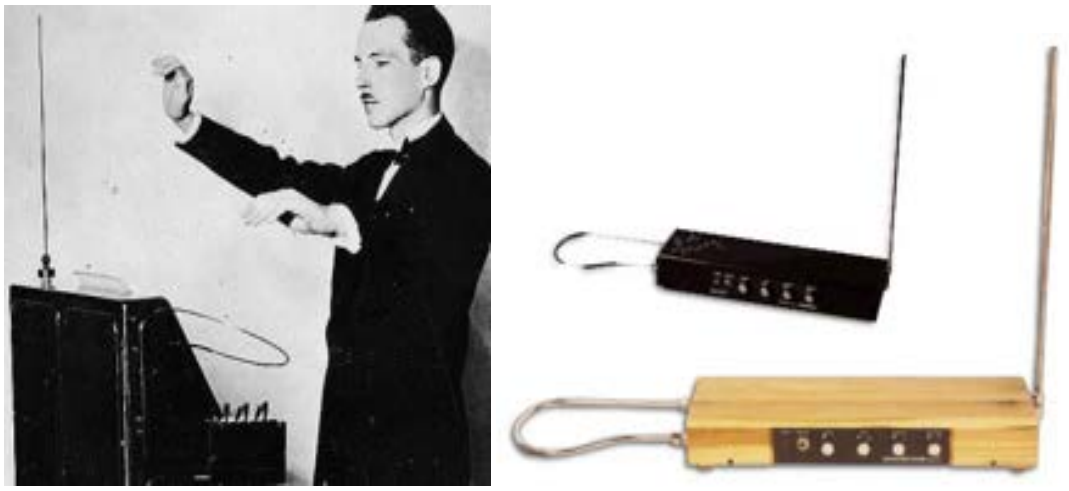


Figure 2-1. Professor Theremin was performing with Theremin & Modern design of Theremin by Moog's Music

Computer Music After 1945

Beginning in the 1950s, the development of computer technology inspired musicians to explore new technologies in composition, sound synthesis and performance. Max Mathews, regarded as the "Father of Computer Music" at Bell Labs developed the first music programming language, i.e., MUSIC I in 1957. Synthesis of sound began in 1950s and direct synthesis of music by computers became possible in the 1970s, giving rise to the development of digital synthesizers in Bell Labs, Stanford University, and the Institute of Sonology in The Netherlands.

Figure 2-2. Max Mathews with his Radio Baton

Computer Music on Personal Computers After 1970

The first microprocessors in 1971, Apple computers in early 1970s, IBM Personal Computer in 1981, MIDI in 1984 gave birth to the synthesis of music, production of music applications and tools, multifunction sound cards, software samplers and sequencing programs on PC platform. Laurie Spiegel developed Music Mouse in 1981 on Apple Macintosh to control automatic composition in real time; Max was introduced by IRCAM in 1989; Pro Tools was developed by Digidesign in 1991. At that time, applications were controlled mainly by mouse and keyboard.

Computer-based musical instruments and tools after 1980

Professor Tod Machover is one of the greatest contributors to the development of digital musical instrument. He joined the New Media Laboratory of the Massachusetts Institute of Technology in 1985. He focused on the development of "Hyperinstruments" from late 80s to early 90s aiming at augmenting traditional instruments with added sensors. Examples include Hypercello which had been performed by Yo Yo Ma, and Hyperviolin. The Brain Opera project in 1996 offered interactive music experience that included contributions from both on-line participants and live audiences[1]. It was finally housed in Vienna's House of Music.

[1] http://park.org/Events/BrainOpera/

Figure 2-3. Professor Tod Machover with Cellist Yo Yo Ma

Late 90s witnessed the boom of Internet and its popular use in public. Apart from music download, Internet fosters collaborative music composition and performance online. Quintet.net is one of the examples of interactive network environment developed to enable performers in five different locations to play music together with a conductor controlling the performance (Renaud, Carôt, Rbeelo, 2007). It was developed using a graphical programming language called Max/Msp.

There are numerous interactive art works and installations created using Max/Msp. Max is a graphical programming environment for building music and multimedia applications. It was first developed in the mid-1980s at IRCAM by Miller Puckette. In 1996, signal processing module was incorporated into Max to become Max/MSP. In 2003, Jitter was added and released for video and matrix data processing. This allowed musicians to work on video and image processing complementing music performances.

As summarized by Sharp, there is a tendency of new interfaces developed in 2000s towards multimodal, shareable, mobile, augmented/mixed reality and robotic (Sharp 2007). Musical controllers developed in this period were mainly made to explore

these new technologies for experimental and performance purposes. ReacTable was a good example to use projected multi-touch screen to allow multiple users to collaborate on a shareable tabletop interface. Users can interact with the objects for creating and manipulating music for encountering not only multimodal experiences of sound, sight and touch, but also human contact. (Jordà, Geiger, Alonso & Kaltenbrunner 2007).

Figure 2-4. Users interact with the objects on the tabletop interface

Apart from personal computers, the increasing power of microprocessor and lower storage cost enabled music generation and performance feasible and portable on Laptop computers in 2000s. On the other hand, some music games not only ranked top in sales record, but also changed the way people interacted with and enjoyed the music. "Wii Music" launched by Nintendo allowed multiple users to play different instruments like a band. Users not only react to the music beat, but can also change tempo and improvise. As reported by NDP Group, a global research firm called "Guitar Hero" was the number one best-selling franchise in the U.S. in 2007 with sales of $1 billion in the North America alone (Goncalves 2008). They provided an unique interactive experience through gaming.

Table 1 below lists the major inventions and events that influenced the development of music technology.

Period	Development / Product	Description
Before 1945		
1895	Telharmonium	Developed by Thaddeus Cahill, an electro-mechanical instrument which used tone wheel design to produce and modify tones. Music can be distributed by telephone system.
1924	Theremin	Developed by Leon Theremin. Regarded as the first gesture driven electronic musical instrument. One of the first instruments which used beat frequency technology to produce tone with vacuum tubes.
After 1945		
1950s	Development of Computer Technology	New development in music composition, sound synthesis and performance.
1957	MUSIC I	Developed by Max Mathews at Bell Labs, as the first music programming language
1970s	Digital Synthesizer	Direct synthesis of music by computers. Development of digital synthesizers in Bell Labs, Standford University, etc.
After 1970		
1971	First microprocessor	
Early 1970s	Apple computers	Laurie Spiegel developed Music Mouse in 1981 on Apple Macintosh to control and compose music.
1981	IBM Personal Computer	
1984	MIDI	Standardized communication of musical signals such as pitch, volume, timbre, etc. within digital interfaces

1989	Max	An audio development software developed by IRCAM
1991	Pro Tools	Developed by Digidesign as digital audio production software
After 1980		
From 1986 – early 90s	Hyperinstruments	Project implemented by Tod Machover, Professor of Music and Media at the MIT Media Lab to augment traditional musical instruments with added sensors
1996	Brain Opera	By MIT Media Lab to offer interactive musical experience from both online participants and live audiences.
Late 90s	Internet boom	Online collaboration of music composition and performance. E.g. Quintet.net
1996	Max/MSP	Signal processing module was added to Max
2003	Max/MSP with Jitter	Video processing feature was added to Max/MSP
2000s	New Interfaces	multimodal, shareable, mobile, augmented/mixed reality and robotic, tangible, wearable
	Music games	Changed the way people interact with and enjoy music. E.g. Wii Music and Guitar Hero

Table 1: Historic landmarks in the development of music and technology

As seen from the development of computer music, there had been some inventors made use of electronic means to perform music. With the emergence and popularity of personal computers, a lot of works dedicated to generation or composition of music notes and synthesis of sound owing to the computation power. Later on, there were increasing numbers of works and examples exploring the interactive features and techniques. Since musical instruments are always performed or controlled by human players, computer-supported instruments are no exception. The bloom of Human Computer Interaction study gave birth to a great variety of new interfaces associated with innovative methods of interaction. Computer vision, computer

listening and multi-touch technologies equip the computer to be a capable multimodal system. This gives rise to art or multimedia installations in various scales to mobile phone applications.

While interactive features and techniques applied to interactive music performance systems are greatly enhanced with the advance of technology, generative methods contribute by offering alternatives to music composition and exploring creative sources.

2.2. Generative Techniques Used in Interactive Music Performance Systems

While a computer has been adopted as a tool for creating music and enabling interaction between users and the systems, there was another stream of musicians compose music with algorithms. The term "Algorithm" is widely used in the computer science field to define any logical sequences or steps to carry out processes and achieve desired results. Thus, when it is used to compose music, a new term "Algorithmic Composition" was invented, which means the formal steps to create music without or with minimal human intervention. One of the pioneers using computer algorithms to compose music, David Cope, described algorithmic composition during an interview:

> *"A computer algorithm is a step-by-step code for producing some desired result. …… Algorithmic music, then, is a step-by-step recipe for creating new composition".* (Muscutt 2007)

Composing with algorithms does not necessarily require a computer, but it is the fastest and most efficient way. Mozart's musical dice game was a famous example to assemble scattered music fragments into a new piece by throwing a dice, forming the whole piece by random choices. This by no means suggests an alternate way to compose music and provides a new source of inspiration. Although many people think that composers usually write music from inspiration with their gifted talents,

there are in fact, a lot of methods without boundary that the music is created. There are occasions that music is composed according to some forms and rules, like those pieces from Bach and Beethoven.

The techniques supporting computer-assisted composition with algorithms can be found from the simplest method of random generation to most complicated form with artificial intelligence. From the example of Mozart musical dice game, it is not uncommon for musicians to compose and perform music with randomness. Great pieces can be found from improvisers who perform randomly shifting with emotions and the audience. However, they can hardly be repeated. Random seed generator from computer algorithms gives birth to a blossom of generated pieces and random actions can be generated when the users dance, walk and breathe…. John Cage has made notable use of randomness in his works. In one of his works, Reunion, random actions are generated when the players move over the photo-receptor equipped chessboard. The movements trigger sounds from the system and each time the piece is different. Markov Chain is a random process and is commonly used for music composition in many music applications. Midi notes will be generated according to their probability weightings. A probability matrix is constructed for each note according its probability vector in first order or second order sequence.

Music can be composed through observing the natural phenomena in which chaotic behavior can be observed in natural systems such as weather or mixing of fluids. Chaos theory is formed to take in the chaotic behavior and nonlinear dynamics equations are deduced from the nature. Music can be generated following the chaotic behavior with those equations processed within the algorithms.

Evolutionary Music is distinguished from others by its usage of techniques and methods inspired by natural evolution. Same as evolutionary art, evolutionary music is initialized and evolved through repeated application of computation techniques analogous to biological selection, mutation and reproduction. The most frequently used techniques are genetic algorithm and cellular automata.

When genetic algorithm is employed, unanticipated results can be generated through evolutionary process. It is a complex nonlinear system in which outcome cannot be predicted without running the simulation. Miranda explained that evolutionary computing encompasses a variety of techniques centered on Darwinian search algorithms. "The search is powered by processes analogous to natural selection, mutation and reproduction. The basic idea is to maintain a population of candidate solutions that evolve under a selective pressure favoring the better solutions. Parent solutions are combined in various ways to produce offspring solutions, which then enter the population and are evaluated for themselves to produce offspring. As the cycle continues better and better solutions are found." (Miranda 2007). A fitness function can be used to evaluate fitness values of individuals among members of the population to choose the fitter individuals to produce the next generation.

Cellular automata consist of simple discrete deterministic mathematical models for the studies in physics, mathematics, biology and computational systems (Wolfram 1982). Apart from simple construction, cellular automata are capable to generate complex patterns with complicated behaviors. They were first introduced by von Neumann and Ulam as simple models to study self-reproduction of biological processes. However, any system carries discrete and deterministic nature in local interactions can be modeled as a cellular automaton. One of the simplest examples is called elementary cellular automaton introduced by Stephen Wolfram (Weisstein). There are two possible values for each cell (0 or 1) and the state of a given cell in the next generation is determined by the values of the nearest neighbors (left and right side of the central cell).

The term "Generative Music" became popular when Brian Eno used it to describe a unique genre of music that is generated by the applications to be ever changing and unrepeatable. He had been the keyboard player of the band Roxy Music in early 70s. He used SSEYO Koan software which was developed by Pete Cole and Tim Cole to create the album "Generative Music 1". However, SSEYO Koan was later obsolete and replaced by Noatikl which is a music engine running on Mac OS and Windows.

There is also a mobile phone version called Miktikl which features music generation and mixing. Figure 2-5 is a visualizer of the software displaying graphics and text.

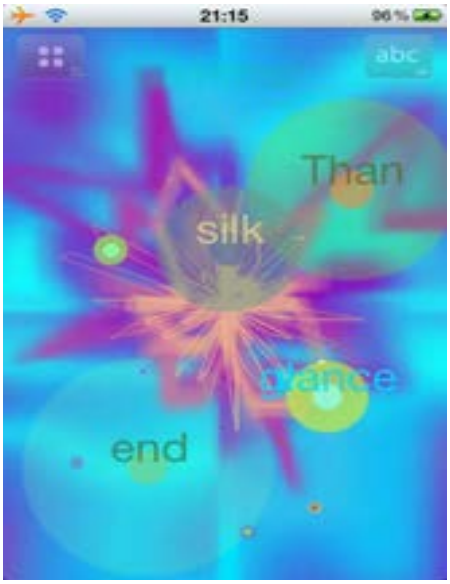


Figure 2-5. Visualizer of Miktikl

2.3. Summary

In recent decade, people are fascinated by new technology and they are inevitably chasing after new models of digital products and new version of applications. Music applications equipped with innovative interactive features can easily attract people's attention. However, it is unavoidable for applications built on new interfaces to be replaced when newer interfaces come. This makes music applications of this kind rather short-lived and re-writing of code is necessary. Such phenomenon enhances user experience interacting with the products or systems, but it overlooks the need to extend the intelligence and creativity with regard to music making. While generative techniques can provide creative solutions and generative systems give rise to sophisticated generative and transformative outcomes, they are underused by existing interactive music performance systems.

Chapter 3

3. Literature Review on Theoretical Framework

This chapter reviews theoretical studies and classifications of interactive and generative music systems together with existing computational theories and models developed based on human-computer-interaction.

3.1. Classification of music performance systems

Rowe made a classification of music performance systems in 1993. This classification was built on a combination of three dimensions with the intention to identify the characteristics of interactive programs in order to draw similarities and relationships between them.

3.1.1. First Dimension:

Distinguish between Score-driven and Performance-driven systems

Score-driven systems

Score-driven programs use stored music fragments with predetermined events such as beat, meter and tempo to match against music arriving from the input source. For example, composers can specify some events to occur on the downbeat of each measure.

Performance-driven systems

Performance-driven programs do not have a stored representation of the music that is expected to be found at the input. They tend to employ more general parameters involving perceptual measures such as density and regularity to describe the temporal behavior of the coming music.

3.1.2. Second Dimension:

Responsive systems which are transformative, generative, or sequenced

Transformative

Transformative methods apply transformations to the existing musical material to produce variants. For transformative algorithms, the source material is the complete musical input and the variants may or may not be related to the original. The material is often live musical input with transformations applied when it arrives.

Generative

For generative methods, the source material will be elementary or fragmentary, such as stored scales or duration sets. Generative technique makes use of sets of rules to produce complete musical output from the stored source materials, for instance, taking pitch structures from the basic scalar patterns according to random distribution.

Sequenced

Prerecorded music fragments are sequenced in a timely fashion. It can be responsive to real-time input and some aspects of these fragments such as playback tempo or rhythmic variations may be varied in the performance.

3.1.3. Third Dimension:

Instrument and Player paradigms

Instrument Paradigm

In instrument paradigm systems, an extended musical instrument is constructed to capture the performance gestures from a human player. These gestures are then analyzed by the computer for generating an elaborated output.

Player Paradigm

An artificial player is usually constructed in systems following player paradigm in which there is a musical presence with a personality and behavior of its own. However, it may vary in the degree to which it follows the lead of a human partner.

In this classification, Rowe tried to distinguish individual differences of the systems categorized into three dimensions. He then drew similarities and relationships between those systems among dimensions. For example, score followers need to realize a particular score from a human instrumental soloist against a stored score in order to do accompaniment. The response method is sequenced. However, they can also be regarded as player paradigm systems as they realize a recognizably separate musical voice, assuming the traditional role of a accompanist. Although there can be other methods to do the classification, but it did identify major types of system and drew attention to the similarity and relationship between them.

He categorized interactive music systems in a number of ways: the music source which determines the temporal behavior and timbre of the music performed; the response methods which generate or change the ways music is varied and performed; the types of players either a human player with an external instrument or an artificial player. The continual rapid change of technology however, suggests some amendments and additions to the classification. With robust development of hardware devices and software applications with decreasing cost, there are numerous methods and sensors to capture signals such as motion, gestures, sound, image, etc. which can also be the factors determining the way music is performed besides stored music fragments. In addition, live music input or signals do not arrive in a direct way. They may come from the network or internet that systems in this category operate or perform in a collaborative network environment. Usually there are multiple users collaborating at the same time and the actions they perform will affect the music timbre as well as the behavior of other users. As far as the instrument paradigm is concerned, as Rowe suggested, there can be ubiquitous equipment such as video capture for the human players to interact that no extended instrument is needed.

3.2. Wanderley's Theory towards evaluating Musical Controllers

Extended instrument, or musical controller, is regarded as one kind of musical instruments in music applications. Ease of use and accuracy of the data detected by the instrument is very critical in manipulating a performance. In view of this, Wanderley reviewed the existing works about evaluation of input controllers in HCI perspective to suggest some methods to evaluate the usability of musical controllers. He proposed four areas to look at and some musical tasks to be focused on such as control of pitch of isolated tones or a number of different frequencies, basic musical gestures like vibrato and trills etc. (Wanderley & Orio 2002).

3.2.1. Learnability

Learnability refers to the time needed to learn a new controller in a performance. Musical task accounts for the time needed to learn to replicate simple musical gestures by experienced musicians.

3.2.2. Explorability

Explorability is related to the features of the controller such as precision and range and how they can be coped with the mapping strategy. It is particularly interesting to know how their capabilities can be explored with the gestures and gestural nuances that can be applied and recognized.

3.2.3. Feature Controllability

Controllability of certain features is the relationship between gestures and the changes in performance features. How well these features can be controlled in terms of accuracy and resolution depend on how the users perceive this and what music task is performed. For example, a controller may be regarded inadequate for pitch control because of reduced accuracy, but it can be excellent for controlling timbre due to the inherent functioning of our perceptual system.

3.2.4. Timing Controllability

Musicians are used to performing musical tasks with very precise timing. Instead of measuring time needed to perform a task, musical task is suggested to measure the temporal precision that a musician can control the performance and its relationship to tempo.

3.3. Bongers' Interaction Theories

Bongers also studied interactive music systems based on the research mainly carried out in the field of human-computer-interaction. He examined on the relationship and interaction among performers, system and the audience stressing the impacts of sensors, modalities and cognition on the overall performance. He regarded extended instrument as a sensor which acts like sense organs of a machine and it is often used to input signals from the surrounding environment into the system. A number interaction models were presented with descriptions of interactivity, cognition and modality. They are grouped in three categories namely "Performer – System", "System – Audience" and "System – Audience" (Bongers 1999).

3.3.1. Performer – System

Figure 3-1 illustrates how a human communicate with the machine in an interaction loop. The "machine" in the diagram is defined as a square and is wider (as is the case with computers which consist of a number of linked elements or devices connecting through networks and MIDI protocol) while the human is being round. Sensors are treated as sense organs of a machine. They convert any physical energy from the environment into electricity to be interpreted in the machine world. Through the sensors, the machine can communicate with its environment and be controlled. Machine output is presented through actuators. They convert electrical energy into energy forms that can be perceived by human beings. For example, images are

projected on a screen to be visioned by human eyes. Usually, interaction takes place by means of an interface or instruments which include sensors and actuators.

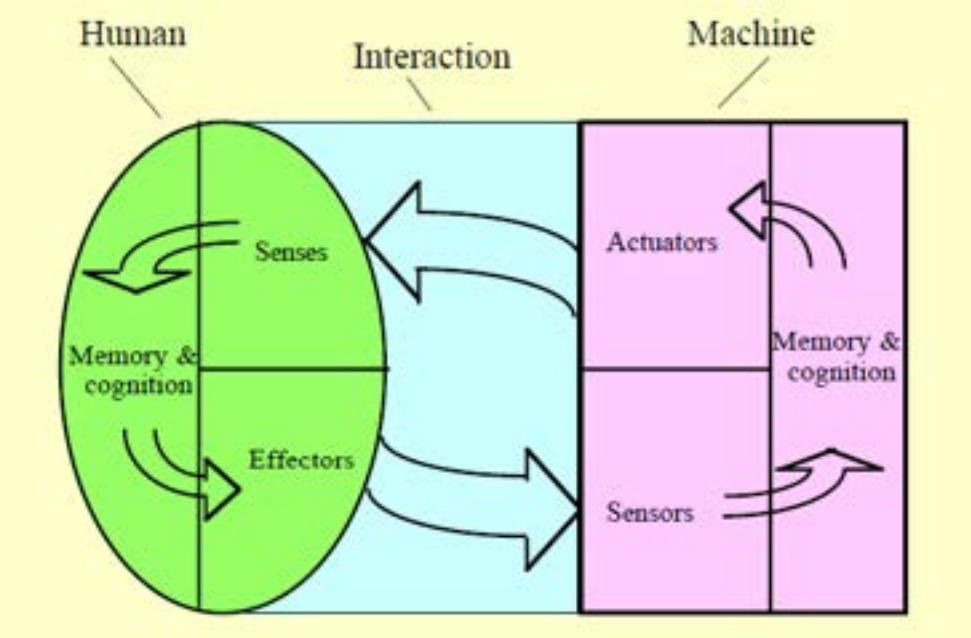


Figure 3-1. Human-Machine Interaction

3.3.2. System – Audience

In figure 3-2, interaction takes place between the system and the audience in several modalities such as seeing, hearing, touching and smelling. Usually, the audience can trigger the interaction by pressing some buttons like clicking a mouse to view selected images. Also, a merely person's presence in a given space can have influence over the parameters of an installation work.

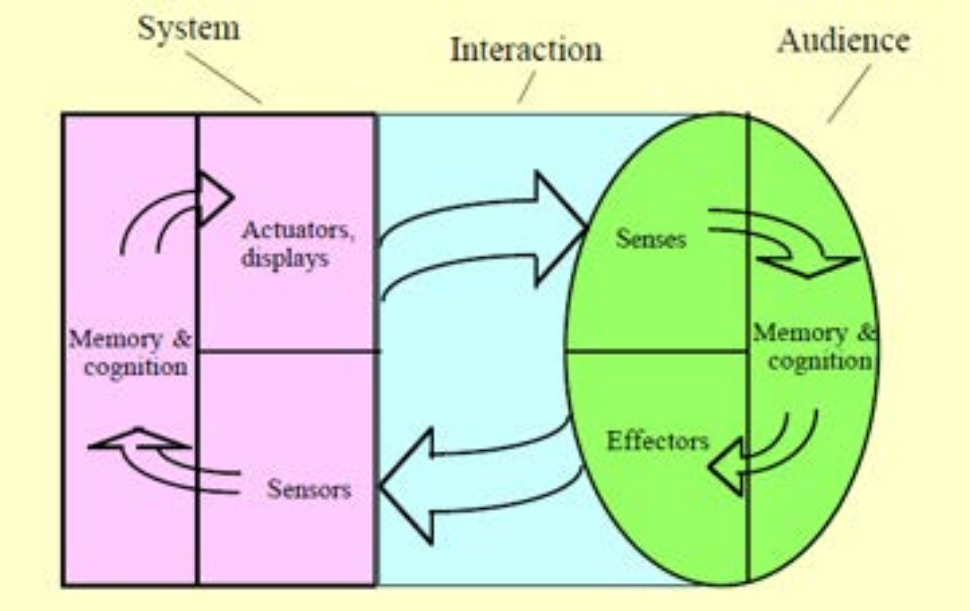


Figure 3-2. The interaction between audience and installation

3.3.3. Performer – System – Audience

In a music performance, the performers and the audience are active parties communicating directly to each other. However, new channels can be opened to enable interaction between performers and the audience through the machine system. First, there is interaction between the performer and the system. Second, there is interaction between the work performed via the system and the audience. This model shows that the performers and the audience can interact via the system, but the audience can also participate through subtle or non-verbal communication to the performers to influence the performance.

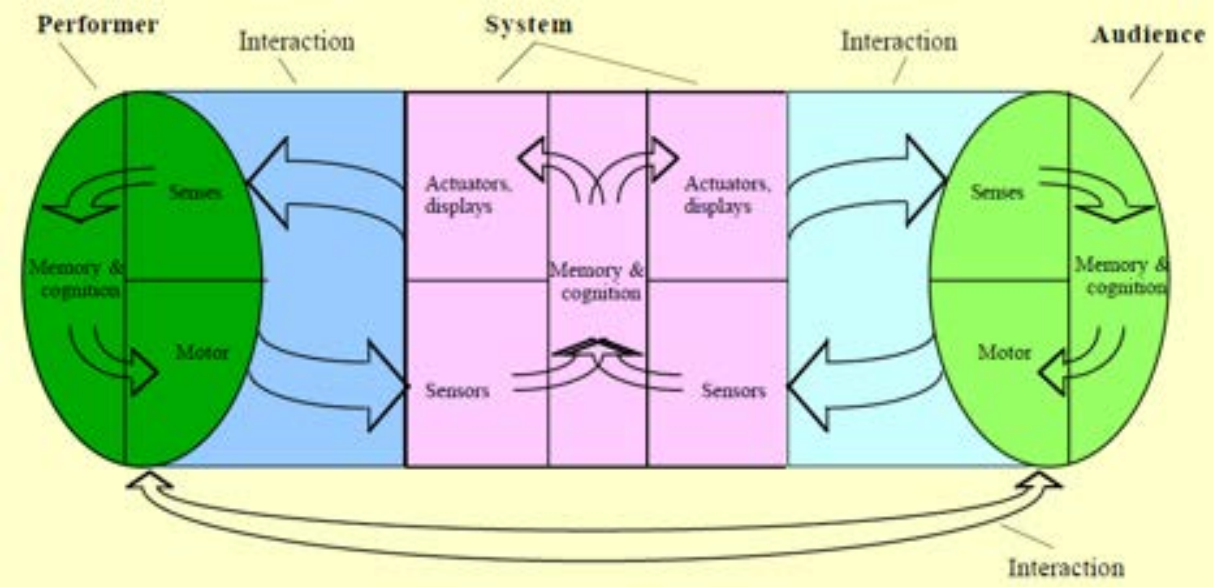


Figure 3-3. Interactions between performer, system and audience

3.4. A framework for algorithmic music systems

Rene Wooller, Andrew Brown and other authors jointly developed a framework for comparing process in algorithmic music systems (Wooller, R., A. R. Brown, et al. 2005). Within the framework, algorithmic music systems are positioned along two main dimensions of function and context. Along the function continuum (x axis in Figure 3-4), musical algorithms are positioned from analytic, through transformational, to generative. Context is the surrounding information that influences the computation of an algorithm and it ranges from narrow to broad along the context continuum(y axis).

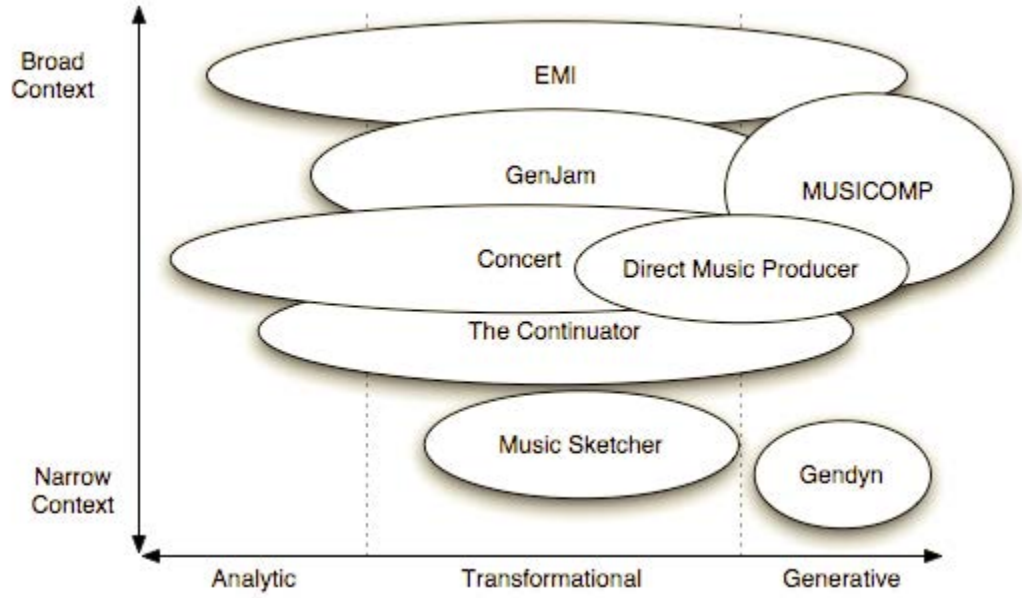


Figure 3-4. Framework for comparing process in algorithmic music systems

Analytic:

Algorithms can be considered analytic if they produce outputs by distilling sets of data and extracting specific features. They tend to reduce potential data size. One of the examples could be a process that takes a set of sequences and outputs a set of notes and the set of notes can be a scale extracted from a database of riffs.

Transformational:

Transformational algorithms tend to alter information rather than impose significant impact or change on the general inclination of data representations or the actual size of data. For example, an algorithm can transpose individual notes to change the pitch value of the note sequence but maintain its parameters and structural relations.

Generative:

An algorithm tends to be generative when the resulting data representation has stronger reinforcement than the input over the general orientation of music and the actual resulting data will be increased. For example, a chaotic algorithm takes a seed number and generates a sequence of notes which enlarge the size of data.

Contextual Breadth:

Contextual Breadth measures the size of context which is the world-state data and the arguments that are accessed by an algorithm. It has two dimensions namely temporal and textural. The contextual size ranges from narrow to broad along the continuum. For example, an algorithm with notes being influenced by four parameters has a broader context and it is highly context dependent. On the other hand, an algorithm where notes are influenced by only single parameter has a narrower context and it is rather context-free.

3.5. Summary

From the theoretical framework described, we can have a better understanding of how the interactive as well as generative music systems are categorized and studied. The study of Human-Computer-Interaction made a lot of contributions to address issues involving interaction, usability of interfaces, cognition and modalities when designing the interactive music performance systems. Generative techniques provide alternative methods to composition and help inspire creativity for the sake of music performance. However, there are lack of theoretical studies to make a bridge between systems designed for user interaction on one hand, with systems which are highly algorithmic and generative on the other hand. New theoretical framework is going to be proposed to introduce new user experiences which can be further enhanced and suggest solutions for a more engaging system or product.

Part 3 Propositions

Chapter 4

4. A Public Interactive Media Performance

This chapter reports and reviews a public media performance held in July 2009 at Jockey Club Creative Arts Center in Hong Kong. This is a typical mixed media performance supported by digital musical instruments. It is going to summarize the interactive features being applied, observation and interesting findings which serve as the background study of an interactive performance in a city like Hong Kong.

4.1. Augmenting Media Performances with Interactive Technology

4.1.1. Augment traditional music performances with new digital musical instruments

The merits of the traditional musical instruments are well appreciated and there are numerous virtuosos pursuing professions in respective areas. Their status is not going to be replaced by any newly designed instruments. There had been earlier attempts by Tod Machover at MIT media lab to augment traditional musical instruments like violin and cello with additional sensors involving new interactive techniques. In recent decade, newly designed digital musical instruments have been in blossom with innovative, disruptive and affordable interfaces and technologies. There had been too much focus on HCI scientific research, resulting much less concern for content development. Most of them are being studied for experimental purpose, seldom were designed to collaborate with traditional ones so that they can work together for an integrated and mixed media performance.

4.1.2. Collaboration among musicians

Musicians jam with each other in an interdependent way. Interdependency can be achieved when each one is responding to what is heard and reacting to other members' actions. Computer based musical instruments are mostly used to generate beat patterns to synchronize with the music played in a performance. For example,

Max/Msp and Ableton Live are utilized to produce sequenced beats and sound effects to accompany traditional instruments like guitars, keyboards or trumpet in a jamming session. Different instruments with different interface designs involve unique interactive techniques. This can be elaborated by some of the sessions of the performance to be reported in the later section of this paper.

4.1.3. Performer and audience interaction

Limited by the conventional design of a performing theatre, performers are usually located in the focal area where they are heard, viewed and listened by the audience. In order to enhance performers and audience interaction, seating arrangement, spatial location of people and technologies are studied and experimented. Numerous attempts had been made to either shorten the distance between performers and the audience or encourage audience participation. Although flexibility of the theatre design is introduced, studies relating to interaction design are insufficient. Expectation and feedback of the audience are explored and evaluated in this paper.

4.2. Performance @JCCAC Hong Kong

An interactive mixed media music performance is still rare in Hong Kong. Sponsored by the Hong Kong Arts Development Council for the venue, such kind of performance had taken place in the Blackbox Theatre in Jockey Club Creative Arts Centre which was redeveloped from an old industrial building. Details can refer to Figure 4-1. Most of the team members are Master and PhD students of design and media technology with musical backgrounds at various levels.

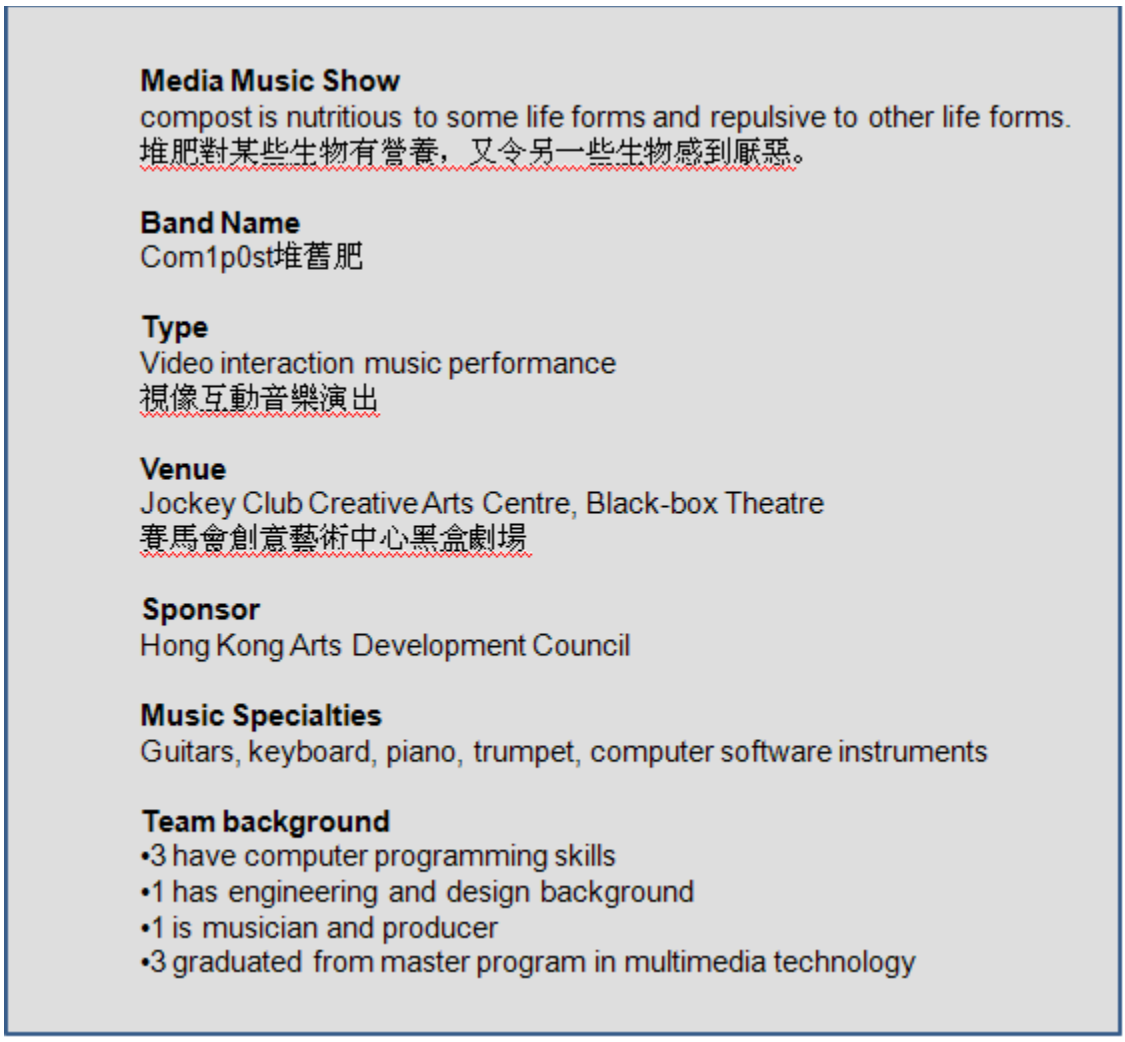


Figure 4-1. Com1p0st Interactive Media Performance @JCCAC Hong Kong

Although the show served different individual purposes, it did explore some interesting observations and findings. It is not yet a detailed experiment, but more than a performance.

Objectives were identified to examine a few areas:

1. **How to augment a traditional music performance with new digital musical instruments?**
2. **Is there a change in the way performers interact with each other with both new and traditional musical instruments?**

3. **Can interactivity be increased with the use of computer technology between performers and the audience?**
4. **Would the audience find the show creative and enjoyable?**

There are more than 15 sessions, but they were all structured in a star shaped form (Figure 4-2). The form was created by the team members Ming-sun Ho, Jupiter Chan and the author. We usually had casual talks about contents to be included during lunch and they were drafted on the scratch papers. Finally the ideas were summarized and consolidated to a form. The five key components are: Voice, Offensive, Improvise, Ambient and Traditional. All components connect with each other to build inter-relationship. Sessions were created when components cross one another. All the contents and ideas for the show were generated within this framework. The show did not explicitly inform the audience any specific messages although it did have something to tell. Instead, the audience was given freedom to construct the meanings.

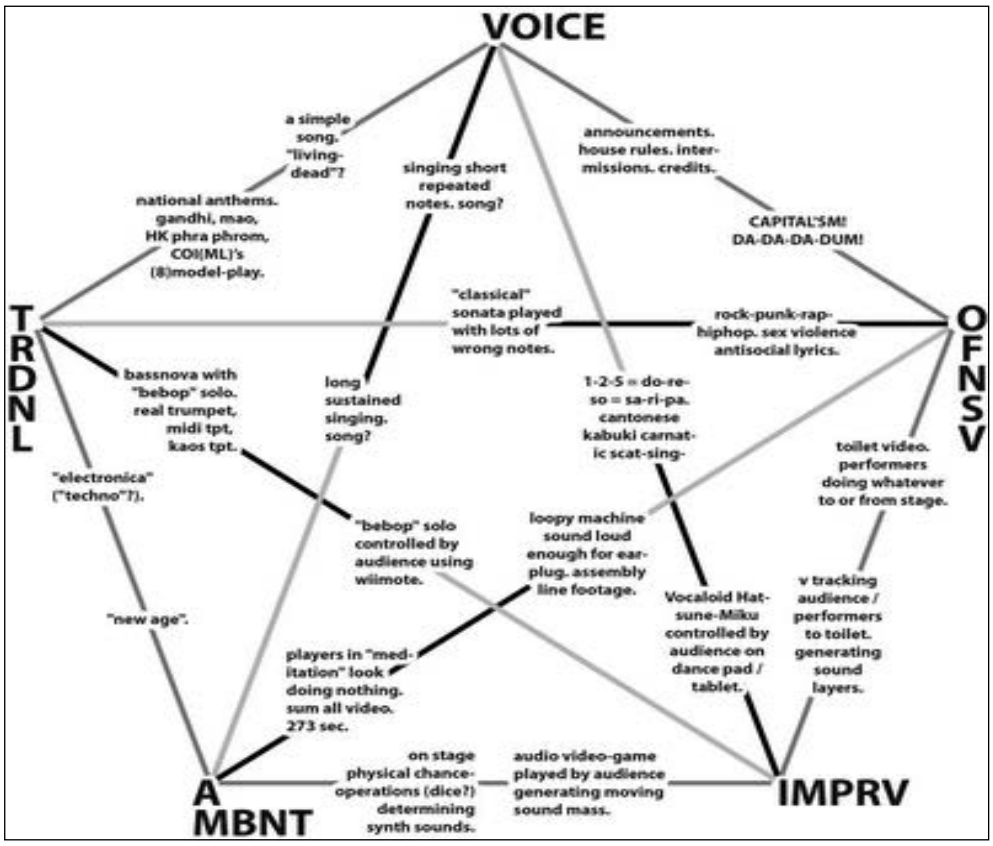


Figure 4-2. The Star Shaped Structure of Contents

4.3. Technical Description

Although it was our objective to add more interactive features in our media performance, the type of hardware and software tools to be used and how much they should be used were determined by the preferences of the band members and the contents. Time was also a critical issue in that case. More time, effort and resources would be able to accommodate larger system scale. In our band, however, ideas kept changing with hidden thoughts unfolded when the show was approaching. With large quantity of footages including images and sound clips, it was relatively handy to select appropriate ones and dispose unwanted pieces even time was running short. However, when technology was involved in making artistic content, it did not sound flexible because more time and effort were required in the tasks of software and hardware testing and computer programming. In order to allow more flexibility, we opted for solutions which offered accessible and inexpensive tools as well as ease of programming.

4.4. Hardware and software tools

The setup consisted of basically one Apple Macbook Pro and one Fujitsu laptop. The Macbook was mainly used to connect to a midi keyboard with Garageband software for piano performances. Max/Msp was installed to trigger patches for interactive performances. The Fujitsu laptop was installed Ableton Live, Max/Msp and Tapper for real time performances.

4.5. Interactive Features

4.5.1. Throwing something to the audience (in Throw Wii session)

In order to interact directly with the audience, we decided to put a Wii controller inside some everyday objects. In this case, we chose a mushroom ball. The audience was quite surprised that the ball can produce music notes and improvise when it was

being turned around and thrown. We then sat among the audience and threw the ball together. The accelerometer readings in X, Y and Z axes were captured[2] by the Max/Msp patch to generate pitches of “Do”, “Re”, “So” and sound effects when the thresholds were reached.

Figure 4-3. Wii Controller and the mushroom ball

[2] Wii controller’s accelerometer values are captured and handled by a Max/Msp object called “aka.wiiremote” developed by Masayuki Akamatsu

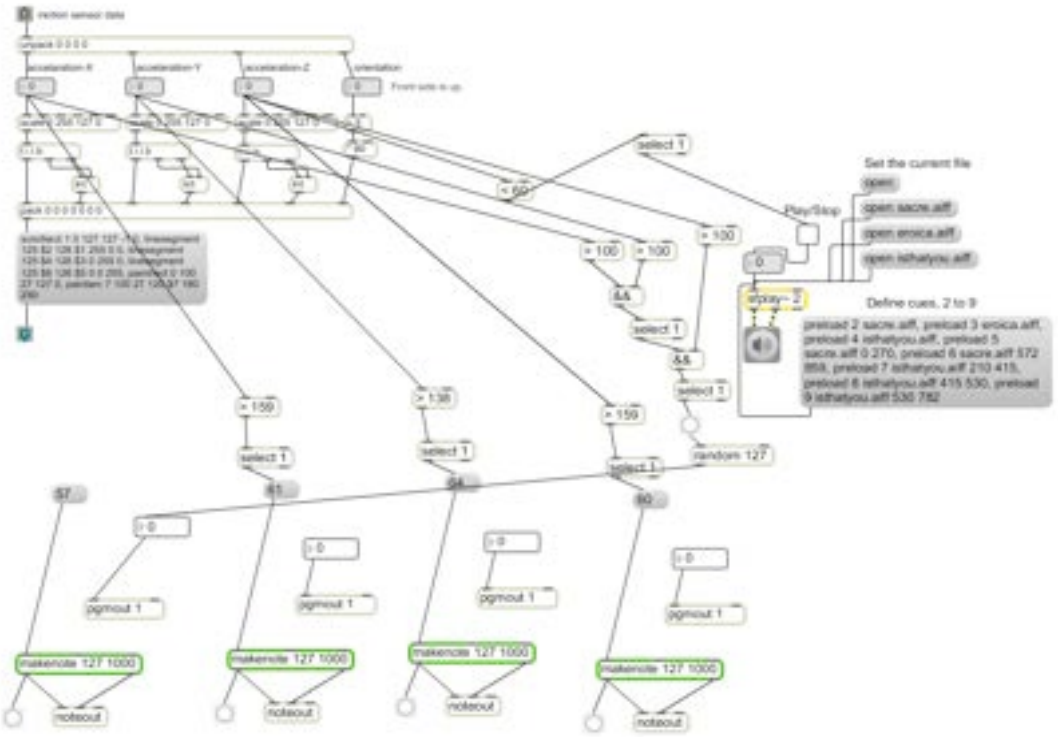


Figure 4-4. Max/Msp patch capturing accelerometer values of Wii controller and generating music notes and sound effects

Figure 4-5. Performers played with the audience with the new musical instrument

4.5.2. Interact with motion

In the vocaloid session, we connected a dance pad with a tapper software in which any steps on the pad can control the music rhythm. The sound was converted to human like singing voice using Ableton Live. That made the human voice sang according to the performer's steps.

Figure 4-6. Vocaloid session with dance pad

4.5.3. Other devices

Apart from these, some portable devices were used. Kaossilator was used for melodic part and accompaniment for improvising and jamming sessions. iPhone was used to generate and manipulate the beat pattern with the installed DJ software.

4.6. Interactive Media Performance Framework

Since media performance is regarded a kind of contemporary art, it is integrated and evolving with the changes of society, culture as well as technology. Thus, an open system is suggested to accommodate any new ideas and creative ingredients (Figure 4-7).

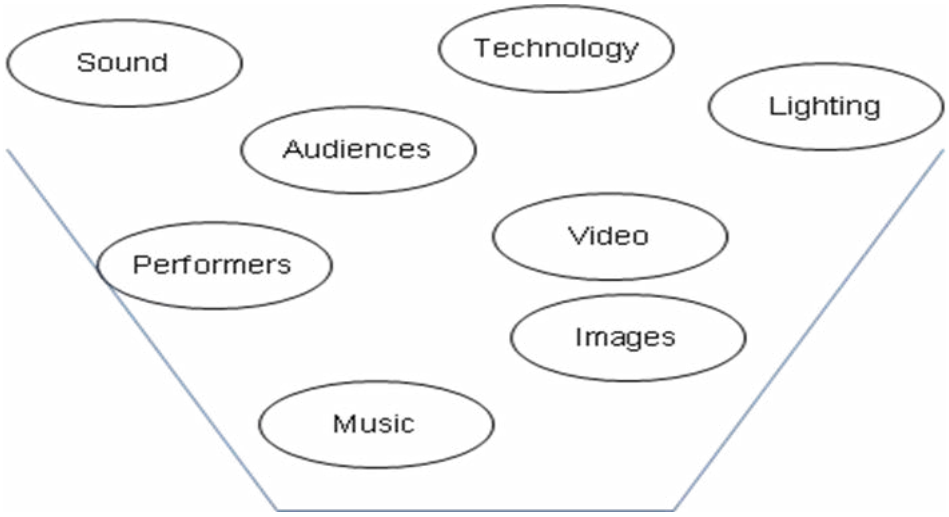


Figure 4-7. An Open System for New Creative Ingredients

A conceptual diagram (Figure 4-8) illustrates how interaction bandwidth can be enlarged when the contents become interactive. In a typical media show with pre-recorded contents, the audience interacts with the show by perceiving what are received and understood either with or without a common ground with the performers. The audience usually responds by giving feedback or facial expression. When the contents become interactive with or without the introduction of technology, the audience interacts by participating and inputting actions to the media system. The system thus responds immediately by giving feedback to the audience and the performers. As indicated by the diagram in Figure 4-8, the interaction bandwidth is enlarged from the inner circle to an outer bigger one.

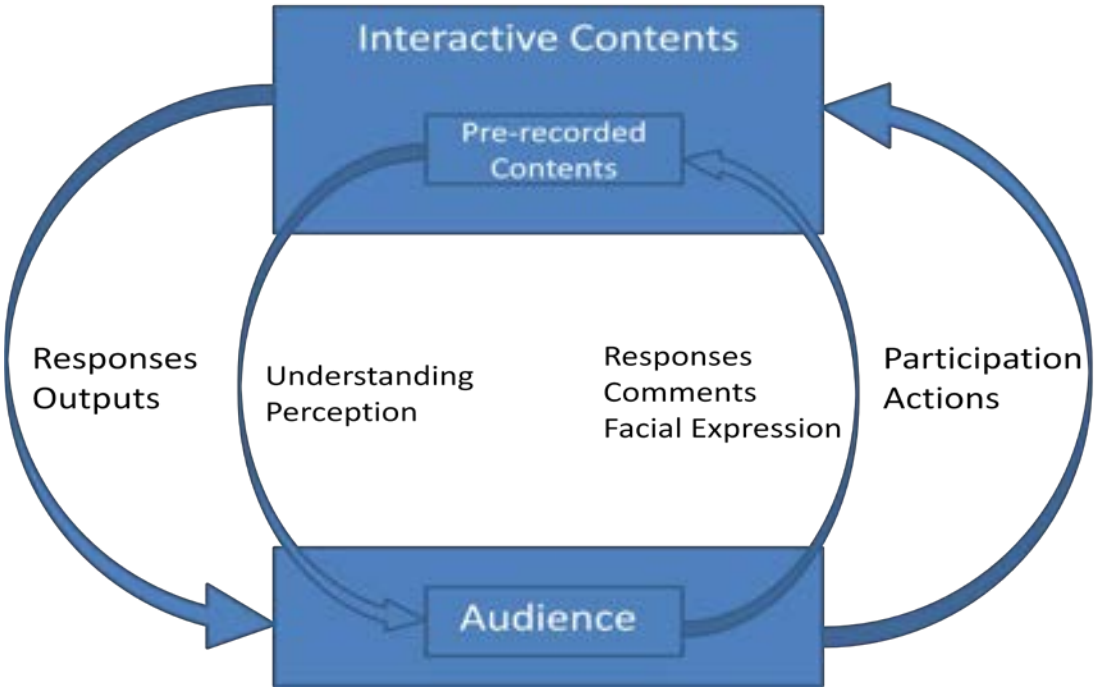


Figure 4-8. Interaction Bandwidth enlarged

4.7. Discussions

There will be discussions on how the incorporation of digital musical instruments changes the way designers and musicians design the content and interact with each other.

The show accommodated 80 seats and we had 26 people came to it excluding all workers. Four people were finally invited for an interview. Feedback from the interviews provide information evaluating the level of interactivity between the performers and the audience.

4.7.1. How to augment a traditional music performance with new digital musical instruments?

Computers, no matter hardware or software, are as a matter of course regarded as tools only for making creative contents. Sequencers have been used for music composition and sound production. It is not uncommon to use more than a half virtual instruments for professional production like music recording or making

advertisement scores because of cost saved. In a live mixed media performance, digital musical instruments are often used too to bring some new ingredients and excitement. To work with traditional musical instruments, interaction should go beyond simply rhythm sequencing. Different interfaces involve unique interactive techniques to generate specific sounds.

If the sounds from some interfaces are highly expressive and the controls are easy to operate, then they can be used for making melodies. For example in our rehearsals and jam sessions, we used Ableton Live, Garageband and Kaossilator (a portable device for live performance and recording with touch pad which requires scratching and moving of the fingers) for improvising melodies. For those not fast and accurate enough such as the dance pad, we used it as a bass instrument in a Bossa Nova piece and a trigger of synthesized beat patterns. Software interface design also plays an important role in affecting how digital instruments can collaborate with traditional ones. Buttons, sliders and menu selection can afford frequent changes to the system options during performances and collaboration with traditional musical instruments.

4.7.2. Is there a change in the way performers interact with each other with both new and traditional musical instruments?

Like other musicians, we spent a lot of time in ensemble during rehearsals. Because it was the first time we performed together, we needed more time to learn and understand each other. No matter what instruments we used, we needed to express ourselves while following some chord patterns and responding to triggered changes. People may think that laptop performers only need to point and click, drag and drop, eyes staring at the LCD monitor with minimal facial expression. If new interfaces are being used, they are mainly performed and explored in experimental exhibitions with various kinds of sensational feels and gestures communicating to the system.

In our case, those playing guitars, keyboard and trumpet required skilful techniques even though they were improvising. For those who were playing computer instruments, there was no special technique or practice required. However, we did

need to listen to each other and accompany all together. The computer performers would have more control over the status changes and the overall effects.

4.7.3. Can interactivity be increased with the use of computer technology between performers and audience?

In order to enhance interactivity between performers and the audience, we did introduce some sessions like "Rave Party" to encourage them to dance with us. People in Hong Kong are generally passive and do not expect to participate much. Hopefully most of them were willing to dance and had fun together. In the "Throw Wii" session, we were throwing a toy ball among the audience. There was a Wii controller hidden inside. When the ball was thrown, the motion readings in X, Y and Z axes will trigger some midi notes. In this way, people holding the ball were improvising. The performers sat among the audience and played with them. Thus, the audience participated in the improvising session.

All four interviewees agreed that the show was interactive with technology and it was the first show of this kind that they had ever seen. They were asked about the sessions they liked and disliked. Two of them mentioned that the "Throw Wii" session was most interactive because the performers were playing together side by side with the audience. Besides content and technology, seating arrangement in that case helped a lot.

4.7.4. Did the audience find the show creative and enjoyable?

The four interviewees all have design background with two specialized in animation. They commented that the show was creative overall. For the most creative part, different people had their own individual preference.

Apart from being creative, we aimed to provide an enjoyable performance and experience to the audience. Although there are lots of interactive media performances in the world, not many of them are enjoyable. That means, either people cannot get some fun from them or they are astonished by the first 5 minutes

experience but fail to maintain sustainable interest. When the interviewees were asked if they would come if a similar show was available, the answers were positive.

4.8. Summary

This performance took place in the preliminary stage of the research in which the author was part of the team participating in the performance. It provided valuable background information as well as practical experiences in designing media contents and implementing interactive applications. It studied the reaction of the performers and the audience when new digital musical instruments were brought about.

Chapter 5

5. Proposed Theoretical Framework

The proposed theoretical framework provides a configurable and adaptable solution to supporting interactive music performance through a mechanism of adjusting the interactive and generative intensity of the system. Both generative and interactive techniques are incorporated through the implementation of an interactive music performance system, in order to enhance interactivity and user experiences by extending the engagement of the users with the system at cognitive and computational levels. This framework also provides sharable components so that users can cooperate and exchange knowledge with the system in the creative process.

5.1. Conceptual Design Models

Reviewing the technological development, computer-based music systems are on one hand highly interactive with disruptive interfaces, but are very automatic and mysterious on the other hand. In order to understand and analyze the wrestling force between system interactivity and generation, two driving forces are identified and they are graphically represented in figure 5-1. In order to support adaptive configuration, there is a slide bar in each of the proposed design model to adjust the intensity of interaction and generation. The slide bar can go in either direction. Going to the right increases the space for interaction and going to the left gives more space for generation.

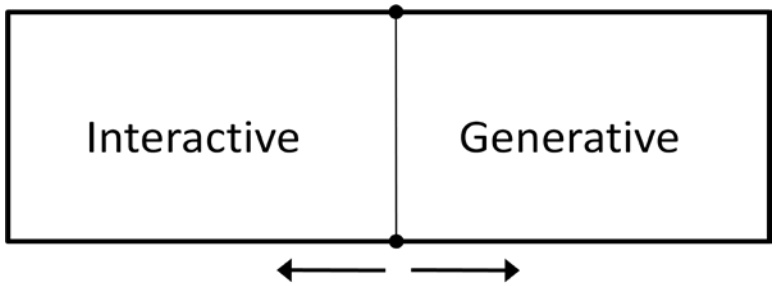


Figure 5-1. Configurable design model for interactive music performance systems

The configurable nature of the system design model suggests three typical case scenarios according to the orientation of the slide bar.

Scenario 1

In this case, the slide bar is going to the left and the system is generative oriented. The system is likely to be self-generative with rules and algorithms, which produce undetermined and variant music. With limited user controls, users are able to make little customization and evaluate the quality of the performance.

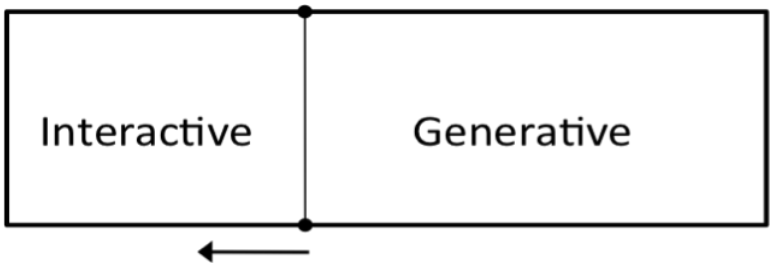


Figure 5-2. Generative oriented design

Scenario 2

In this case, the system is interactive oriented with the slide bar going to the right. It enables users to have more control of the system. The design induces participation from the users and facilitates sharing of knowledge and experiences in the creative process. Users can have their ideas transferred into the system.

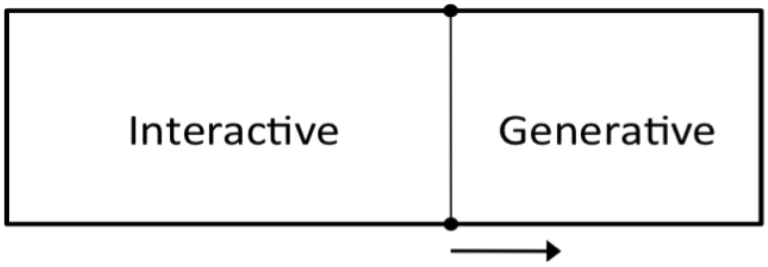


Figure 5-3. Interactive oriented design

Scenario 3

In this case, there will be a balance between interactive activities of the users and generative operation of the system. Collaboration is enhanced when users and the system both participate actively in the creative process during performances.

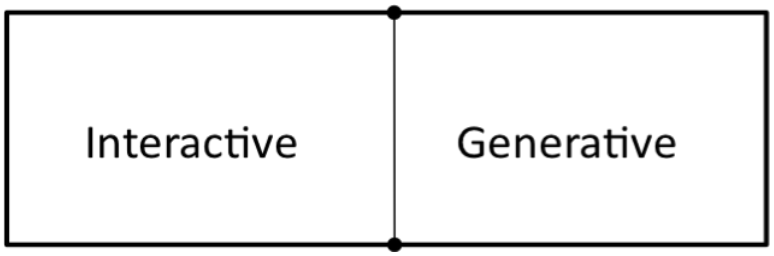


Figure 5-4. Collaborative design

5.2. Enhancing User Experiences

Interaction design plays an important role in providing experiences desired by the users when they interact with the products or systems. It aims at creating experiences that are attractive, engaging, participatory, memorable and extensible. Shedroff stated that "Experiences are the foundation for all life events and form the core of what interactive media have to offer." (Shedroff 2001) He mentioned that attraction is necessary to initiate the experience. It can stimulate our senses cognitively, visually or auditory. To be engaging, the experience must be cognitively important to hold the audience attention and interesting enough for them to continue the experience.

A system is engaging when it can attract attention instantly. Shedroff stated that:

> *"The engagement is the experience itself. It needs to be sufficiently different than the surrounding environment of the experience to hold the attention of the experience, as well as cognitively important (or relevant) enough for someone to continue the experience.… … for an experience to have an*

extension, which can merely prolong the experience, revive it, or form a bridge to another experience." (Shedroff 2001)

In order to enhance an experience, it should have an extension when it is initiated. In this sense, besides engaging the experience, the design should enable it to extend to another kind of experience in a different cognitive level. Thus, in order to have a more profound design, the system is able to i) engage and ii) extend.

5.2.1. To Engage:

In order to provide an engaging experience, a two-layer design layout is proposed to demonstrate the ideas and processes of attracting attention and prolonging the attention .

Layer 1 : **Attract attention**

Beautiful appearance
Sophisticated design
New and unique experience
Participants' interest
Easy to use and learn

Layer 2 : **Continue attention**

Higher level of difficulty
Another new experience
Participation induced by abstraction
Participation induced by additional duties (creation, decision making)

To attract attention, it will be easier for products or interfaces made of beautiful and sophisticated design. Easiness to use, new and exciting experiences can attract an attention and keep users exploring new experiences. To continue the attention, the users can be induced by another new experience or be challenged by a higher level of

difficulty. They can also be engaged in additional duties such as creation and decision making.

5.2.2. To Extend:

The extension can be achieved by providing another kind of experience which is unique and different from the previous or existing experiences that the users encounter. The critical task is to induce participation. The abstraction of the artwork invites participation requiring the audience to be progressively involved in the cognitive perception and construction processes. In addition, they can also actively participate in the creative process.

It will be a unique and new experience if the user can participate in the composition process when he or she is interacting with a music performance system. The generative methods for algorithmic composition are exemplified in previous section. A space should be reserved to have a better understanding of how people make music in the context of musicianship. There are thousands of methods that people can use to compose music. Each person can have his/her own way of making music as long as it is comfortable as a way to express creativity. Some people will settle on forms, rhythm patterns and rules to decide a music genre or chord progression to follow; Some listen to other people's music to seek for ideas that may risk imitating other people's work; Some may have the melodies or harmonies come to their minds when they are inspired; Still some create from memories.

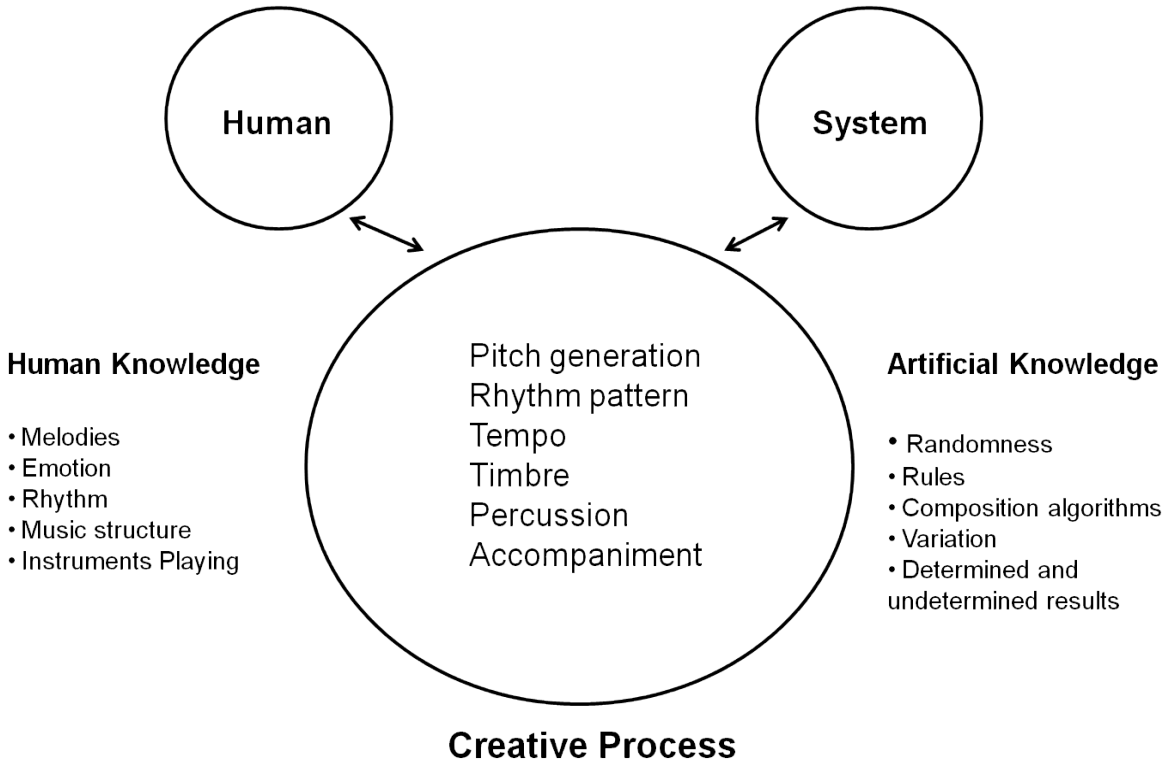


Figure 5-5. Interaction model for musical knowledge sharing in a collaborative environment

There can be a big difference between a human and a machine in the way of composing music. The conceptual design model proposed in figure 5-5 offers an opportunity to understand the nature and differences of knowledge embedded in a human and the system. It will be an exciting exercise to see how each of them can contribute to the creative process in a collaborative environment. The design of the system opens some portions for both the human and the system to participate.

While human beings possess the knowledge of performing and composing music, computers possess the artificial knowledge of manipulating and generating both determined and undetermined results with algorithmic composition techniques. Humans can offer melody pieces, alter the flow and emotion of the music generated and performed. They can input their knowledge of music and interact with the system with their own instruments. Collaboration takes place when the users and the system participate and exchange knowledge in the creative process.

Chapter 6

6. Ethnic Minority Culture and Elements

In modern cities, music serves the functions of entertainment, performance, emotional and artistic expressions. Interactive music is the new branch of experimental music normally connected with contemporary or electronic music performed in a metropolis. In the province of China such as Yunnan and among the twenty-five ethnic groups, music is strongly attached to the folk culture and social setting of their own. It would be senseful to study the ethnic culture that the music cannot be separated from the social functions. Then, we can go in details with their folk songs, dances and musical instruments.

Figure 6-1. Yi Minority in Yunnan Province[3]

This research took the music of Yi minority of Yunnan province as a case example. Yi minority is one of the fifty-five minority groups in China distributed in Yunnan,

[3] Picture accessed online @http://www.ecotourism.com.cn/minorities

Sichuan, Guizhou and Guangxi provinces. It ranks sixth among all other minority groups with more than seven million population. In Yunnan Province, there are more than three million of Yi people concentrated in an area surrounding Jinsha and Yuanjiang rivers. Most of them live in mountain areas with a small number live on flat land or valleys. The long history of Yi can be dated back to Qin dynasty (221 BC - 206BC). During the period of Qin and Han, Yi and other minority groups of Tibetan-Burmese language branch had already form a large community among Hengduan Mountains in Sichuan and Yunnan provinces.

Figure 6-2. Yi communities in Sichuan and Yunnan Provinces[4]

Folk songs of Yi minority cannot do without dances. They can also be called dance songs that dances come with singing and instrumental music. Yi people dance in a group in a circle or a semi-circle usually in anti-clockwise direction. They dance when they are singing and some men play musical instruments when they are dancing as well. The instruments being played are mainly flute, sheng and some string instruments such as sanxian in various sizes. Regarding the origin of the dance songs,

[4] Picture accessed online @http://www.khamspirit.com/

there are different sayings, but there is a well-known legend. In ancient time, one group of Yi people was fighting with an enemy who was invading their territory. One night, they were trapped on the mountain top and cannot break away. Some men thought of jumping, crying, singing and firing up torches pretending that the reinforcement was coming to rescue them. They broke out from the attack when the enemy became less restrained.

Cangyuan rock paintings discovered in Cangyuan County in China provide evidence that dance songs appeared three thousand years ago. The paintings on the ancient rock show that there were a few people dancing in a circle, waving hands and playing instruments (supposed to be "Hulusheng"). This looks very similar to nowadays dances in Yunnan that singing is accompanied with movements either dancing or moving with or without music.

Figure 6-3. Cangyuan rock painting and Yi Hulusheng dance[5]

6.1. Social functions Served by Folk Songs and Dances

6.1.1. Festival celebration

Torch festival is one of the famous festivals celebrated by Yi minority. It usually falls on 24th or 25th of June of lunar calendar, around august of western calendar.

[5] Cangyuan rock painting picture from the book of "Study on Yunnan nationalities music" & Yi Hulusheng dance picture accessed online @www.baidu.com

They believe fire has the power to get rid of evils and insects so as to hope for a good harvest. Each household needs to light up torches and place them in front of the door. When night comes, people walk around the field, holding small torches and place them in the field corners.

Figure 6-4. Torch Festival[6]

There are a lot of activities during the festivals, horse racing, wrestling, bulls fight, sing and dance parties. The climax is the bonfire party where people play musical instruments like sanxian (three stringed plucked instrument) and yueqin. Villagers including visitors, men and women, young and old form circles singing and dancing around the bonfires.

6.1.2. Communication

Most of the Yi people are engaged in farming activities. The hardship and daily activities happened in the farm yards are described in their work songs. They use

[6] Picture accessed online @www.cultural-china.com

simple farming tools made of wood and bamboo. These materials are also used in the making of musical instruments such as flute, sheng, drums, etc. to go with the dances and songs they play when they are off. "A xi de xian ji"("阿細的先基") can be claimed as the poem of Genesis belonging to AXi people (a major branch of Yi minority). It tells the long history of AXi people as early as before the world came into existence. It was circulated in Yunnan Mile County and was divided into two parts.

Figure 6-5. "A Xi De Xian Ji", history book of Axi People

The first part described how the world was created as to how the heaven and the earth were separated at the very beginning. It further told the early life of humans in primitive society. The second part illustrated the unique marriage and customs of the people. This poem or song written by Yi language was sung by dedicated people with their own styles. The selected people needed to learn the whole song and pass it to the next generation verbally.

6.1.3. Social activities and courtship

Dances and songs play a very important role in courtship for young men and women. It is a rare chance for them to get to know each other in order to look for marriage partners. Especially during big festivals such as "Torch Festival" or "March

Gathering”(三月會), singing and dancing continue days and nights. In these occasions, men play a three-stringed instrument called “Sanxian” while women sing, clap hands and kick. Men learned playing Sanxian when they were small and practiced it well in order to attract women’s attention. Love songs will be sung at that moment expressing affection among couples. It can be in a antiphonal way that they are singing in response to each other.

Figure 6-6. Left foot dance during “March gathering”

Most of the Yi families live in groups or villages in scattered areas over the mountain and basin areas. It is a very good opportunity to gather and meet people from different regions during festival times. They dance, sing and move in a number of circles formed in various sizes. Being lined up in a circle, they face each other and any new comers can join instantly. The dance steps are relatively simple with kicking and stepping so that visitors can learn and join immediately as well.

6.1.4. Entertainment

Singing and dancing can be regarded as the major type of entertainment for Yi people. During day time, they work very hard for farming and livestock keeping, they then sing and dance after work for leisure. Although dances fulfill practical significance for ritual ceremonies, weddings and funerals, people do rely on them for fun. Usually they will dance in different age groups with groups of young people and elderly. The dance songs are different for different age groups with faster and heavier beats for

young groups. Elderly has more leisure time and they organized some communities to learn and practice songs together for killing time. Although nowadays there are more choices of entertainment for them such as television programs or CD playing, singing and dancing are still important elements in their daily lives and cultural heritage.

6.2. Formations

6.2.1. Dance

Left foot dance is a very famous dance of Yi minority. It will be performed whenever there are big festivals, weddings and new houses constructed. Especially when Lunar March 28th comes, it will be danced three days and nights. It was named "left foot dance" because left feet is always put first. In general, left feet is regarded weaker as compared with the right feet. Some scholars believe that the higher position of women in this traditional society is one of the reasons that Yi people prefer to make the first step with the left feet.

Figure 6-7. Left foot dance in circles[7]

[7] Picture accessed online @cultural-china.com

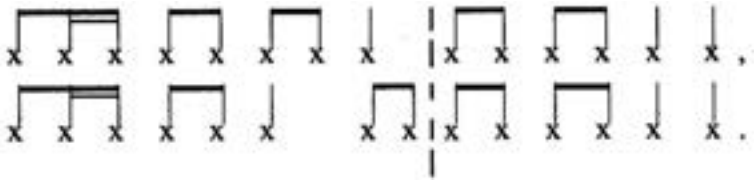
The dance form is relatively simple, with a few to dozens of people in a circle. A smaller circle will become a bigger circle and more circles will be formed. They face each other, shoulder to shoulder, hand in hand moving in an anti-clockwise direction. The steps are mainly stepping, raising and kicking with little movement on upper body. "Left foot song" will be sung in this occasion and there are some male players play sanzian and huqin as the commonly performed musical instruments.

6.2.2. Rhythmic Pattern

Rhythm plays a vital role in dance songs. It synchronizes the beats and speed between dances and songs. Some Chinese scholars believe that the rhythm of dance songs always go with the pattern with the second beat being stronger as outlined below:


or


Professor Alan Thrasher from the University of British Columbia inferred that for most of the dance songs, the most common rhythmic patterns of initial phrases are:



And, final phrases are usually:

(Thrasher, 1990, p.84)

It can be generally agreed that homogeneity of patterns can be found in dance steps, rhythmic and melodic motifs. Dances normally last from five to ten minutes or even

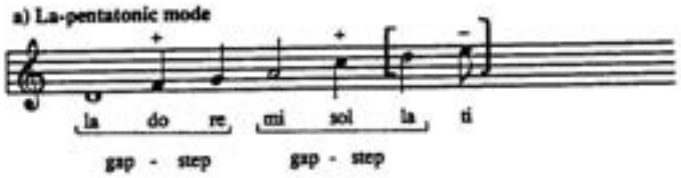
longer in a four beat pattern. It is very common for the same set of dance steps to repeat most of the time and so do the rhythmic and melodic patterns. Although the songs sound repetitive, it is very easy to learn and memorize, especially convenient for new comers to learn and join.

6.2.3. Melodic Pattern

Yi folk songs are characterized by composition of five tones namely "Do, Re, Mi, Sol, La". It is called pentatonic scale. Actually, there is no scale or model theory from Yi culture. Different modes of pentatonic scale from Han theory are being used to study the melodic pattern. Professor Thrasher had applied the La, Sol and Do pentatonic modal forms(Thrasher, 1990):

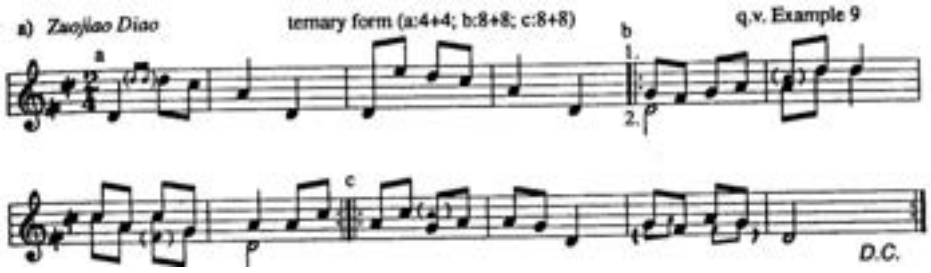
La-pentatonic mode:

In this mode, the aural presentation of the pitches is being la – do – re – mi – sol with "d" being heard as "la". According to Professor Thrasher, almost 75% of the repertoire is in this mode.



(Thrasher, 1990, p.79)

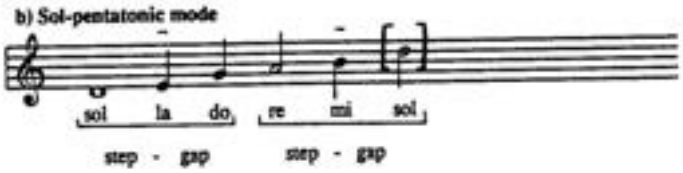
Below is the excerpt of the dance song called "Juojiao Diao", the "Left foot dance".



(Thrasher, 1990, p.83)

Sol-pentatonic mode:

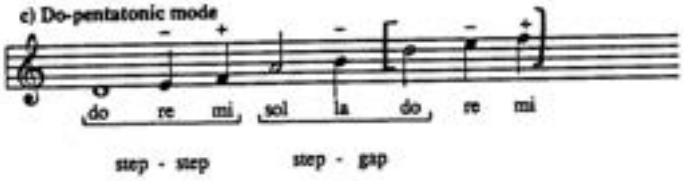
In this mode, the pitches sound like sol – la – do – re – mi. It can be seen that "d" and "a" also dominate the modal structure like La-pentatonic mode. However, they are heard as "sol" and "re", so it gives the mode sol-pentatonic.



(Thrasher, 1990, p.79)

Do-pentatonic mode:

In this mode, the pitches on the scale sound like do – re – mi – sol – la. The same, "d" and "a" dominate the modal structure, but they are heard as "do" and "sol". Thus, it is in the mode of do-pentatonic.



(Thrasher, 1990, p.79)

Portamento:

Portamento is a common singing style of Yi songs. It is the sliding between two pitches, either ascending or descending. The distance between the two pitches is usually 5th apart. On ascending, the main pitch is on the second, so the first pitch will quickly slide to the second. During descending, portamento also begins on the beat with downward sliding to the last pitch. The last pitch usually ends with weaker and slower voice, sometimes it is rather indeterminant.

6.3. Ethnic Musical Instruments

The musical instruments of Yi minority got popular for their handy design especially suitable for playing while dancing. As Yi people are scattered in different regions, the commonly used musical instruments will be different. For dancing in major ceremonial events, sanxian(三弘）and huqin(月琴）are usually performed. These instruments are performed by male players and sometimes they take the lead in varying the dance patterns.

6.3.1. Sanxian:

Figure 6-8. Big sanxian and the dance[8]

The design of Yi sanxian has some differences across different areas. In Honghe region, the design of sanxian looks similar to Han style with a flatter drum-like chamber. Unlike the one in Milo, the chamber is made of a cylinder, with lamp skin on the face. Azi people thought that the sound of the traditional sanxian was not strong enough, so they invented the big sanxian. The radius of the chamber of big sanxian is about one to one and a half feet. The stand is three to four feet long. The sound is much stronger and rough. It is very suitable for playing rhythm in dance songs while the small sanxian is appropriate for playing the melody.

6.3.2. Huqin:

Huqin belongs to the two-stringed fiddle family, like erhu. It was believed that the tribal people of north west China introduced it. It consists of a round or hexagonal sound box at the bottom with a neck extending from it. It usually has two strings with a bow moving between them. One string produces upper pitch range while the

[8] picture accessed online @www.innyo.com

other makes lower pitch sound. Like sanxian, huqin is very handy for the players to play when they are dancing. They usually have greater movement on the lower body. In some occasions, huqin players take the lead initiating the dances and bringing changes to the dance patterns.

Figure 6-9. Huqin

6.3.3. Blow instruments:

Other common musical instruments belong to the blow instruments such as flute, tree leave and Yi mouth string. Tree leave and Yi mouth string are very unique to the Yi culture. Chinese scholars prefer to call the tree leave as "mute"(wood leave). It can make very high-pitched vibrating sound when people put it into the month and whistle. The best leaves are taken from trees of tangerine and grapefruit with an elliptical shape. People take them fresh from the trees. Yi mouth string is made of one or two bamboo flakes, each with eight to ten centimeters long and one to two centimeters wide. Players hold them to the mouth with the left hand and push and pluck the reeds with the right hand. Depend on the way and the amount of air being blown, they can produce various contours of sound with different strength. It is very small in size and can be placed in a bamboo can. People can easily bring it with them and play with it during dancing festivals and courtship.

Figure 6-10. Yi Mouth String[9]

6.4. Translating Yi Ethnic Elements

This section is examining the style and uniqueness of Yi music with the discussion of applicable generative and complexity theories. Before we go into the paradigm of generating music creatively, we have to understand the very nature of the music we are studying. From human's way of making music to system's way of creating music, there is used to be a big gap. We will examine major types of music based on the references obtained from the ethnography and the recordings with a hope to see analogy between the two in some ways.

6.4.1. Songs made by tree leaves

We will start by looking into the songs performed by a tree leaf. It is the practice of Yi people making use of the resources they have in the natural environment to make music. It is very convenient for them to take the tree leaves around them and blow

[9] Picture from The People's Government of Liangshan Yi Autonomous Perfecture accessed @ http://www.lsz.gov.cn & http://liangshan.scol.com.cn

over them. A tree leaf can make a very strong and high pitched sound. Thus it will be used in dance songs very often. From the song recording we did in the Ke Yi Village, there was a very pleasant and lively piece played by a tree leaf accompanied by a huqin.

Its sound came out strongly from the repetitive sound of huqin. Most of the time, it made three to four stable tones. Figure 6-11 shows a number of melodic phrases of this piece. The tree leaf played the solo with a moderate beat.

Figure 6-11. A song played by a tree leaf

They choose those tree leaves which are fresh with round oval shape. A fold line will be made on it and the people blow over it.

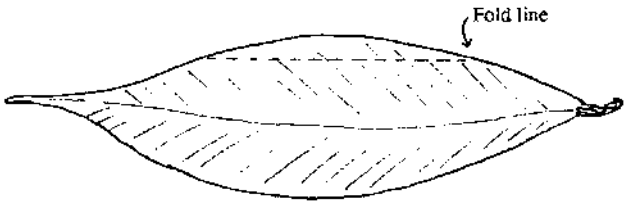


Figure 6-12. A tree leaf played by Yi people[10]

[10] Picture from (Thrasher, 1990)

One of the interesting features of Yi song is portamento, sliding of notes either in upward and downward direction. Figure 6-13 shows the rhythm of the same piece (the song played by the tree leaf) with each music note of equal duration. However, there is a short note sliding from the last note. This lasts throughout the whole song.

Figure 6-13. A short sliding note at the end of the melody phrase

If tree leaves are played in the dance song, the beat will be very fast, up to 140 beats per minutes. It will go with different types of musical instruments, but it is very easy to hear its sound. Given the shape and size of the tree leaf, it is not easy to make a lot of notes with different pitches. Usually, it can produce three to four different tones. This makes the Yi folk songs in this category limited by only a few pitches. In other regions, there are some flutes which can only produce three tones because of the design of these musical instruments.

6.4.2. Dance songs

Based on the dance songs we recorded and collected in the Ke Yi Village, the single type of rhythmic pattern will last the whole song without variation. Figure 6-14 shows a typical rhythmic pattern of a dance song performed by older people. The beat will be slow or moderate. The second example shows a similar rhythmic pattern with a sliding note on beat three. It is also performed by older people with moderate beat.

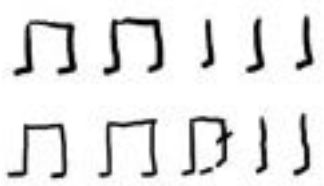


Figure 6-14. Rhythmic patterns of songs performed by older people

Figure 6-15 shows the score of the very famous dance song in the village. It is one of the AXi moon dances performed by the young people with a very fast beat. It is very often to be seen as the on-stage performance to the visitors and during festival celebration. The first part of the melodic phrase of the song was shown. It was composed by three major notes with the same rhythmic pattern. There are some changes of the first note with either 4 or 6, then connected with any of the three notes. It always ends with notes 2 with 4.

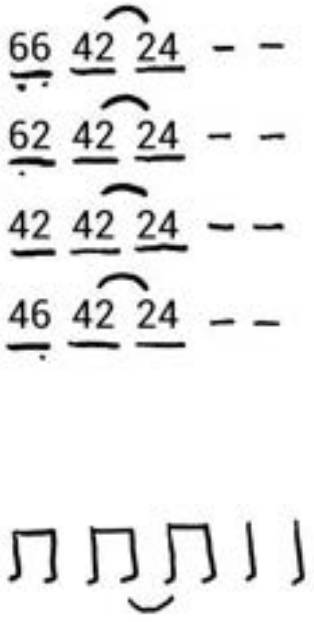
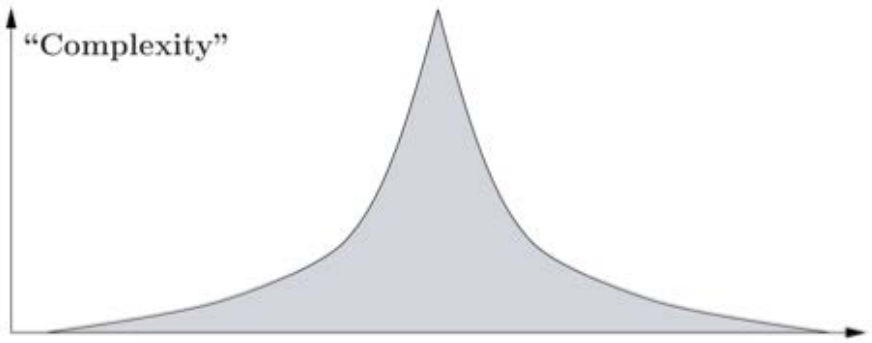


Figure 6-15. Score and rhythm of AXi Moon Dance

From the scores and recordings we collected in Ke Yi Village, the traditional dance songs are characterized by single rhythmic pattern without any variation. There are changes of speed adjusting to the dance speed of older and younger people. The music is mainly composed by three or four music notes. The contour of the melody is rather flat with little variation. The contour will have some peaks in the middle, but for some songs the ending notes of each melodic phrase are the same. Together with steady and repetitive rhythm, these Yi dance songs are highly ordered and predictable.

6.4.3. Between the ordered and the disordered

In generative art, randomization is often used to make disordered work which is difficult to predict. It is a difficult task for the ordered folk songs. Although it is easy to make pieces similar to these folk songs using randomness technique, given restricted choices of music notes and non varied rhythm, these pieces still sound ordered. Galanter agreed in his paper (Galanter, 2003), that highly ordered music is of little intrinsic aesthetic interest. People will easily get bored with the same notes repeating throughout the song. However, with a highly disordered music, it is difficult to continue the audience attention because it lacks structural complexity too. This leads to a discovery of a continuum finding the equilibrium between ordered and disordered systems. Gell-Mann, one of the founders of complexity science, proposed a model to measure "effective complexity" between ordered and disordered extremes. Effective complexity reaches optimum between the two. Figure 6-16 came from the book of Flake(Flake, 1998) elaborating an optimum of complexity in the middle between orderly and random systems.



Low Information Content	High Information Content
High Compressibility	Low Compressibility
Orderly	Random

Figure 6-16. Effective Complexity

The pieces below show some variation. Figure 6-17 is the famous song called AXi Dance Under The Moon which is representative of the AXi people. It is believed to follow the pentatonic scale of "do re me so la". Figure 6-18 shows the piece following this scale too, but with more variation to the rhythmic patterns. They exhibit greater aesthetic interest than the traditional folk songs.

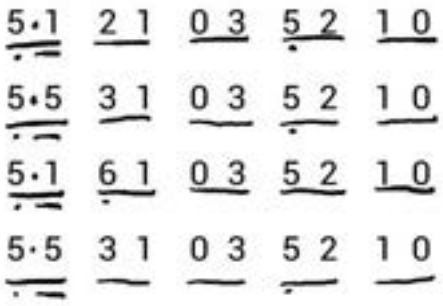


Figure 6-17. AXi Dance Under The Moon

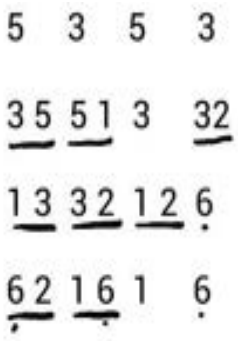


Figure 6-18. The Happy Luosu

6.4.4. Complexity

A complex system comprises of smaller parts or components interacting with each other. It can be regarded as a self organizing system without being controlled by an external factor. It adapts to the changing environment. In the case of experimentation with Yi music, user interaction is the major part of test of interactivity. To the generative system itself, user interaction can be regarded as an external event bringing abrupt changes to the internal components and population. The system then retruns to its steady and self organizing state if further human intervention is not present.

In order to extend the complexity, choatic theory is often adopted by scientists to study unpredictable behaviour. Chaotic theory increases the level of disorderness with its nonlinear path of development in the case of generative music. Yi dance music is highly ordered and repetitive, it will be difficult for the audience to continue the interest. However, its easiness goes well with the dances. It is easy to learn and join immediately with better colllaboration. They interact through the dances and songs which are serving a lot of social functions of Yi. People can associate the way of communication and affection that are being inherited through the songs.

6.4.5. Experiment with chosen ethnic elements

The way they communicate the affection is not going to be tackled in the research and the experiment. In order to experiment some of the characteristics mentioned, selected ethnic music elements are being studied to make pieces to go through the generative process.

From the illustration of Yi ethnic music elements, homogeneity is found in the melodic and rhythmic patterns with occasional alteration. In music composition, a motif represents a distinct phrase that could be repeated or varied throughout the process of music sequencing. The repeated melodic phrases and rhythmic patterns of Yi songs can be recognized as motifs to be composed within the generative system. These motifs form the basic unit that makes the music piece distinguishable. The generative system makes use of them for the composition process. It acts like a bridge translating ethnic elements to be understood by the system. This section looks into a number of elements namely melodic pattern, accompaniment and percussion.

A. Melodic Pattern

In order for the system to generate repeated melodic pattern, a table containing the notes occurrence of a given motif is stored and repeated. Time duration is specified to control how long the motif should repeat. Minor or major changes to the melodic patterns can be made by alternating the motif tables stored. Variation can also be introduced by generating new music notes slightly or very different to the original melodic patterns being referenced. The system can store a number of rhythmic patterns to be accorded when the music is being generated. For a given piece, for example a dance song or a love song, a number of common patterns can be pre-stored and selected during the composition process.

Although some scholars believed that Yi songs are characterized by pentatonic scales (melody made of five tones), there is no modal theory in Yi music. Yi songs are not confined to five tones namely Do, Re, Me, Sol, La only. According to the design of some musical instruments, there are songs made of three or four tones. There are also some pieces made of more than five tones. Generative system needs the rules configured to do the composition. The use of tones in Yi music development provides creative source as generative rules to the composition system. It can generate music similar to Yi style, but blend into other styles such as modern or western if possible. Variations can be brought about by introducing alternative types of rule.

B. Accompaniment

Yi musical instruments also spark inspirations to the generative system in making music. Take "Hulusi" as an example, a flute made of a hulu chamber with three or five pipes. Besides the melody, it can make a second tone in 5th or 7th interval at the same time. To make music accompaniment, generative systems usually make use of chords, but Yi music has no chords. The way that Hulusi makes the second tone gives a new method for the generative system in accompanying the melody. Together with chord progression, more choices are available for music accompaniment.

C. Percussion

From ethnographic observation carried out in the Ke Yi village, I could see no drums for the percussion. They used Sanxian in medium or big sizes instead to make the "dong dong" sound as the beat sound. There are more percussive sounds for selection within the generative system as a way to augment the percussion generated.

Part 4 Methodology

Chapter 7

7. Methodology

Live music performance is an event or action taken by performers at a particular space and time with the audience. It cannot replicate itself. This research applies interactive and generative techniques to the music performance. In order to understand the interaction between performers, audience and the interactive system, active participation in the performances enables first hand and real life acquisitions of knowledge and experiences. Despite contemporary context, an ethnographic field trip was conducted to study the culture of an ethnic minority group. In order to evaluate the quality of performances, a number of research methods such as observation, experiments and interviews were adopted to collect data and feedback from the users.

7.1. A Public Interactive Mixed Media Performance

A real-life media performance called “Com1p0st” was performed in 2009 July at Black Box Theatre of Jockey Club Creative Arts Center in Hong Kong. The renting of venue and equipment was sponsored by The Hong Kong Arts Development Council. There were four major team members including the author. Most of them are Master and PhD students of design and media technology with musical backgrounds at various levels. It was an interactive mixed media performance with traditional and new media contents created by digital means. We added some sessions making use of computer algorithms and interactive applications for the purposes of live performance and interaction with the audience. In order to understand how the group members create ideas, interact, and make decisions in a collaborative way, participant observation was adopted with the author participated in the performance. With this opportunity, it is possible to learn how the audience react and adapt to the interactive performance with or without multimedia technology.

This serves as the background contextual study of a public media performance with active participation.

7.2. Participant Observation

Participant observation research method is suitable for real-life events where people being studied are in connection with other stakeholders and organizations in the research process. The researcher acts as a facilitator rather than the one who reinforces the objectives in order to help the studied subjects contribute different ideas and perspectives. He or she will be the insider, to observe and also participate. The research process and outcome will be influenced by the subjects involved instead of the methods predetermined outside. In contrast with the conventional research,

> *"participatory research embodies an approach to data collection that is two-directional (both from the researcher to the subject, and from subject to researcher). The process itself is dynamic, demand-based and change-oriented"* (Narayan-Parker 1996)

In this case, the author was one of the performers to create ideas and design the performance. I was also the keyboard player and the computer programmer to develop some applications for the interactive sections. At the same time, I was an observer to learn how each team member contributed ideas and collaborated. It was also valuable to get firsthand information of dealing with any issues relating to the performance and the audience feedback and recommendations. Followed by a number of individual interviews with the audience after the show, evaluation was conducted and future recommendations can be collected. This serves as a performance as well as a research exercise collecting background information and preliminary data.

Evaluation

There are some interesting enquires about how performers collaborate and the spectated experiences of the audience without and without digital technology:

- How to augment traditional music performances with new digital musical instruments?
- Is there a change in the way performers interact with each other with both new and traditional musical instruments?
- Can interactivity be increased with the use of digital technology between performers and the audience?
- Would the audience find the show creative and enjoyable?

Findings were documented and the questions relating to the audience experiences were explored through observation and interviews with the selected spectators. The whole performance and the research process including findings were presented in a conference paper. This leads to the emergence and evolution of the theoretical framework formulation and prototype development.

7.3. Theoretical Framework Formation

This thesis presents a theoretical framework which incorporates both generative and interactive techniques in order to enhance interactivity and user experiences through interaction and collaboration between users and the system. It provides a configurable and adaptable solution to support music performance through a mechanism of adjusting the interactive and generative intensity through the implementation of an interactive music performance system. This serves as the foundation for future system design.

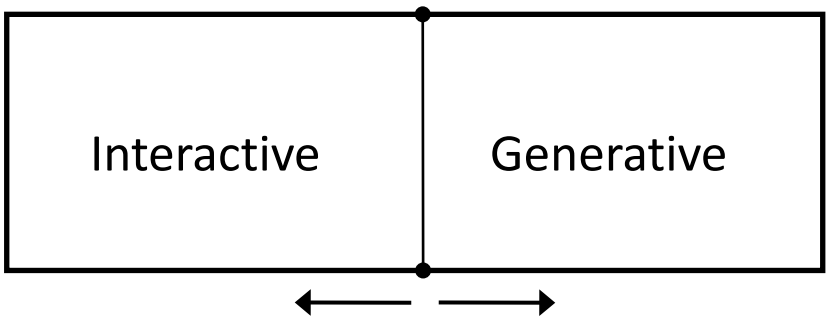


Figure 7-1. An interactive and generative framework

7.4. Prototype Development

Prototypes serve a good purpose of gathering user requirements and helping users redefine what they want especially when the needs are not clearly defined at the very beginning. A number of system prototypes were developed based on the configurable design proposed. The intensity of system generation and user interaction can be adjusted by the users. It can be a generative, interactive oriented or a balanced design. The tools being used are prevalent in media performances and visual design.

Max/MSP

Max/MSP is the most frequently used development tool by performers, composers, artists and scientists for performances, composition, experiments and art installations. It provides an interactive visual programming environment for creation and manipulation of audio, graphics and video processes. It has been in the market for over 20 years. In the graphical environment, objects, linkages and values are defined simply by "drag and drop" and they can be visualized on a patch.

Processing

Processing, developed by MIT, is an open source programming language offering an integrated programming environment for digital art and interaction design. Artificial

intelligence and generative algorithms can be utilized to create animation, generative art and simulated visual effects. With the given libraries and contributed code libraries from the open source, it is effective and easy for the artists to do the coding using Java language. It is not made for sound projects, but other sound and midi libraries can be incorporated into it. In fact, it is more powerful working with visual effects and interactive applications that include fascinated imagery and generated sound.

7.5. Ethnography of Yi Minority Culture

Contemporary cultural contexts are not difficult to attain by the availability of case examples and performances online and on stage. Extension to a different culture requires intensive research and in-depth participation and observation. In this case, Yi minority ethnic music of Yunnan Province in China was selected as the example. Case study research method is in general used to examine contemporary and real-life event happened at a specific place and time while the phenomenon, context and results are unknown. Normally, the aims are known and the research questions are about "how" and "why" instead of "what". Yin stated that case study is an empirical inquiry that:

> *"investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."* (Yin 2009)

The intensity was further enhanced by the execution of an ethnographic fieldtrip and an experiment fieldtrip to the same village in Yunnan Province. The village belongs to Axi people of Yi minority where its long history and heritage of the folk songs and dances can be traced. The culture and custom are unique to the minority and its surrounding environment.

Chapter 8

8. Ethnographic Field Trip

8.1. Uniqueness of the research

Interactive music is unique out of all other music genres in the way the music is composed or performed. It can do with or without the help of human performers. Yet, designers and software developers have the major control of how the music is being analyzed, manipulated and composed. In recent contemporary media performances, digital technology and computer algorithms are utilized to create exciting interactive experiences to the audience. They are often associated with western music or electronic music nourished by western culture and elements. However, they are still regarded as experimental as they evolve with new invention of technology. It is a challenge to experiment innovative technology with oriental culture. In this research, Yi minority ethnic music of Yunnan Province in China is chosen as the centre of the study in order to generate irreplaceable and essential cultural elements. It advances this research to an unexplored area which yields unanticipated results and valuable insights in different dimensions.

Yunnan Yi minority music is unique in the ways Yi people make music in a natural setting with the musical instruments that they invented. Yi minority has more than 3 thousand years of history. Uniqueness and richness can be found in their music making in response to their ways of life, religions and ecology. Singing and dancing are part of the lives of Yi people. Apart from festivals, they sing and dance for courtship, farming, entertainment and social activities. Their music is unique in the way they sing, song structure, rhythm patterns and the musical instruments made for performances in different occasions. They are passionate in learning, inheriting and spreading their music and dance culture.

8.2. Ethnography as the Methodology

Ethnography is often adopted as a methodology if the research needs to study people activities and the social meanings in a given field. This research primarily studies the theoretical design issues involved in the interactive music performance systems. Attempt was made to study a number of areas such as how people make music in their natural environment, the musical instruments they use and folk music in different aspects. Brewer interpreted ethnography as:

> *"Ethnography is the study of people in naturally occurring settings or 'fields' by means of methods which capture their social meanings and ordinary activities, involving the researcher participating directly in the setting, if not also the activities, in order to collect data in a systematic manner but without meaning being imposed on them externally."* (Brewer 2000)

To be precise, ethnomusicology as the division of ethnography or musicology, is favored by researchers to study music in its cultural context. Meyers stated in his book that:

> *"Ethnomusicology includes the study of folk music, Eastern art music and contemporary music in oral tradition as well as conceptual issues such as the origins of music, musical change, ……...function of music in society, the comparison of musical systems and the biological basis of music and dance"*
> (Meyers 1992)

There is no better method other than an ethnographic field work being conducted in the associated community or a group of people with the researcher being in touch of their daily activities so as to understand certain practices. In this case, we chose to

study Yi music and its related social functions and the characteristics of their music and dances.

8.3. Fieldwork Setting

Ke Yi Village

An ethnographic field trip was conducted in 2010 December to a village belonging to Axi people of Yi group and it is called "Ke Yi Village". It is located about 100 kilometers east of Kunming, the capital city of Yunnan Province. This village is one of the major Yi branch with Axi people living in Milo County of Yunnan Province with about two hundred households at present. She has over 300 years of history and is the birth place of their famous folk dance “Axi Tiao Yue", is translated as “Axi Dancing Under The Moon ". With the recent tourist and cultural development within the province, Ke Yi was named one of the "Ecological and Cultural Village" in the country. Because of the richness in culture and natural resources, visitors and researchers are attracted from every part of the world

Figure 8-1. Ke Yi Village

We stayed in the family of the Axi group patriarch for four days. A forum was organized in the village during the stay discussing issues regarding inheriting the tradition of the dance of "Axi Dancing Under The Moon". Visitors from other parts

of China and villagers were invited to the forum followed by music and dance performances performed by Yi musicians and the dance troupe. Videos were shot about the performances and field notes were taken to record the daily events and any observations made. Sound recording was also carried out to record the wine songs they use to sing to the visitors during wine toasting. Songs recorded were finally published in the music CD of Axi songs and music.

Figure 8-2. Home of the patriarch of Axi Group

8.4. Brief Description of Yi Minority Music

Yi minority music of Yunnan Province is the focus of this case study. Central Yunnan province is located on the high Yunnan-Guizhou Plateau of southwestern China with Kunming being the capital. She is populated with different tribes of Yi, Bai, Dong, Mongolian, Miao and others. 25 ethnic groups are found in Yunnan including Yi, Bai, Hani, Tai, Dai, Miao, etc. with Yi being the major group. Out of more than 8 million Yi people, over 4.5 million live in Yunnan Province[11].

Dancing is continuous, day and night during the festival days. Apart from farming, people dance on the occasion of weddings, funerals, festivals and other ceremonies.

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11 http://en.wikipedia.org/wiki/Yi_people

The dances are large group social dances in circular formation and the circles are formed spontaneously by several musicians and dancers. Other participants can join anytime or leave the circles when they need rest. Dancers and musicians will stand close together to step identical patterns which mainly involve steps, kicks, jumps, stomps.

8.5. Getting Access

Ke Yi Village is situated on the mountain area in Mile County. Although this village is accessible, connection with the people there beforehand is very important in order to stay and do research in the village. My university has been collaborating with the Yunnan University in Kunming and we have a collaboration centre there. Professors of the Yunnan University have been actively involved in the social research conducted within the Ke Yi Village. Apart from online searching, background study of the culture of Yi minority was aided by seminars organized by professors and students of Yunnan University. It was a precious opportunity to get to know more about the village. It will be very difficult to have the people perform the folk songs and dances if you do not have any relationship with the people in charge of the dance team. Luckily, accommodation was generously provided by the villagers.

Before this field trip, Yunnan ethnic minorities gave me the impression that people are enthusiastic, hospitable and very good at singing and dancing. Regarding their music making and dancing, to my knowledge, they are improvising, accommodating to the ecological environment and there is integration of singing, dancing and instrument playing. I stayed in Kunming, a city dominated by Han, for two days before heading to the village. It took around three hours drive to get to the field, the Ke Yi Village.

8.6. Axi Dancing Under The Moon Forum

Figure 8-3. Axi Dancing Under The Moon Forum

The first day when I arrived the village, I saw some of the villagers and visitors gather at the open ground waiting to join the discussion forum regarding "Axi Dancing Under The Moon", a famous traditional dance of Yi minority group. There was a team of young men and women danced and sang to welcome the guests at the entrance.

Figure 8-4. Dancers welcoming guests

On the other side, older men and women were also dancing, playing instruments for pleasure, with smiling faces encouraging guests to join them. Because of the coming performances, some of the performers were doing rehearsals, singing and dancing with their instruments. Most of them were older people, the speed of the dance was moderate and the steps were simple. They lined up in a circle, moved to the left three

three steps and kicked with the right legs two times, then moved back to the right three steps and kicked with the left legs two times. This made the rhythm in 5/4 beat, rather than 2/4, 3/4 or 4/4.

Figure 8-5. Dance by older people

Most of the time women sang and danced with hands clapping while men danced with their own instruments. I tried to join them and the steps are so easy that I could dance with them immediately. Some of them welcomed new guests to join but not all of them were necessarily eager to do so. Easiness to learn enables new comers to participate and enhances interaction.

Figure 8-6. Folk musical instruments

The instruments were mainly Sanxian, bamboo flute, Huqin (a small two-stringed fiddle, erhu is commonly known instrument of this type) and tree leaves as well. They are very handy that they can be worn and played while the performers are dancing. While these instruments are commonly used for accompaniment, Hulusi, usually comes with five pipes but of various sizes can produce beautiful melody for solo performances. One of the unique features of Hulusi is its dual-tone capability. Usually it can produce a second tone which is 5th or 8th interval to the primary melody notes.

Figure 8-7. Hulusi

Hulusi belongs to blow instrument and is not usually used in dances. In most occasions, the male players need to lead and dance in the team. They often play bow and pluck musical instruments such as sanxian, huqin or erhu. Those who play blow instruments such as flute and tree leaves usually do not dance a lot because blow instruments consume relatively more energy.

8.7. Background of Axi Dancing Under The Moon

Every Axi person know how to dance "Axi Dancing Under The Moon", no matter children, women, young and old men. It is a representative dance of Axi people and they dance it for festivals, harvest celebration, leisure and courtship as well. Some Chinese scholars noticed that it was often danced under the moon, so it was named. The one we see nowadays on TV or stage is a fast and rather complicated version performed by young men and women. By origin, it was a very simple dance with jumping and hands clapping. It's old name "跳樂", in Axi languagemeans jumping and clapping in older time. It also means jumping and happy in later time. Thus it is a happy dance and people dance for joy and happiness.

There were no official documents about the development of this dance. It was estimated to occur in Qing Dynasty with about two hundred years of history. At that very early time, this dance can be joined by people at all ages in a circle. They were only stepping in counter-clockwise and clockwise directions with one leg crossing over the other. Usually one step with one hands clap. It was then modified to have jumping, with one leg jumping plus one hands clapping. The musical instruments were mainly sanhu(erhu like), flute, tree leave and huluxian(modified to sanxian later). The music speed was moderate and in 2/4 beat at that time.

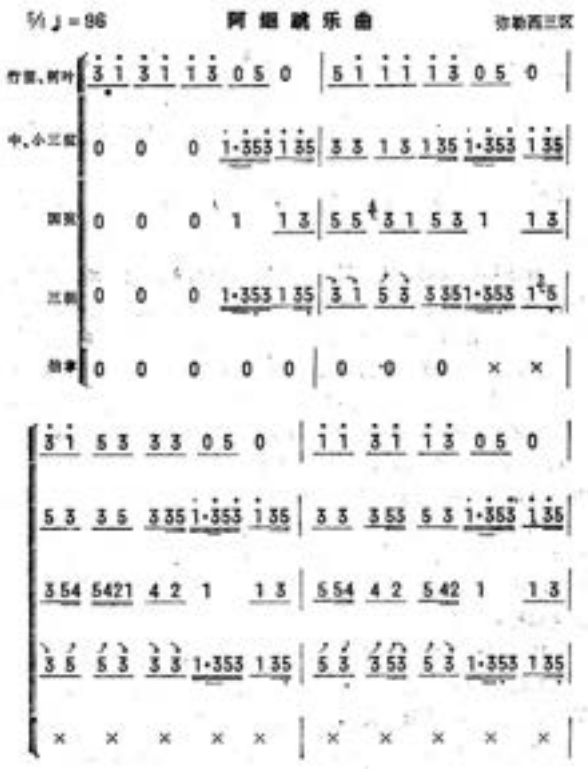

Figure 8-8. Score of Axi Dancing Under The Moon

Young people thought that the traditional version was rather slow. They preferred it to be more energetic and passionate. Instead of a circle, they made new arrangement that women and men were lining up in two individual queues but facing each other. They further introduced more variations to the dancing gestures of hands and legs and the music speed was much faster.

Modifications were not only limited to the speed and melody, but also beat pattern. 5/4 beat appeared and it was a brand new beat. This made Axi music so distinguished from other genres. This young version gradually made it separated from the version performed by the older people. Young people preferred to dance with peers in social gatherings and their dances were drastic and more enthusiastic while older people preferred to dance slower and elegantly.

Figure 8-9. Sanxian played by Axi People

There was a big change to the design of sanxian, a musical instrument made of three strings used to accompany dance songs. Originally, it was smaller in size and was used together with flute, erhu, etc in traditional dances. It was modified to have bigger size to produce louder sound. It was good to make strong rhythm that it was frequently used in dances performed by the young people. This also caused changes to the flutes that they can generate high, middle and low pitched sounds in different designs.

8.8. On Stage Performances

There was no festival during my stay in the village. Villagers need to work or do farming over the mountain areas. They normally take a rest after dinner and spend some time watching television. It is not common to see them dancing and singing in their living environment except on stage. When there are any events or coming of visitors, they can earn extra money by performing on stage in the restaurant there. At the beginning, there would be a person telling the history and story of Axi people. The dances demonstrated their culture and everyday life regarding hunting, farming, marriage, etc..

Figure 8-10. On stage performance to visitors

The visitors watched the performance when they were dining. The dancers would go over to the visitors and toast wine with them singing the wine songs. It used to be a cheerful moment when everybody was celebrating. Although they sometimes looked tired, but they always wore smiling faces in and out of the performances.

8.9. Song Recording

One of our main task was songs recording. Despite some misunderstandings, finally we organized a recording section inviting singers and instrumentalists. There came more than ten singers with young women and men in each team. There were few men who played Sanxian, flutes and tree leaves. We managed to gather all of them at around 9:30 pm. At first they looked rather tired, as they needed to work the whole day over the mountain area. Usually they will take a rest after dinner and watched television for leisure. Singing and dancing usually happen during festival time while some dances may last a few days. The songs we recorded are sung during wine toasting. Women sang with very high pitched voice while men sang with lower but stronger voice. The musical instruments were mainly used for accompaniment while the flutes in some songs were playing the female vocal part. Thus, this made many of the songs full of very high pitched vocals and instrument sound. Although they looked tired, but still had smiling faces when they were singing. A few songs later, they looked more energetic and happy.

Figure 8-11. Song recording with the wine song singers

We had recorded more than ten songs and different categories of wine song were recorded. They sang those for welcoming new guests and giving blessings in a group, in a very loud and cheerful voice. They were seldom sung in solo, but in antiphonal manner between men and women. Besides celebration, these songs are important too in building relationships. Most of the songs are in very bright tone while there are few started with a minor tone but turned into a brighter tone.

8.10.Everyday life

Although many people, especially the young had left the village and work in towns, villagers there are mainly farmers growing crops, vegetables and keeping livestock. Some work over the mountain building houses and collecting wood. They are not governed by the conventions and rules of Han, they opt for freedom in their lives. This can be seen from their marriage. When the boy and the girl are in love and they want to marry each other, the boy will carry a bucket of water to the girl's home to meet with her father. The girl will then carry some charcoal to the boy's home the next day.

Figure 8-12. Livestock keeping

There are many religions in Yi minority. Han Buddhism, Daoism, some worship animals, sun, wind, etc. in other regions. Walking around the village, I found a Catholic Church and there were few people worshipping there. They were reading the bible, in a tone very similar to the way they sing "Axi zan gi" (a very long song telling about how the world was formed, Axi people culture and their ways of life). Finally I found out that they usually sing in this tone when they read words aloud. It sounds like reciting a poem, a rather flat tone with littler variation.

8.11.Summarized characteristics of Yi dances and music

Here are some of the characteristics of Yunnan Yi dances and music being observed in the village:

- There is integration of singing, playing instruments and dancing.
- They usually dance in a circle or semi-circle.
- Stepping on the ground involves greater movement in every direction while kicking remains in rather stable position.
- The same melody and rhythm patterns repeat many times (usually in dance songs).
- 5/4 beat is quite common.
- Antiphonal in love songs or wine songs (responsive singing).

8.12.Publishing of “Axi Dancing Under the Moon” Ethic Music CD

A music CD containing Axi folk songs representing Axi people of Yi minority was jointly published by The Hong Kong Polytechnic University and The Yunnan University. It was the original recording of the songs in the field without modification. The songs were sung and performed by the singers and musicians in the Ke Yi Village.

Figure 8-13. “Axi Dancing Under the Moon” Music CD

The CD features “A xi de xian ji”, a very long song or poem telling the history of Axi people since the world was created. Famous dance songs such as “Axi dancing under the moon” and wine songs were recorded. There are also some solo pieces played by their unique musical instruments such as Yi mouth string and flutes. The distribution of the CD was helped by The Yunnan University and the profits earned will be used to help the people of the village.

8.13.Summary

The field trip provided an opportunity to have some ideas about the daily lives of the villagers. It is valuable to see how they are passionate about the dances and music of their own as an important portion incorporated into their works, social activities,

courtship and marriage. It also provided fruitful ethnic elements for creating contents and music pieces for performance and experiment purposes.

Chapter 9

9. Experiments Design

In order to evaluate the effectiveness of the conceptual models proposed, a number of prototype systems were developed. They served as tools for collecting data and user experiences during the execution of the experiments. The place to carry out the experiments was Ke Yi Village of Yunnan Province, the same village where the first ethnographic field trip was taken. The prototype systems developed for the experiments took the flexible configurable design as proposed in the theoretical framework. There are generative and interactive modules while the relative intensity is adaptable to the preferences of the users. It attempted to incorporate Yi minority ethnic elements into the performances so as to make them sound familiar to the villagers who were interacting with the system.

The design of the experiments and the interviews aimed to collect insight and data in relation to the following research objectives:

- Improving interactivity and enabling exchange of musical knowledge between the system and the users who interact with it;
- Enhancing user experiences and extending engagement of the system to a deeper cognitive and creative level by incorporation of generative and interactive techniques;
- Enabling collaboration between the system and the human performers in the creative process.

9.1. Areas To Investigate

The adaptive design of the conceptual models proposed in Chapter 5 suggests design guidelines towards interactive music performance systems. It not only allows users to adjust the relative intensity, but also make comparison between the generative and

interactive performances. Thus, the experiments will be divided into generative as well as interactive performances while the same groups of participants will be able to experience and compare both performances.

9.1.1. Comparison between generative and interactive performances

For the generative performance, participants need to listen to it and then comment. As this performance makes reference of one of Yi folk songs, so it will make sense to know if they can recognize the song. For the interactive performance, it will be interesting to learn their immediate responses and experiences as for all of them, it can be the first encounter.

For both performances, the participants need to briefly describe them and make comment on the quality respectively. Future comments are significant if continuous enhancements are needed. However, inquiry about collaboration with the computer system is necessary for interactive performance as this module allows users to interact and collaborate.

9.1.2. Interactivity

In addressing the research objectives, interactivity is one of the key areas to investigate. Interactive features are incorporated so that users can interact with the system through musical elements such as melodies or rhythm. Exchange of musical knowledge is possible in this way.

9.1.3. Enhancement of user experiences and engagement of the system

With the objective to enhance user experiences and engagement of the system, both interactive and generative techniques are incorporated. Interactive experiences can be enhanced by generative capability of the system while generative systems can be

augmented by interactive capability with the intent to enhance the engagement of the system. Thus, we look into the areas of interestingness of the performances.

9.2. Before The Experiments

Apart from background research and design guidelines formulation, the first ethnographic field trip conducted in 2010 provided valuable information and resources for carrying out the experiments. Generative and interactive features were designed in the prototype systems in order to allow users to control the relative intensity. The development of the systems took iterative approach in which phases of design, implementation, testing and evaluation will the repeated or iterated during the development cycle. System design, implementation and testing were performed by the author while prior evaluation was carried out with the supervisor of this research and some invited guests in Hong Kong.

Before going to the village, system demonstration was shown to the professors and post-graduate students of Yunnan University in Kunming. Issues of concern were identified followed by the discussion of the experiments arrangement.

9.3. Arrangement of the Experiments:

Currently there are around two hundred households in the village. Children and young people need to go to the towns or cities to further education in secondary schools and universities. Most of the villagers there are middle-aged couples and children aged below twelve. We expected the age difference is large and decided to divide them into two age groups. One was the primary school students and the other was adult villagers.

They were given the same pieces to experience and the same questionnaire. The experiments were planned as:

1. Listen to the generative piece performed by the system (generative module).
2. Selected participants will be given a questionnaire.
3. Helpers approach individual participants to help them complete the questionnaire.
4. Participants start interacting with the system (interactive module) with their own musical instruments.
5. Participants play a portion of the music piece at their own choices.
6. The system will play the melody that the participant has played and will make an echoed melody as a response to the user. It sounds like echo singing in ethnic songs.
7. The participant listens to the music and then decides to interact again.
8. When there is no further interaction by the participant, the music generated by the system will go on and variations will be made.

9.4. Design of the questionnaire

Both adult villagers and primary students groups were given the same questionnaire. Comparisons could be made between the two age groups and between different performances. Questions were designed based on the areas that would be investigated. Details can refer to the sample of the questionnaire attached in the Appendix.

Personal Information:

For both adult villagers and primary students groups, general information of the participants will be collected. Since participants of the adult villagers group perform some duties in the dance team, so their roles and responsibilities will be recorded. This may impact their experiences and feedback of using the system.

Rating Scale:

When the participants are questioned about the quality of the performances, a scale from “very good”, “good”, “normal”, “poor” and “very poor” can be chosen. If using words to describe the pieces, a number of words such as “interesting”, “exciting”, “nothing”, “boring” and “strange” are provided. They can also specify with their own words.

Open Questions:

Questions are open-ended when participants are asked about the experiences of interaction and collaboration. They are free to provide any suggestions for future improvement.

9.5. The Equipments Used

The equipments were relatively simple. There was a laptop with the prototype system written by Max/MSP. A handy microphone which captured the sound and performed pitch analysis and rhythm detection. Musicians in the village played the melodies they were familiar with their own musical instruments such as flute, banhu or erhu. The melodies went though the composition and manipulation processes within the system. The resulting music would then be sent to a pair of speakers.

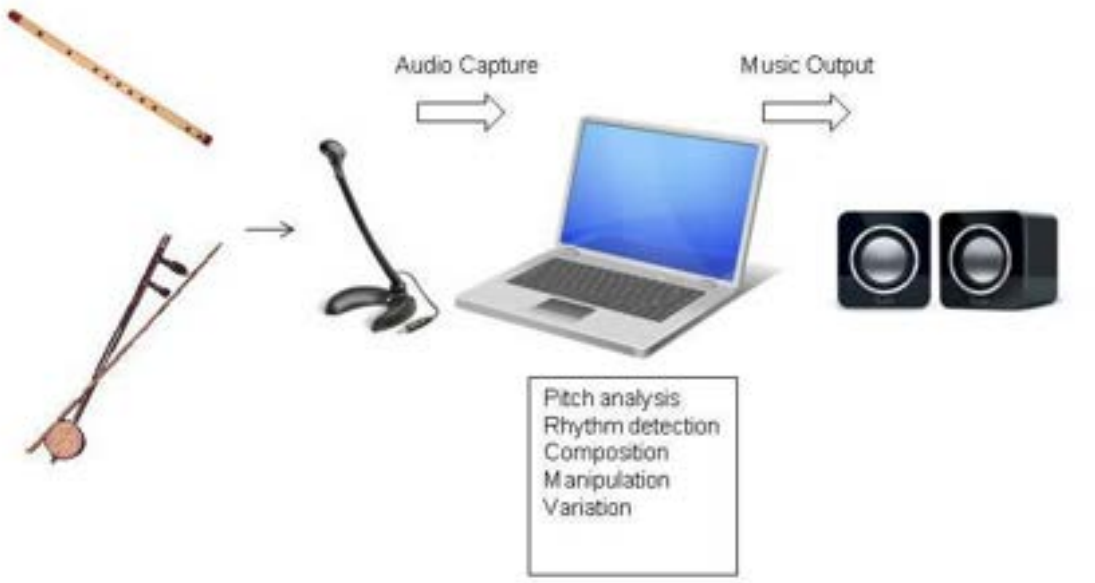

Figure 9-1. Equipment setup for the experiments

9.6. The Experiments

A second field trip was organized to evaluate the implemented prototype systems in Ke Yi Village, the same village where the ethnographic field trip was conducted. Observation and interviews took place to collect data and user feedback. The whole trip took one week from 5 December 2011 to 11 December 2011 and two days were spent in the village. Adult villagers were invited for the experiments first followed by a group of primary students. They were both given interactive and generative performances to evaluate the experiences.

9.6.1. Experiments conducted with the adult villagers

In the night of 7 December 2011, we arrived Ke Yi Village and began to invite some villagers to participate in the experiments. Most of them need to work during

daytime, so they were able to come after dinner around 8:00 pm. The experiments were conducted inside a local restaurant which houses a stage where performances usually take place to visitors and guests. A few older women came first followed by many others afterwards with finally a total of 80 to 100 people. We started the experiments by making an announcement informing villagers that boxes of audio CD which feature the original recordings of AXi folk songs and music performed by the villagers were produced and distributed.

A man in his seventy started to try with his Banhu. As he was the first player, so he spent relatively more time adjusting to the system. He played banhu to the microphone, the system analyzed the melody and converted the pitch to midi notes, from analog signal to digital format. The system played the recognized notes and tried to replicate resembling to the original melody. Then it made variation by swapping the position of the notes. It was designed to respond or make echo to the melody the user played like echo singing. The user could interact anytime to the existing performance. If there was no further intervention, the system would make variation further by changing the rhythm pattern, percussion and generating new notes with computer algorithms (i.e. chaotic theory).

Figure 9-2. Experiment with the banhu player

He played a piece then everyone listened to the playback of the melody and the variant version made by the computer. The system can recognize 80% of the melody played by the user, but the sound volume was rather weak with unexpected large

group of people. Other men continued to play flutes and tree leaves, but the result was better with flutes. Afterwards, some people tried to interact with the system with other instruments and played together. Unfortunately, the system was designed to handle one instrument at a time.

Figure 9-3. Experiment with the flute player

After this, they were given a generated piece to listen to and then commented. The piece took reference of one of the folk songs that they are familiar with and it is called "AXi Dancing under the moon". Helpers began to interview people with a given questionnaire. 20 people were being interviewed aged from 28 to 85.

9.6.2. Experiments conducted with the primary school students

We arrived at the primary school of the village around 10:00 am on 8 December 2011. As students beyond primary 4 are required to study outside the village in towns or cities, we can only have primary 4 as the most senior students there. A class with 10 students aged 10 to 12 was invited to the experiments. Each one was seated with a questionnaire dispatched. They looked rather quiet. Helpers began by playing games with them and they were elaborated with the publishing of the audio CD and the details of the experiments. They were given a generated piece to listen to first. They were instructed to fill in part one of the questionnaire that evaluates the generative performance. Most of them were clear about this but they did have some

difficulties in filling the suggestions for future improvement question. Then they were invited to play with the system. They were shy and no one dared to come out first, so we played games with them and the loser had to come out. One student came out but he did not know how to play musical instruments, so we gave him a toy guitar to start with. He looked quite curious about this and played some random notes, but he could not tell if the system was playing back the melody he played or not. The second student did in a similar way but he added some notes that he was familiar with. This time he could tell that the system was playing back his notes and he looked quite satisfied. Followed by a girl who played a flute with a very familiar Chinese Han folk song praising the greatness of mothers. After 5 students had tested it, we invited them to fill in part two of the questionnaire which evaluates the interactive performance.

Figure 9-4. Experiment with the primary school students

Summary

The experiments conducted in this field trip provided valuable sources of data. After the data collection process, analysis took place to look into a number of areas of interest. Data was summarized and categorized to generate results to be presented in the results chapter.

Part 5 System Design and Implementation

Chapter 10

10. System Design and Implementation

Todd Winkler had listed in his book the common components in designing and developing an interactive composing system. He identified the following five major processes analogous to a music performance when listening, interpreting, composing and performing are required. (Winkler, 1998)

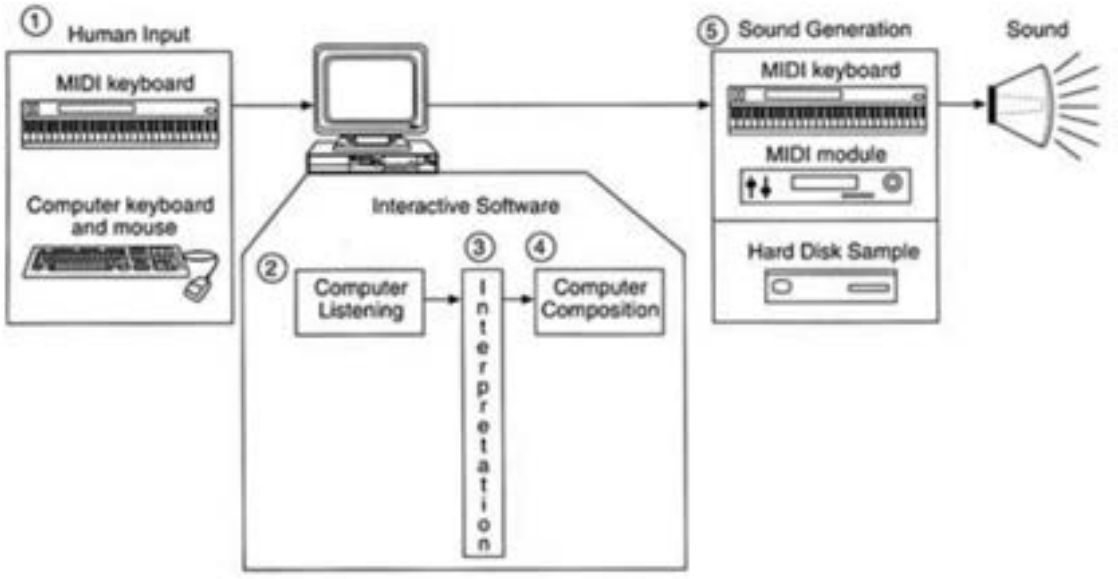

Figure 10-1. Basic components of an interactive composition

1. Human input, instruments – The computer receives from human players the input which will be converted to digital format.

2. Computer listening, performance analysis – The computer receives and analyze the performance information such as pitch, timing, rhythm and other particulars.

3. Interpretation – The system interprets the listened information and generates data useful for composition and performance.

4. Computer composition – Based on the interpreted data, the computer system generates music using a variety of methods.

5. Sound generation and output, performance – The computer plays the music and sends the sound to the output device.

This model is rather conventional when midi keyboard, computer keyboard and mouse were pictured as the input devices as nowadays there are already tons of choices of interactive devices and methods. For computer listening, techniques for capturing and analyzing inputs are sophisticated enough making analogy of human listening. Winkler agreed that the first two steps are very practical and limited while the last three steps are artistic decisions limited by a composer's skill and imagination.

10.1.Proposed System Design

The proposed design of the system comprises all the major components suggested by Winkler. The human players use real musical instruments to interact with the system; the system listens and analyzes the music played; it interprets and generates parameters influencing the composition process; a variety of generative methods are being used to compose the music and finally the music is played and sent to the output system.

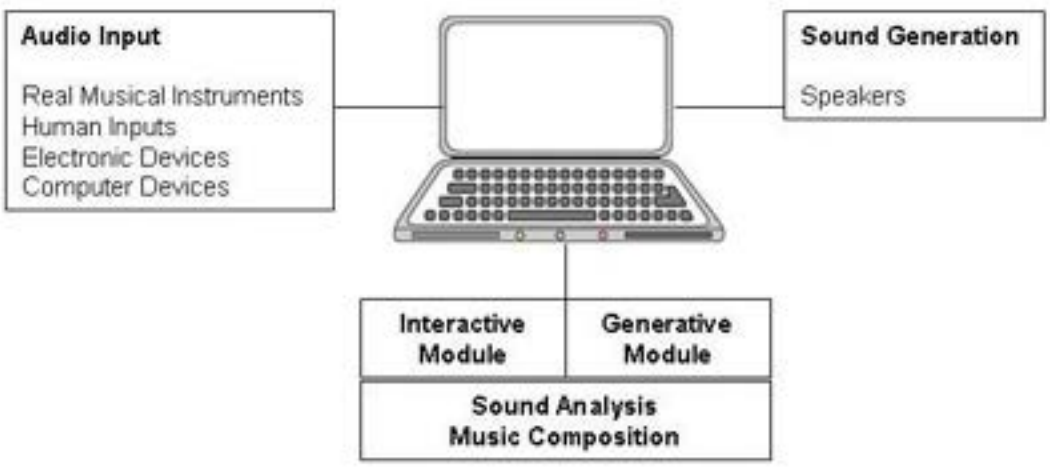

Figure 10-2. Proposed system design components

However, it differs by shedding light on the pulling forces towards either interaction or generation when solving the issues of designing and developing an interactive music performance system. This design also follows the conceptual models presented in the Proposed Theoretical Framework chapter. The proposed design models can provide an adaptive and configurable solution in designing systems to be either interactive intensive, generative intensive or adjustable intensity.

10.2.System Architecture

The system comprises of interactive and generative modules that can be controlled by the users through interaction. Users can decide when to interact and the system is adjustable to determine which module will come into play. It is developed with Max/MSP which provides an interactive and graphical programming environment for multimedia applications.

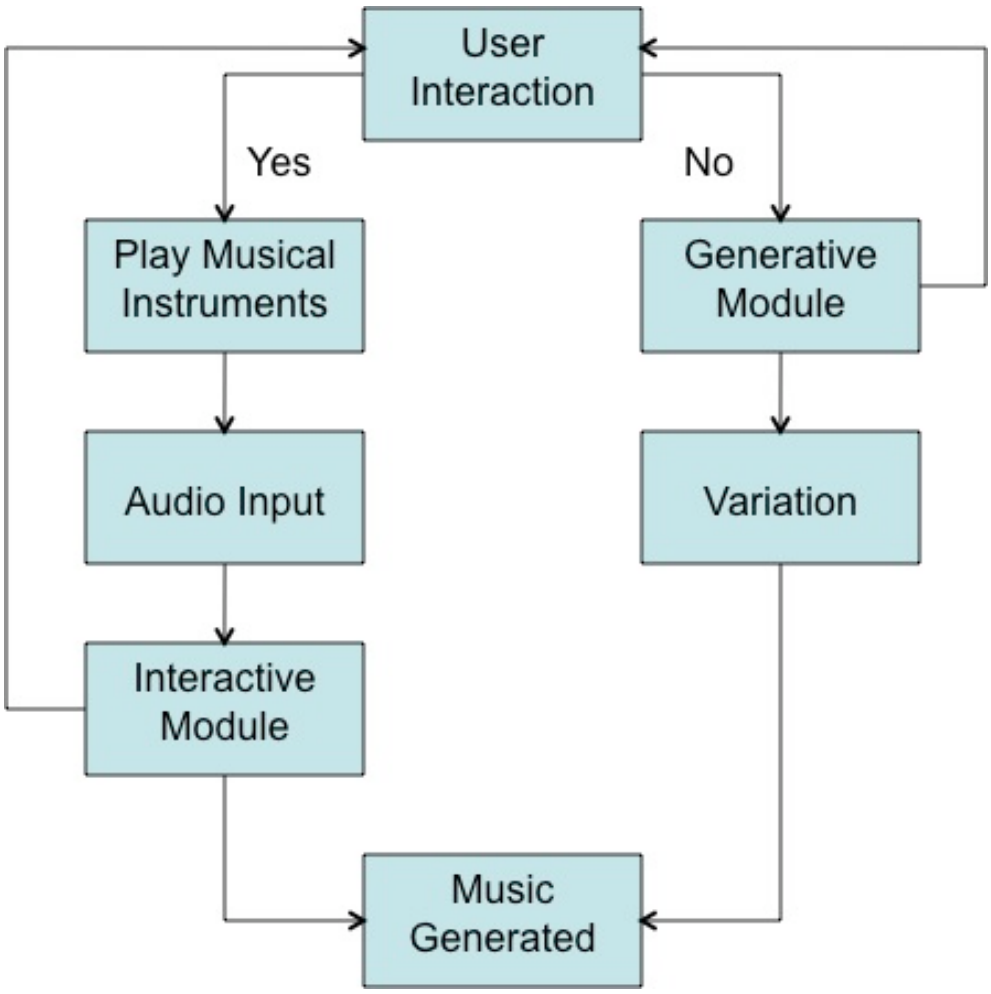

Figure 10-3. System Overview Flowchart

The system can check if there are any interactive activities from the user. Interactive module will start immediately if user interaction is detected. The user plays with a musical instrument to input some melodies to the system. Music is generated as the output. The system keeps checking if there are any continuous interactions. If no user interaction is detected, the generative module will be initialized. Music will be generated and the variation sub-module will start to make variations to the music composed. In this mode, the system is able to keep track of any new interactive activities and the flow is iterated.

10.3.Generative Module

Within the generative module, there are four major components or sub-modules: Melody generation, rhythm control, music accompaniment and percussion generation.

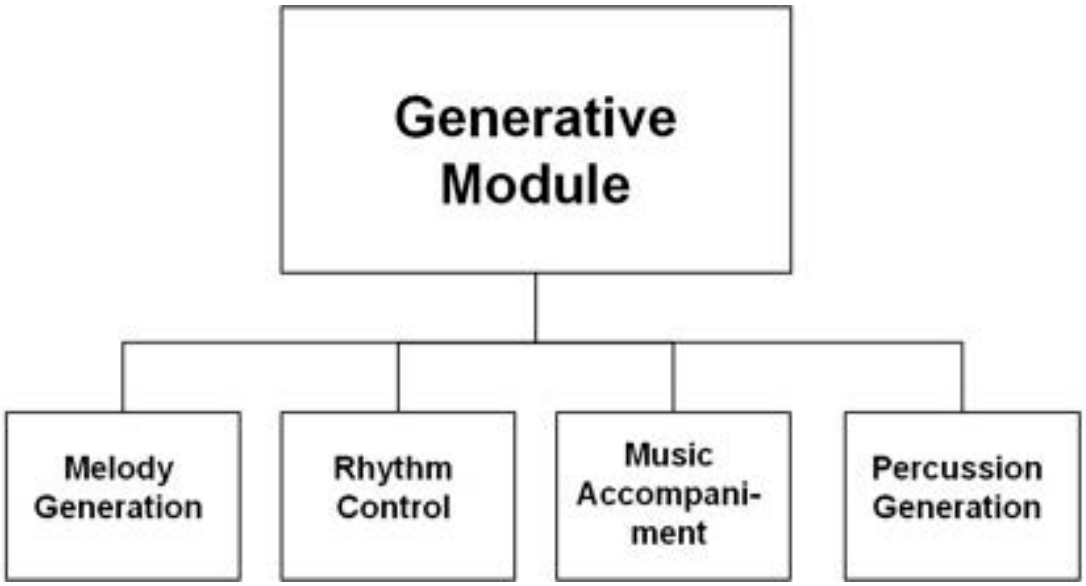

Figure 10-4. Generative Module System Structure

Within the generative module, each of the four sub-modules works together to compose a complete piece of music. There are some preset patterns in the rhythm control and percussion generation sub-modules. The melodies are composed based on the rhythmic patterns selected. The music accompaniment follows the melodies generated. Percussion generation sub-module joins the composition process to make the music piece complete.

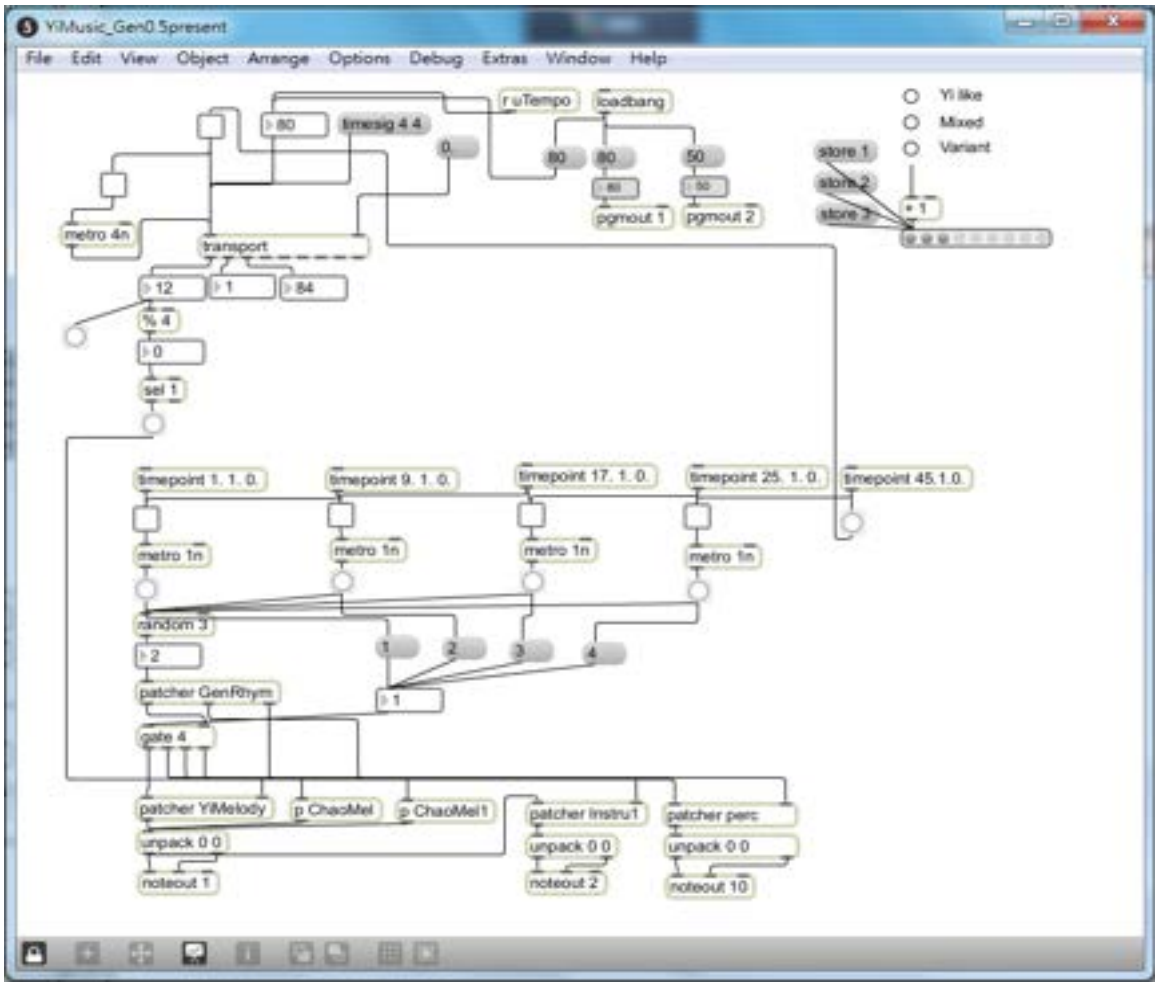

Figure 10-5. Interface of Generative Module

Figure 10-5 shows the system diagram of the generative module. It includes the timing control central to the music generation. A metro will be turned on to trigger and count music beats according to the tempo determined. The "time point" function calls changes to the melody or the rhythm pattern when it reaches the specified music bar. It connects to the sub modules of melody generation, rhythm control, accompaniment and percussion.

10.3.1. Melody Generation:

It generates melodies using two methods. Markov Chain is used to generate melodies familiar with a number of songs chosen as examples by creating tables storing the

probability of notes occurrence. Chaotic theory is used to create another set of melodies with a given initial number to yield unpredictable results.

A song “Axi dancing under the moon” which is representative of the Axi people of Yi minority of Yunnan province was chosen as the example (Figure 10-6). The second song chosen was one of their wine songs sung during wine toasting.

“阿細跳月” / “Axi dancing under the moon”

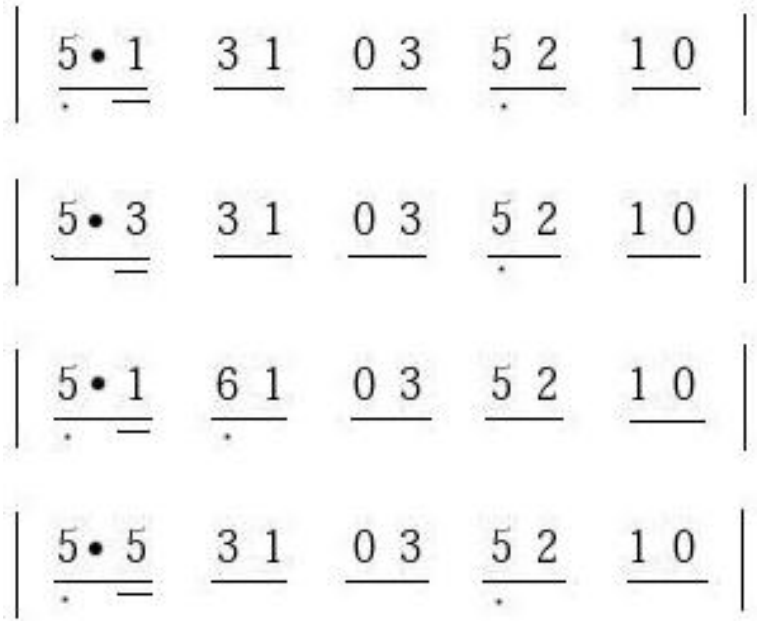

Figure 10-6. “Axi dancing under the moon”, “阿細跳月”

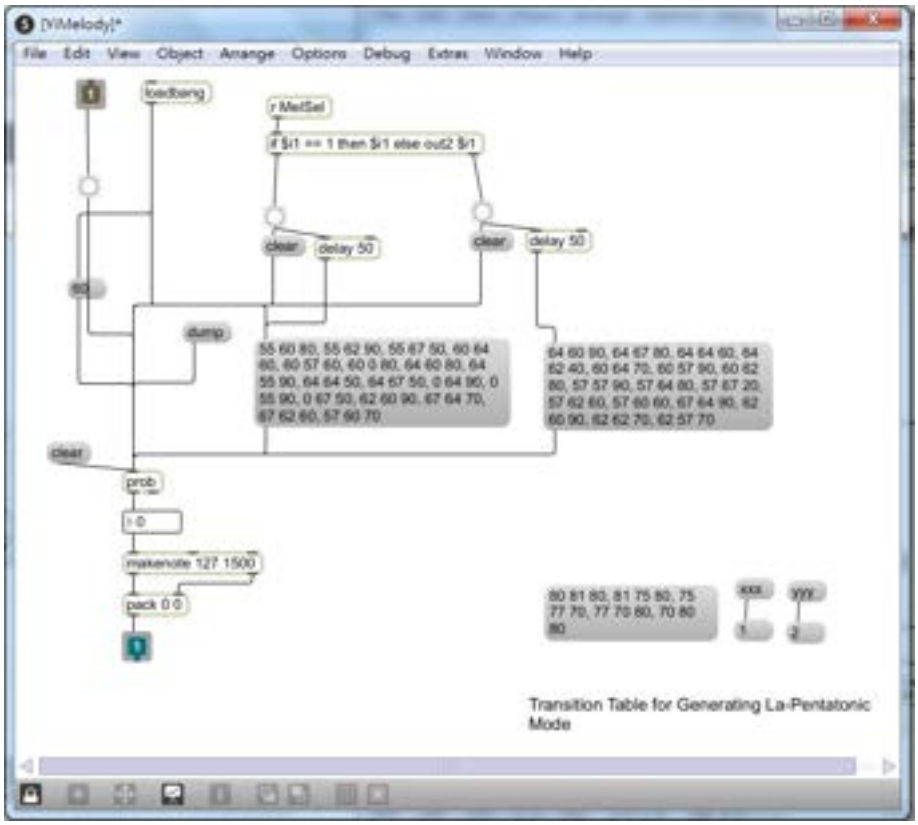

Figure 10-7. Melody generation module

This module can generate music notes or a melody by an algorithm called "Markov chain". From figure 10-7, there are two Markov tables. A Yi song called "AXi dancing under the moon" was studied to generate probability tables showing the probability of a music note following the previous note. For example, 60 62 80 means that the probability of midi note 62 following 60 is 80%. The first table is used to generate first half of the song while the second table can generate the second part.

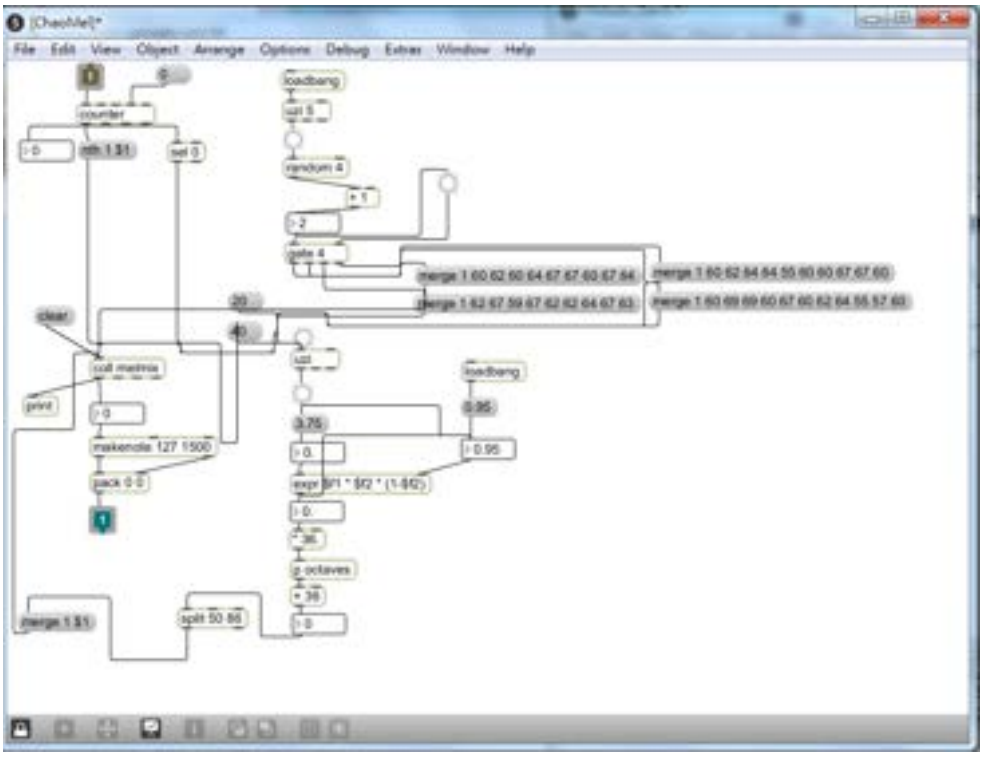

Figure 10-8. Melody generation by chaotic algorithm

Chaotic algorithm is used to generate additional notes which are significantly different from the reference songs. It creates a music piece with a mixture of familiar and unfamiliar, rather undetermined melodies. The formula being used was Logistic Map from Chaotic theory.

$Xn+1 = \lambda * Xn * (1 - n)$

$(0 < \lambda <= 4)$

10.3.2. Rhythm Control:

This sub-module controls how long each note will sustain. A number of beat patterns are stored and three types of the patterns will be selected randomly when the system starts. The notes generated are based on these three selected rhythmic patterns. The user is allowed to alter the beat patterns given by clicking on the grid bar as shown in figure 10-9.

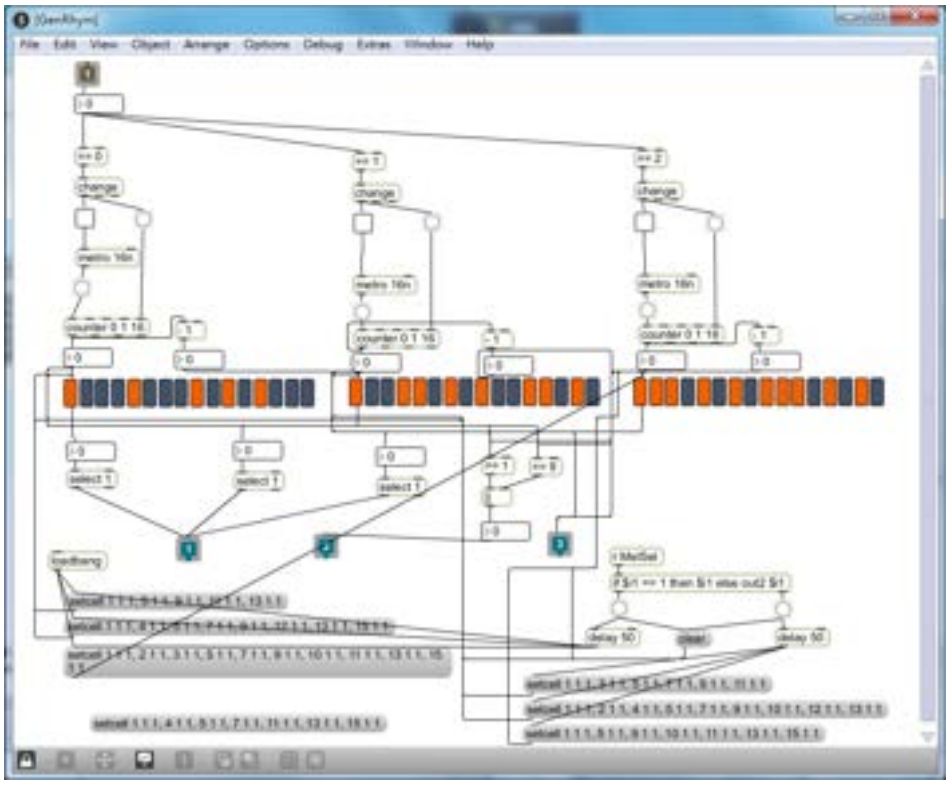

Figure 10-9. Rhythm control module

In figure 10-10 below, there are 16 buttons on the grid bar. In 4/4 beat, there are 16 sixteenth(16th) notes. Each button represents one 16th note duration, 2 buttons represent one eighth(8th) note duration and 4 buttons represent one quarter(4th) note duration. Take figure 10-10 as an example, when music time starts from left to right, the hit of the first button generates one note. After one 16th note time, another note is generated when the third button is hit. This gives 8th note duration to the first note generated.

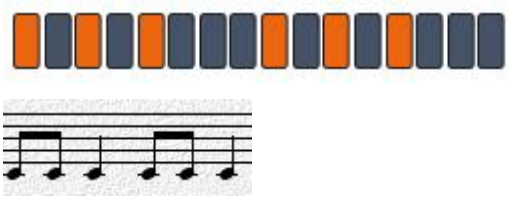

Figure 10-10. Beat pattern 1

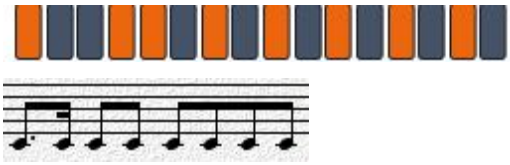

Figure 10-11. Beat pattern 2

10.3.3. Music Accompaniment:

Another musical instrument will accompany the main melody while it is being generated. The user can select the type of instrument and the accompanied notes will appear in chords or in fifth to the melody notes. The design of "Hulusi", one of the ethnic musical instruments of Yunnan was taken as a reference because it can generate accompanied note in fifth or seventh to the note being played.

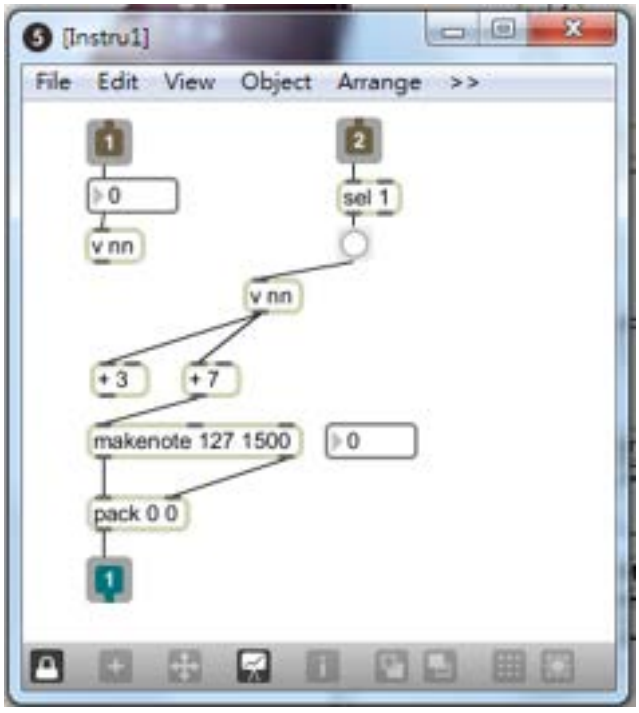

Figure 10-12. Accompaniment sub-module

10.3.4. Percussion Generation:

A number of percussive instruments are available by default and can be changed by the user simply by clicking on the matrix denoting the type of instrument and its

pattern. Each instrument comes with its own rhythmic pattern and different combinations of the percussive instruments form the overall portion of the percussion. These combinations will be changed after certain period of time randomly by the system as the music varies

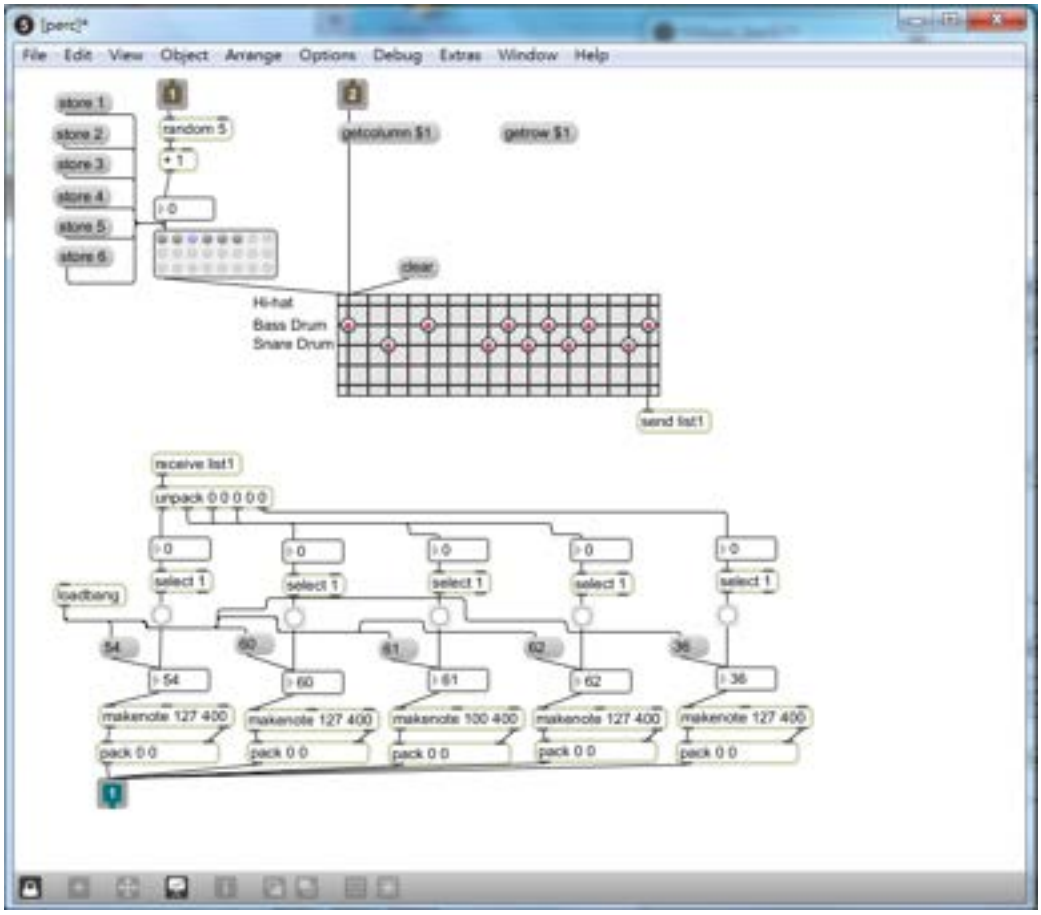

Figure 10-13. Percussion generation module

10.3.5. Screen Interface of Generative Module

Figure 10-14 shows the major patchers or modules of the generative module developed by Max/MSP.

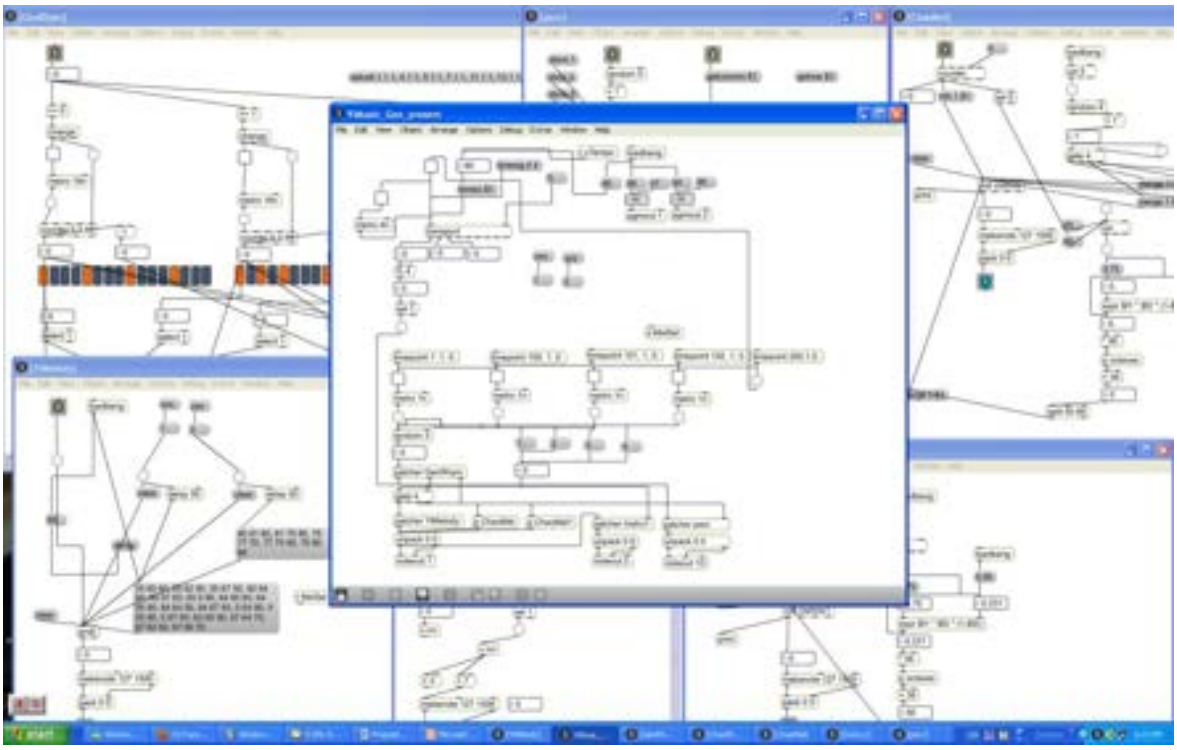

Figure 10-14. Screen interface of generative module developed with Max/MSP

10.4.Interactive Module

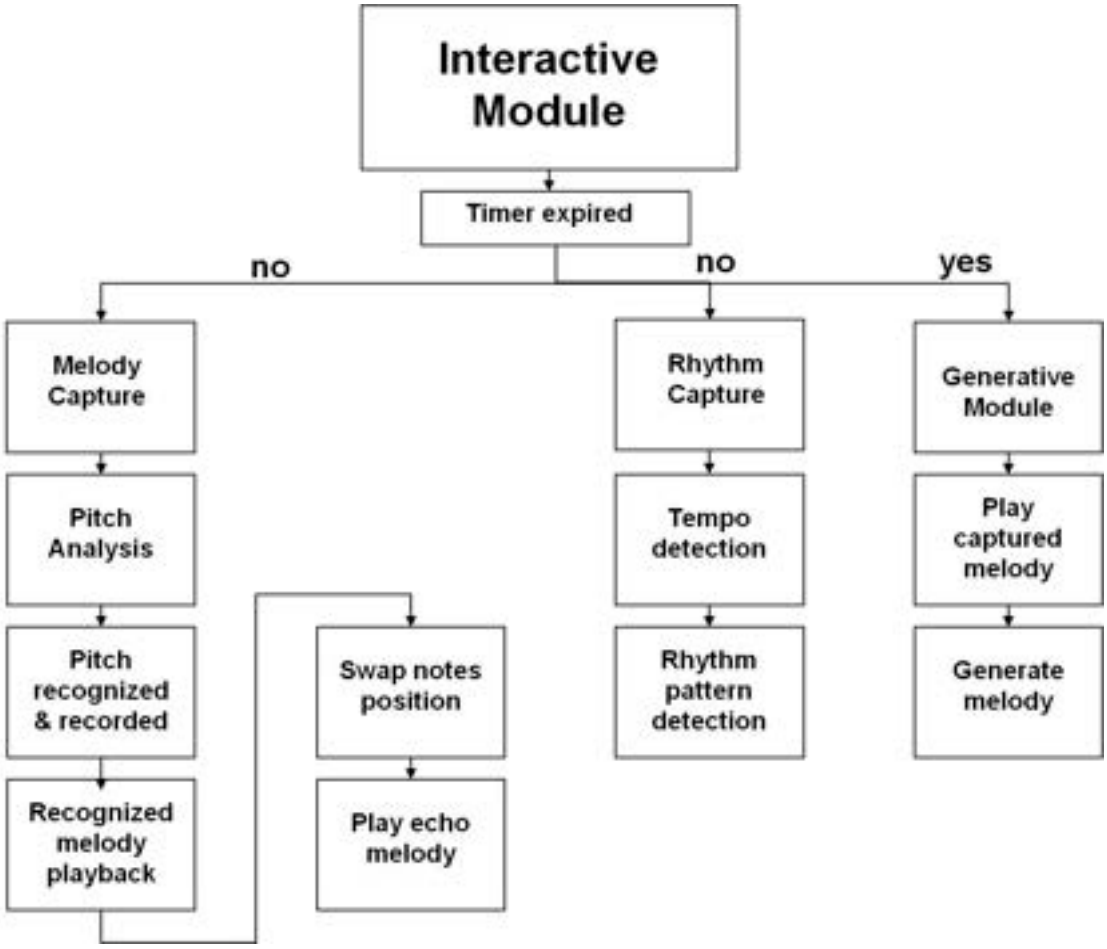

Figure 10-15. Interactive Module System Structure

The major tasks of the Interactive Module are to analyze and capture the melody and beat pattern performed by the user. It will interact with the user first, but will trigger generative module if there is no further human intervention within a given configured time limit or when the timer expires. In order to interact with the system, users do not need any extra digital controllers. They just use their own musical instruments such as flute, erhu, etc..

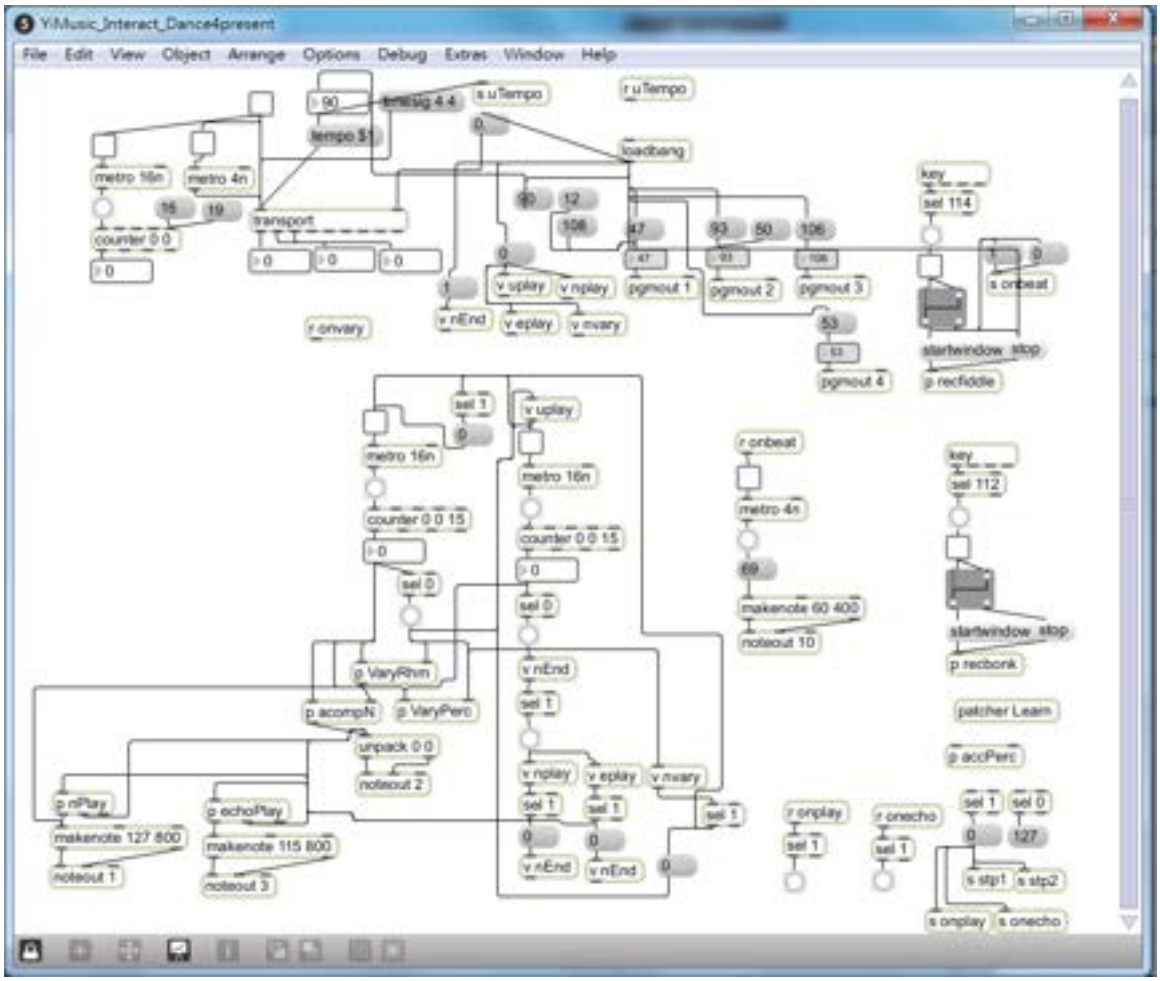

Figure 10-16. Main interface of interactive module

This interactive module also features a central timing control of the beats and tempo. It includes major components to analyze pitches, detect tempo and rhythmic patterns. It will then perform interactively with the user and generate variations when necessary.

10.4.1. Melody Capture:

In order to capture the melody played by the user, there must be a function to analyze the pitch. A plug-in called “fiddle~”, developed by Miller Puckette was being used in Max/MSP to analyze the pitch performed by a real instrument and convert it to midi format. After it is successfully recognized, the pitch information will be stored in a internal table with a list of converted midi note numbers. This can be used for further processing by the system for playback and manipulation.

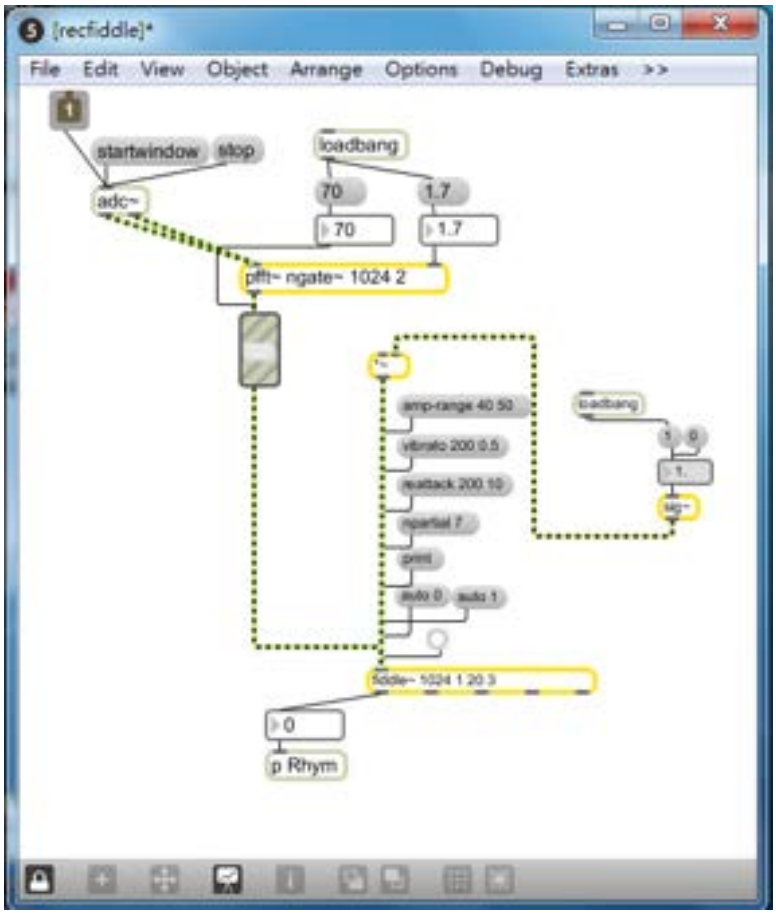

Figure 10-17. Pitch analysis using fiddle~ plug-in

In response to the user, the system makes use of the "Echo singing" method which is a common singing style in Chinese folk songs and ethnic songs. Usually, a woman and a man sing in response to each other, sometimes it looks like questions and answers. First of all, the system plays back the midi notes converted and stored. Then, it makes variation by swapping the notes stored in the table. Rhythm remains the same while some notes are interchanged. The system keeps playing the original melody and the echoed one a few times. Bass melody is changed when the user interacts again by playing a new melody.

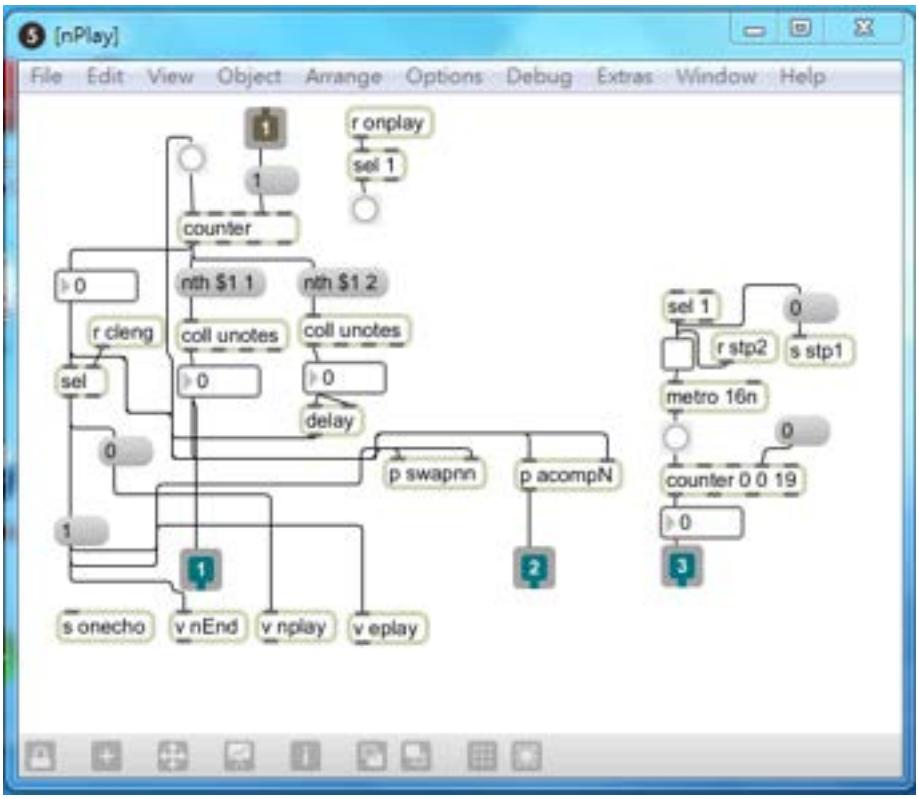

Figure 10-18. Sub-module to playback melody played by the user

This sub-module plays back the melody that the user plays and at the same time swaps the position of these notes and places them into a new table for echo playing.

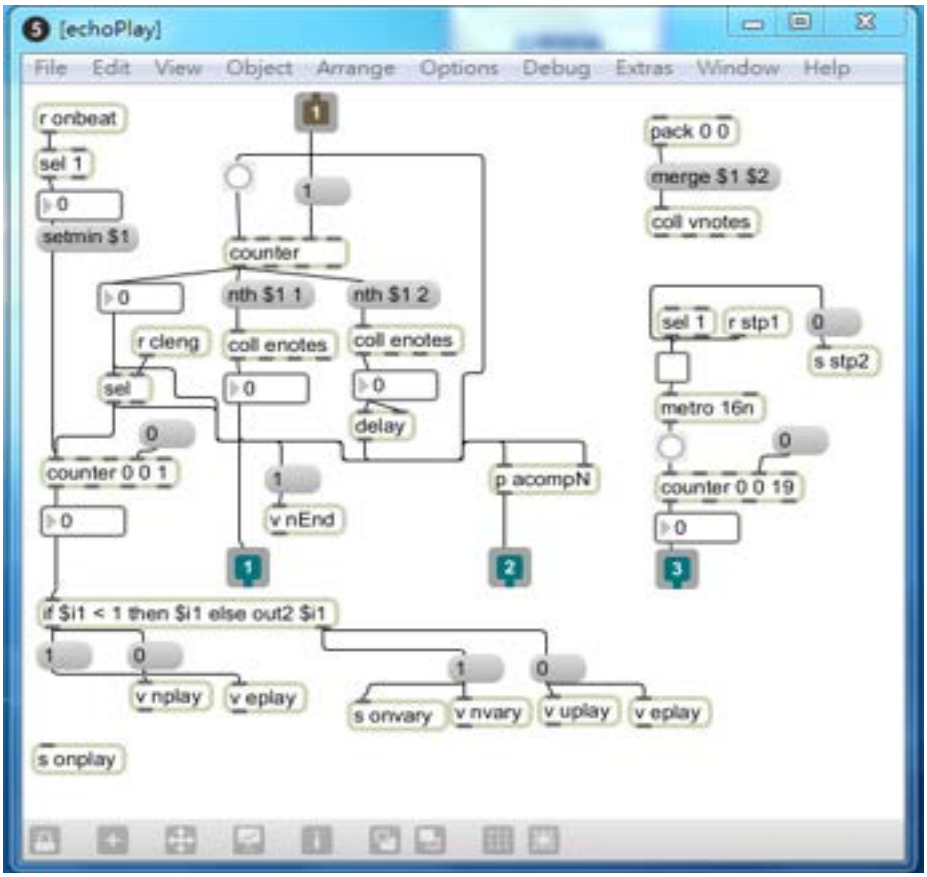

Figure 10-19. Sub-module to play echoed melody

This sub-module plays the swapped notes stored in the table as an echo or response to the melody that the user played. This process repeats when the user inputs new melodies.

10.4.2. Rhythm Capture:

There are two parts in the rhythm capture: tempo and rhythm pattern detection. An external plug-in called “bonk~” was being used in Max/MSP to detect beats performed by the user. The average beat duration detected can determine the beats per minute and the tempo. The beats detected in varied time duration can determine the rhythm pattern as required by the user.

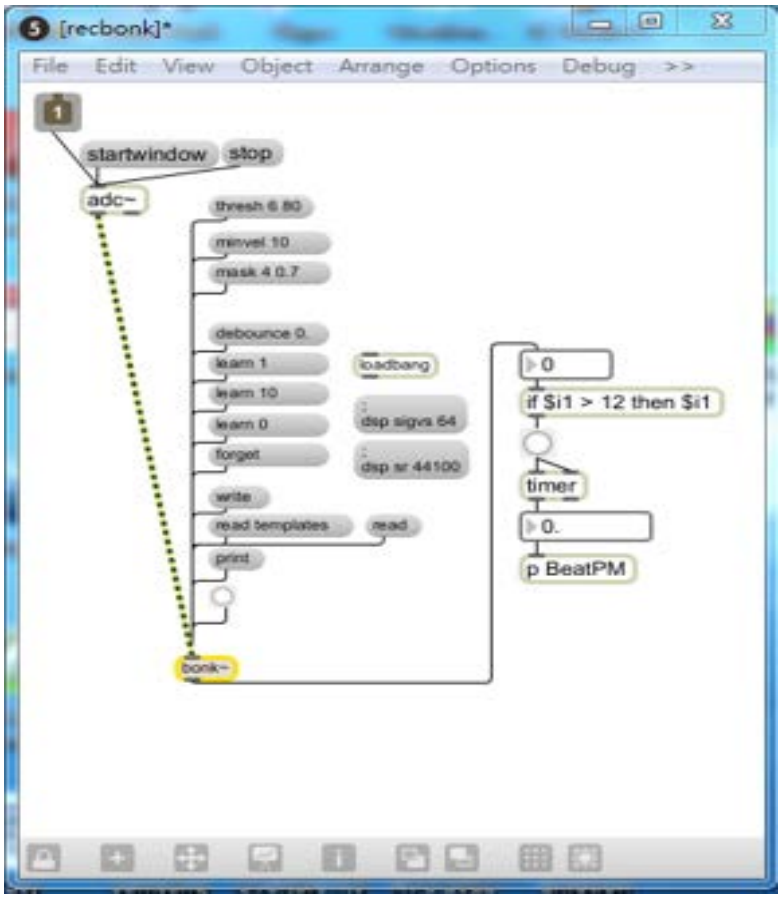

Figure 10-20. Sub-module to detect beat attack

This sub-module detects any attacks as beats carried out by the user. It connects to another sub-module to determine beats per minute and rhythmic patterns as indicated by the figure 10-21 below.

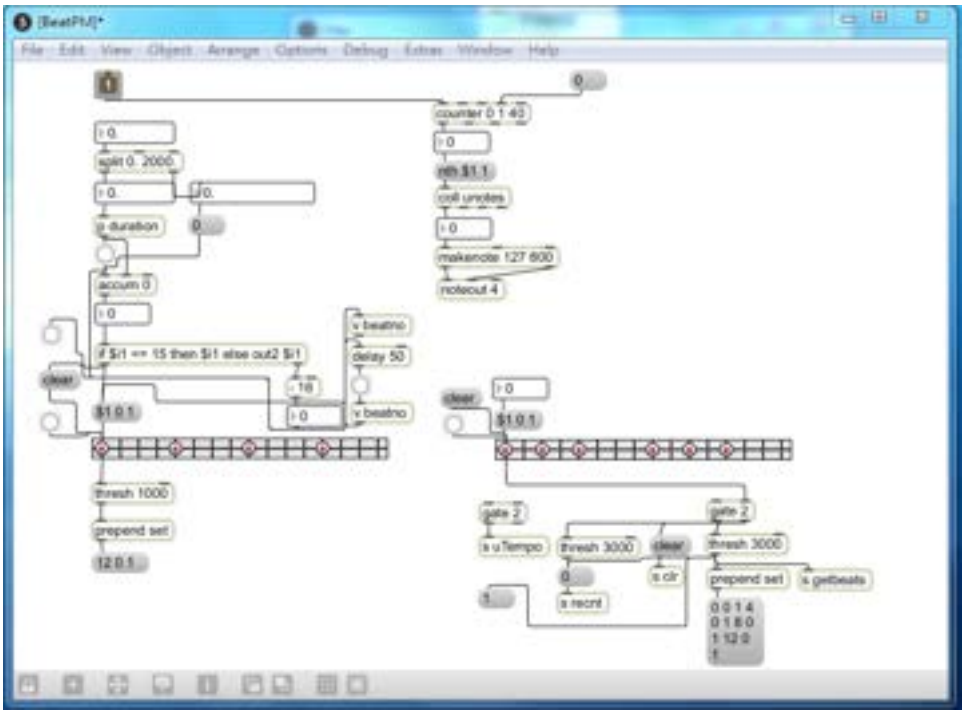

Figure 10-21. Sub-module to detect rhythmic patterns

10.4.3. Generative Mode:

If no further human interaction in a specified time limit, the system will turn on the generative mode to generate some varied music. This mode, however will use the notes captured from the user to make further variation by changing the notes position, duration and rhythmic patterns. It will also introduce new melodies generated by the algorithm.

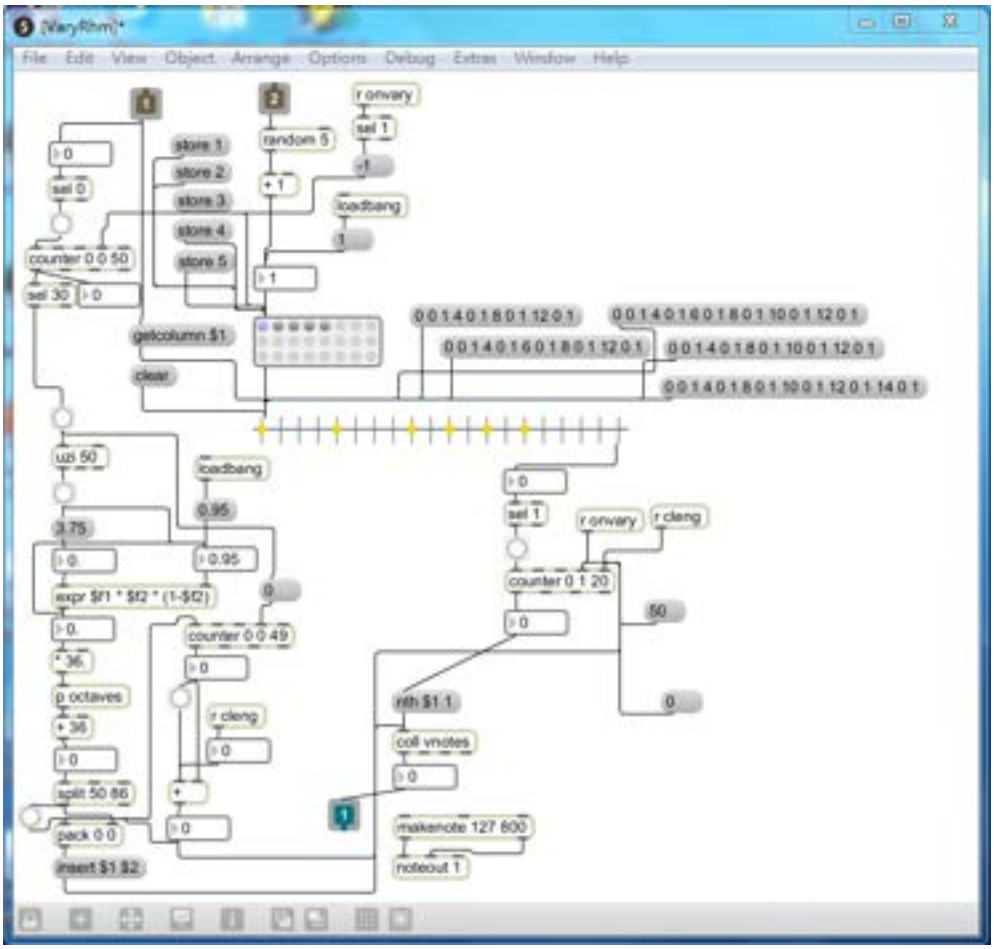

Figure 10-22. Music variation sub-module

This sub-module takes place when varying the music is needed if there is no further user intervention. It is mainly responsible for varying the music performance.

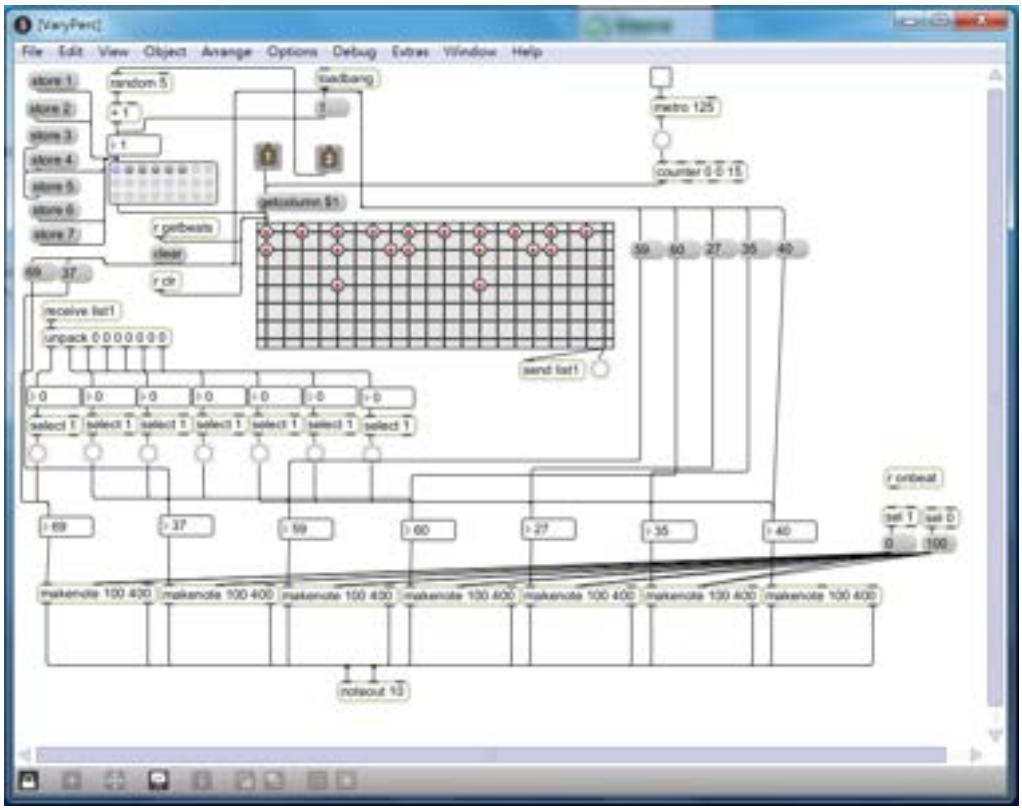

Figure 10-23. Percussion variation sub-module

This sub-module features more than five percussive instruments and different combinations of pattern are stored as presets. They are available and randomly chosen when the system goes into the generative mode that variation is needed as for the percussion.

10.4.4. Screen Interface of Interactive Module

Screen interface of the Interactive Module with major patchers developed by Max/MSP.

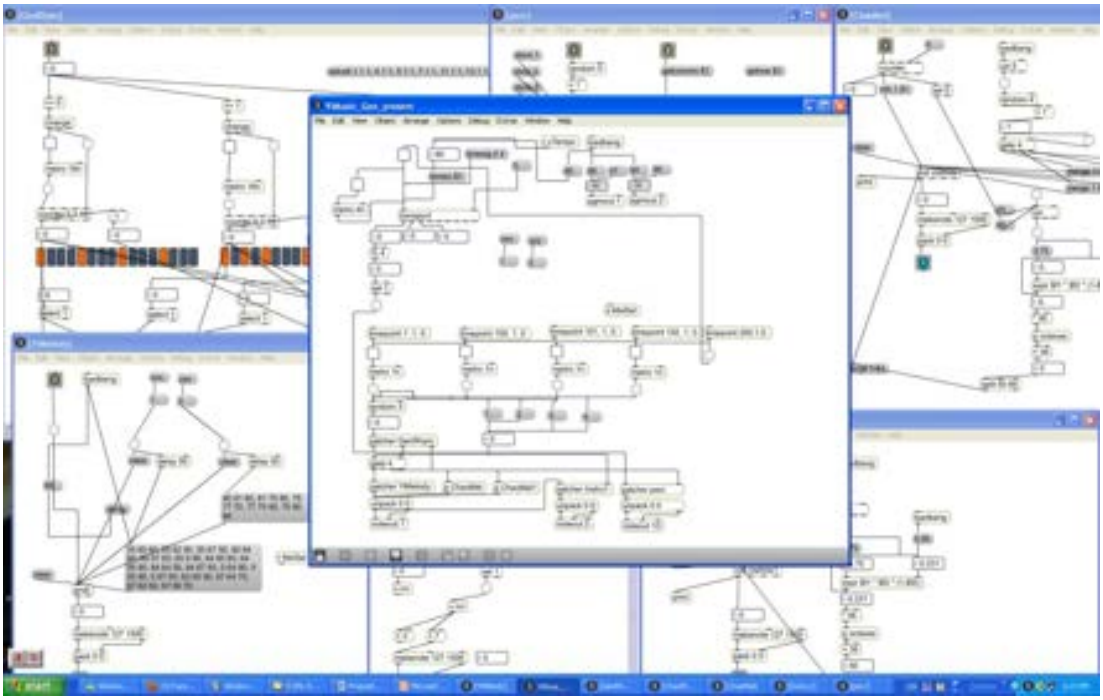

Figure 10-24. Screen interface of interactive module developed with Max/MSP

Summary

This chapter showed the major modules of the system based on the design models proposed. All sub-modules of the interactive and generative modules were displayed to demonstrate the relevant features. They were responsible to create interactive and generative performances to be played by the participants during the experiments. They were regarded as the initial phase of the development cycle.

Part 6 Results & Conclusions

Chapter 11

11. Results

The results chapter analyzes the data collected from the experiments and interviews conducted in the Ke Yi Village in Yunnan Province. The experiments were divided into generative and interactive performances. Participants were encouraged to interact with the system and listen to the music pieces produced. The resulting data was summarized and presented in table and chart format. Open-ended comments or feedback were categorized to yield meaningful data and implications. Comparisons were also made between different age groups in different performances in the experiments conducted.

The adaptive design of the conceptual models proposed in Chapter 5 attempts to address the issues towards designing interactive music performance systems. In view of the problems identified with the designs of highly interactive and generative musical systems, the proposed models provide a continuum to adjust the relative intensity of either interactive or generative orientation. Thus they can be adjusted from highly generative or interactive in nature to a balance between the two. The prototyped systems were developed based on the design models. The experiments were divided into generative and interactive performances. The participants can experience both performances and try to adjust the level of interaction. If the level of interaction is lowered, the system's generative capability will come into play. This leads to a collaborative mode of interactions.

11.1. Areas to analyze

Generative performance was presented first in the experiments, followed by the interactive performance. The analysis of the data looked into each of the performance and proceeded to the comparison between the two.

11.1.1. Generative and interactive performances

For the generative performance, participants need to listen to it and then comment. As this performance makes reference of one of their folk songs, it will make sense to know if they can recognize the song. For the interactive performance, it will be interesting to learn their immediate responses and experiences as for all of them, it can be the first encounter.

For both performances, the participants need to briefly describe them and make comment on the quality respectively. Future comments are significant if continuous enhancements are needed. However, inquiry about collaboration with the computer system is necessary for interactive performance as this module allows users to interact and collaborate.

11.1.2. Comparison between generative and interactive performances

In the generative performance, the participants needed to listen and familiarize with the music generated by the system. The interactive performance, however, required them to play with their own musical instruments. Comparisons were made between the two performances in the areas of interestingness and interactivity in a rating scale. Summarized data will be presented in the sections below.

11.1.3. Interactive experience

In response to the experiments design, interactivity is one of the key areas to investigate. Interactive features are incorporated so that users can interact with the system through transferring musical elements such as melodies or rhythmic patterns. Exchange of musical knowledge is possible in this manner. Thus, during data analysis, interactivity is still one of the key categories. Although Yi music is highly interactive, participants in the village never interact with a computer system. It is interesting to know their first experiences and discover any issues during the interaction.

11.1.4. Impression

Participants were asked about the general impression towards the performances. They provided brief descriptions, both negative and positive. This showed some hints about their attitude to these brand new performances.

11.1.5. Originality

Although some ethnic elements were incorporated into the systems, some participants thought they were not enough. They preferred there would be more ethnic elements such as close resemblance to their songs, beats so that they could dance and feel cheerful.

11.1.6. Collaboration

Collaboration here, refers to the state of interaction when users and the system can participate in the creative process. This is very different to the Axi people's way of making music or collaboration. They collaborate for the sake of social communication. This area helps explore issues regarding collaboration with a computer system.

11.1.7. Quality

Comments on the quality of the performances were gathered with levels of goodness and badness being indicated. This helps understand participants' preferences showing the potential to enhance user experiences.

11.1.8. Interestingness

With regard to the objective to enhance user experiences and engagement of the system, interactive and generative techniques are incorporated. Interactive experiences can be enhanced by generative capability of the system while generative systems can be augmented by interactive capability with the intent to enhance the engagement of the system. Thus, we look into the areas of interestingness of the performances.

11.2.Experiments with Interactive and Generative Performances

11.2.1. Adult Villagers Group

The experiments started when all the villagers invited arrived at the venue. Some of them carried with their own musical instruments, so the interactive system module was initiated first. Those who can play instruments were invited to interact with the system with their instruments. The first player performed with his banhu, followed by flute, tree leave and sanxian players. Other villagers including those who were responsible for singing and dancing were the observers of the experiments. Because of the time limit, villagers were interviewed individually with a questionnaire in the middle of the experiments.

The background information of the adult villagers was grouped according to age ranges and roles or responsibilities they perform in the performance teams to facilitate future discussions. Within the adult group, age ranges from 28 to 85 out of 20 people being interviewed. There is greatest number of people in the age range above 70 while ranges from 30 to 49 are the majority. There are big differences among different age ranges.

Age Range	No. of People
20-29	1
30-39	4
40-49	5
50-59	2
60-69	1
70-	7

Figure 11-1. Age ranges of the adult villagers group

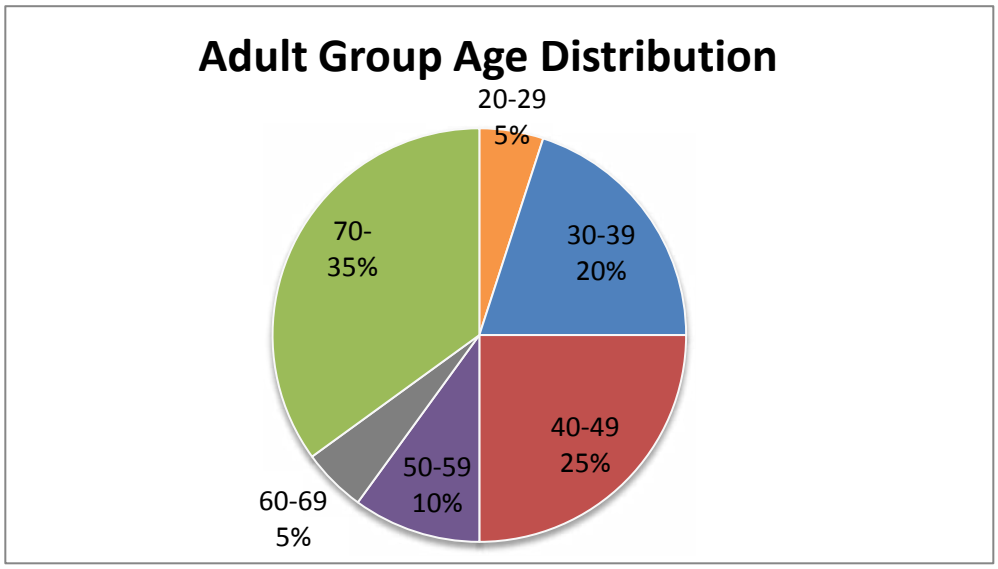

Figure 11-2. Adult group age distribution

Most of the people being interviewed, up to 60%, are members of the dance team. Some of them are dancers and singers while a few of them are musicians playing ethnic musical instruments. The team is responsible for stage performances to tourists or visitors and they can earn some income from these performances. Traditionally, their practices of music and dances are inherited generations to generations. They learn from their parents or teachers in the group. In order to attract more tourists, Ke Yi Village is one of the villages developed as an ethnic eco-cultural village. Performances are frequent and there is some modification to the dances in order to suit the interest of the tourists. There is a committee for the elderly to learn, practice and share songs and dances of their custom. They practice for the purposes of entertainment, social needs and performances as well.

Duties	**No of People**
Dance Team	12
Administration	2
Elderly Committee	5
Teacher	1

Figure 11-3. Duties of participants in the adult group

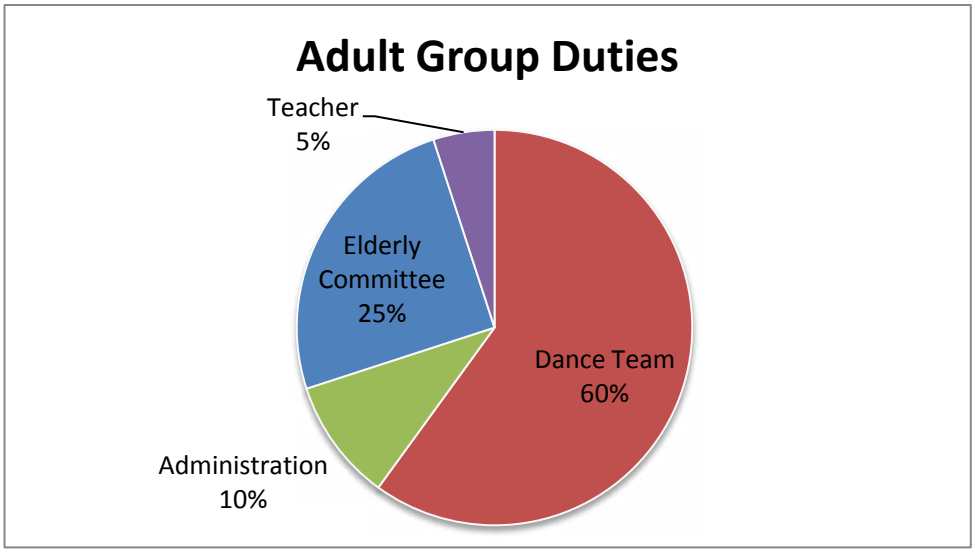

Figure 11-4. Pie chart of the duties of participants in the adult group

They were given an interactive piece to play with first then followed by a pure generative piece. The participants played with their own instruments while the computer captured the sound and analyzed the melody played by the villagers. The system played back the melody with approximately 80% accuracy. It then made variation to the original music notes while keeping the rhythmic patterns. If the villagers interact, the system will keep playing back the original melody followed by variation as an echoed piece. If the villagers stop interacting, the system will make further variations. They were required to play and then listen to the music played by the system. For most people, it was their first time to participate in such experiments and to listen to the music generated by the computer system. Their interactive experiences, feedback, preferences and comments were captured during the interview section. Their responses were then analyzed and categorized.

In the generative performance, they only needed to listen to it. The system generated a music piece familiar to one of their folk songs. It later made some variations to the melody, tempo, rhythmic pattern and percussion. Modification and variation continue until the music sounded unfamiliar and undetermined. Their comments and likeness were recorded.

Interactive Experience:

To all interviewees, it was their first encounter to interact with the system, so their immediate experiences were examined. Out of the 20 responses, 8 reported this was their first experience that they had never heard of. 4 were relatively positive and felt it was interesting, wonderful and meaningful even this was their first encounter while others were relatively neutral. One reported that it was not cheerful.

Originality:

In the experiment of interactive performance, villagers were asked about the first time experience. 5 out of 20 respondents emphasized that it was not original, not ethnic music in the sense that it did not sound like the original music they played. When they were asked about the recommendations, 5 out of 14 comments mentioned that the system should be original to the sound, rhythm and ethnic nature of their music. Some of them requested faster rhythm or singing and these elements can be often found in their songs. In this part, they were invited to play with their own musical instruments to interact with the system. Although they had knowledge of the computer, but they still expected the system can replicate the same of what they played.

In the Generative Performance section, they were asked about the recommendations for improving the generative piece as well. 7 out of 11 commented that the music from the computer system should be familiar to their own music and more ethnic elements were preferred. They preferred music to be familiar so that people can understand, be motivated to dance with the familiar sound and rhythm.

Collaboration

It is a usual practice of the villagers to sing and dance together when they have free time. Most of them think that it is cheerful, playful and affectionate when they sing and dance together. When they were asked about the experience of collaborating with a system, 7 out of 20 responded that they could not understand. Causes may be they were unfamiliar with the music styles and rhythm played by the system and the

quality of sound. There were 4 out of 20 respondents said it was difficult for them to get used to. Also, they could not find the kind of affection usually happened when they sing and dance with the peers.

Impression

The participants were asked about their impression over the performances. Out of 18 responses for the generative performance, 8 described it "Nothing Special" and 6 described it "Strange". Only 2 described it "Exciting" and 1 thought it was "Interesting". The overall impression towards the generative performance was relatively negative. However, for interactive performance, there were 9 out of 20 respondents described it was "Interesting". 5 said it was "Nothing Special" while 6 thought it was "Strange". The majority of people regarded interactive performance to be interesting.

Quality

For generative performance, there were 12 out of 19 respondents thought that it was "General". 4 thought it was "Poor" and 3 regarded it "Good". When compared with the interactive performance, there were 9 out of 20 respondents thought it was "Good". 8 described it "General" and there were only 3 thought it was "Poor". Obviously, there were more people thought that interactive performance was better than the generative performance.

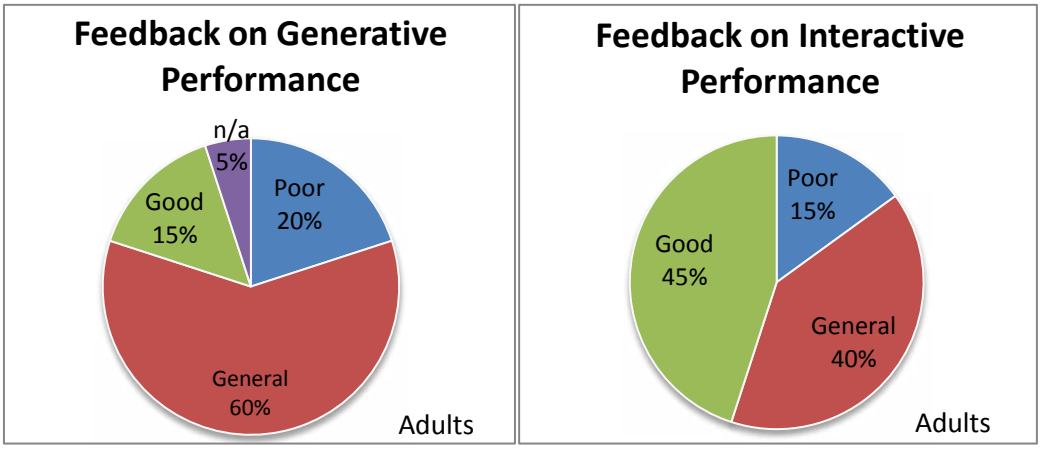

Figure 11-5. Feedback on generative and interactive performances for adult villagers group

Rating of Interestingness

In order to understand in details how interesting the systems were, participants were invited to rate with a scale, from “Very Interesting”, “Interesting”, “General”, “Not Interesting” to “Very Not Interesting”. For the generative performance, there were 7 out of 20 participants rated it “Interesting”. 9 rated it “General” and 4 thought it was “Not Interesting”. For interactive performance, there were 7 out of 20 participants rated it “Interesting”. 8 rated it “General” and 5 regarded it “Not Interesting”. The results between the two performances look similar.

Generative Performance	
Not Interesting	4
General	9
Interesting	7

Figure 11-6. Interestingness of generative performance

Interactive Performance	
Not Interesting	5
General	8
Interesting	7

Figure 11-7. Interestingness of interactive performance

Rating of Interactivity

The level of interactivity was also rated according to a scale, from “Very Interactive”, “Interactive”, “General”, “Not Interactive” to “Very Not Interactive”. This applied only to the interactive performance. Out of 20 participants, 7 rated it “Interactive”. 4 thought it was “General” while 9 rated it “Not Interactive”.

Interactive Performance	
Not Interactive	9
General	4
Interactive	7

Figure 11-8. Interactivity of interactive performance

11.2.2. Primary School Students

The experiments with the primary students were conducted in a classroom with restricted number of students. As students above primary four are required to study in towns or cities, all of the students participated are primary four students aged from 10 to 12. The experiments were also divided into generative and interactive performances and they can interact with the system with or without their own musical instruments.

Interactive Experience:

Unlike the adult group, most of the students do not know how to play musical instruments of their minority group. Some are learning Chinese flute (not the flute of Yi minority) and Han songs. Most of them played with the toy guitar provided to interact with the system. When they were invited to play and asked about their experiences, most of them were very positive towards it. For the interactive performance, they thought it was interesting, playful and cheerful. They looked curious for something that they had never tried before, but they accepted it without

skepticism. Unlike the adult group, none of them require ethnic elements and originality. The reason may be they are not trained with traditional practices and they do not have much knowledge of traditional ethnic music and dances of their group.

Impression:

For the generative performance, out of 10 students, 9 thought it was interesting and only 1 thought it was strange. When compared with the interactive performance, there were only 6 out of 10 students thought it was "interesting". Others regarded it as "Strange" and "Boring".

Quality:

Unlike the adult group, the rating for the generative performance was higher than the interactive one. For the generative performance, there were 8 out of 10 students rated it "Very good" and 2 rated it "Good". However, for the interactive performance, there were 4 out of 10 students rated it "Very good" and 5 rated it "Good". The remaining one thought that it was "general". Both adult and primary student groups were given the same generative piece to listen to. None from the adult group can identify the name of the song, the reference song to the generated piece, "AXi Dancing under the moon" while 2 from the primary student group can name the song. When the generative piece was played to the adult group, the environment was rather noisy and messy with larger group of people from 80 to 100. The volume from the speakers was rather weak in a stage environment and some people sitting further away cannot hear it clearly. In the primary student group, class size was much smaller with only 10 students. It was easier to control the overall process and sound quality with smaller number of people and space. This could be the reason that generative performance was rated higher within the primary student group.

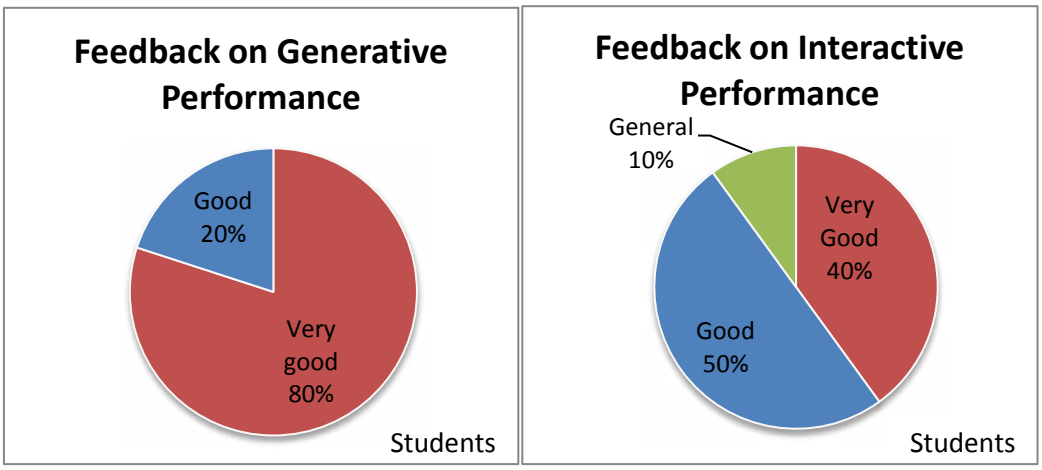

Figure 11-9. Feedback on generative and interactive performances for primary students group

Rating of Interestingness

For the generative performance, there were 7 out of 10 students rated it "Very Interesting". 1 rated it "Interesting", 1 thought it was "General" while only 1 rated it "Not Interesting. For the interactive performance, there were fewer students, only 5 thought it was "Very Interesting". 3 rated it "Interesting", 1 thought it was "General" and 1 rated it "Not Interesting".

Generative Performance	
Very interesting	7
Interesting	1
General	1
Not interesting	1

Figure 11-10. Interestingness of the generative performance

Interactive Performance	
Very interesting	5
Interesting	3
General	1
Not interesting	1

Figure 11-11. Interestingness of the interactive performance

Rating of Interactivity

This applied also only to the interactive performance. There were 5 out of 10 students rated it “Very Interactive”. 3 thought it was “Interactive” while the remaining 2 rated it “General”.

Interactive Performance	
Very interactive	5
Interactive	3
General	2

Figure 11-12. Interactivity of the interactive performance

Summary

Analysis of the data collected took place in a number of areas of concern presented above. This revealed some design issues in relation to interactivity, user experiences and collaboration. The summarized and categorized data yielded interesting implications to be presented in the conclusion chapter.

Chapter 12

12. Conclusions and Future Work

This chapter discusses implications derived from the experiment results and presents the conclusions for this research. It suggests future improvements and any sustainable installations and experiments that can extend the research.

12.1. Research Objectives

This research presents a theoretical framework proposing a configurable and adaptive model to adjust the levels of interaction and generation when the system is interacting with the users. This adaptability not only improves interactivity of the system, but also empowers its generative capability. Given the interactive and generative forces in operation, a number of objectives were formulated:

- Improving interactivity and enabling exchange of musical knowledge between the system and the users who interact with it;
- Enhancing user experiences and extending engagement of the system to a deeper cognitive and creative level by incorporation of generative and interactive techniques;
- Enabling collaboration between the system and the human performers in the creative process.

Given these objectives, design models were constructed and a number of system prototypes were developed for conducting experiments in the Ki Ye Village of Yunnan Province. In addressing the objectives, discussions centered on a number of areas: interactivity issues with regard to exchange of musical knowledge when users are interacting with the system, enhancing user experiences with the incorporation of interactive and generative techniques and collaboration with a computer system in the

creative process. Valuable insights or implications can be drawn upon to nourish the research leading to future development and advancement.

12.2.Addressing the research objectives

12.2.1.Improving interactivity and enabling exchange of musical knowledge between the system and the users who interact with it

In view of the problems identified with the designs of highly generative and interactive systems. The proposition of the theoretical framework suggests a mechanism to adjust the levels of generation and interaction. It adds on generative capability to interactive systems while at the same time, brings in interactive functions to generative systems. Users can transfer musical elements to the system through interaction while the system can generate musical output in return to join the creative process. Given such infrastructure, exchange of musical knowledge between users and the system is feasible. Interactivity is crucial in this case. It is not dealing with issues concerning technology, user controls or the capability of the interfaces. It tries to make sure that both users and the system can actively interact in the process and be responsive enough to each other.

By all means, interactive features are necessary in order to activate exchange of musical knowledge between users and the system. Otherwise, it would be a purely recorded or generative music for the users or audience to listen to. In the experiment of interactive performance, users played with their own musical instruments to have melodies inputted into the system and let the system replicate and make variations. Although the system cannot recognize all of their instruments, it worked well with string and wind instruments which played distinctive melodies with about 80% accuracy. Under this condition, users agreed that they could get their melodies replicated by the system. Users could interact anytime they wanted. “Echo singing” was featured to let the system generate echoed melody in response to the melody the user played. It sounded like a conversation between people in the way of singing.

Echo singing is very popular in Chinese folk songs especially for the couples to communicate with each other. In this way, not only the system can respond to what it heard, but the user can adjust as well to what the system generated.

However, research results revealed different views on the interactivity of the system being tested in the experiments. In the adult villagers group, more people thought that the interactive module was not interactive (9 out of 20 rated it not interactive while only 7 thought it was interactive). However, in the primary student group, most of them thought that the interactive module was interactive (5 out 10 rated it very interactive and 3 thought it was interactive). This revealed that there was different perception on what is regarded as "interactive". Adult villagers believed that an interactive experience should be cheerful, affectionate and it can communicate with other people. On the other hand, primary students thought that a computer was interactive, so a system built on it was interactive. They could give instructions to the computer and it could provide some responses.

Due to the limited time for the experiments, it cannot afford enough time to test other interactive features such as changing the tempo, volume or variations. This limited the interactive features that can be tested. Furthermore, training before the experiments cannot be organized and users can only learn and try 1 or 2 times in order to make the system operate and respond. This affected the experiences of the people who were testing it and thus the results. However, it did put forth some progress to enable users to interact with the system and have their music elements transferred to it which as a result made responses to the users.

Rowe stated that most of interactive music systems seldom learn when he was discussing the incremental improvement needed for such systems.

> *"A remarkable property of most interactive music systems implemented to date is that they do not learn. They are endowed by their programmers with certain methods for generating music and (perhaps) analyzing the music*

with which they play. Once the program appears onstage, or even in the rehearsal hall, it has largely reached a level of performance that will change little until the concert is over." (Rowe, 1996)

In this research, the generative and interactive framework paves the way for exchange of musical knowledge when users and the system can learn from each other. The prototyped systems being developed offers opportunities for such exchange when users are experimenting with the systems.

12.2.2. Enhancing user experiences and extending engagement of the system to a deeper cognitive and creative level by incorporation of generative and interactive techniques

The system was designed with an adaptive configuration by incorporating both generative and interactive techniques. If the user interacts more with the system, it will be interactive intensive. Otherwise, the system's generative capability will take over. It will be generative intensive and will continue to make variations if no further human intervention is detected after a certain period of time. With this design, interactive experiences can be enhanced and enriched by the creative features empowered by the generative capability. At the same time, generative systems can be augmented by the interactive capability with the intent to enhance the engagement of the system.

From the experiments taken in the Ke Yi Village with the groups of adult villagers and the primary school students, they had different inclinations. In the adult group, there was more people preferred interactive performance while the primary students preferred generative performance. In the adult group, there were 30% people thought that the interactive performance was good. On the other hand, there were 40% students in the primary students group thought that the generative performance was very good. Also, there were more people of the adult group regarded interactive performance to be interesting while primary students thought that generative

performance was more interesting. This could be explained by the fact that most of the adult villagers are performers in the dance team and they know how to play musical instruments. They would be more interested in the interactive module. On the contrary, most of the primary students do not know how to play musical instruments, even those instruments from their own minority group. Thus, they may not sound very interested in the interactive module, but prefer the generative one instead. They were fascinated by the way the computer made music. In fact, the system was adopting the adaptive design to suit users' needs and the users can determine its orientation based on their preferences. Those who play musical instruments are more likely to interact more while some may prefer to listen more and let the system to be self-generative.

The system however, offers additional options. Those who prefer interactive experiences can explore greater creative potential of the generative capability. Those who prefer generative performance can have their experiences enhanced by the capability to interact.

Engagement can be enhanced by attractiveness on one hand, and by offering adaptive choices and extending the experiences of making and enjoying music on the other hand.

12.2.3. Enabling collaboration between the system and the human performers in the creative process

Collaboration requires a joint effort contributed by the people who work together. In this research, collaboration means a joint contribution devoted by human players and the computer system. For it to work well, both parties should actively participate and contribute with their knowledge and effort. Interactivity in this case is crucial and it opens onto collaboration. The design models proposed take this into consideration and suggest a collaborative mode that there is a near balanced level of interaction and generation.

Rowe has been working on artificial intelligence with interactive music systems. He mentioned that by transferring musical knowledge to interactive works, collaboration of humans and computers can be established to have an engaging and fruitful context.

> *"By transferring musical knowledge to a computer program and compositional responsibility to performers onstage, however, the composer of interactive works explores the creative potentials of the new technology at the same time that he establishes an engaging and fruitful context for the collaboration of humans and computers."* (Rowe, 1999)

Referring to the experiment results, most of the villagers in the adult group participate in singing and dance performances to the visitors. They learn, practice and pass the ethnic tradition of their group. Most of them know how to sing, dance and play musical instruments and this tradition is inherited from generation to generation. When they sing and dance with their peers, they think the experience is cheerful, affectionate and wonderful. Collaborating with a computer system is totally a different experience for them. Some regarded it interesting while others thought it was strange if they were not used to it. They could not find the kind of affection they have with their own ethnic performances. They thought that collaborating with a computer system is cold.

It is difficult to achieve good collaboration if people cannot get used to the interactive experience. This was only a very first experience to them and it was totally out of their knowledge and expectation. It is also difficult to convince them to try or appreciate the very different experience especially if they have been conforming to a long established custom of their group. Another reason maybe the interactive features are not sophisticated enough to attract them to interact more. Briefing and pretrial were not available to help them familiarize with the system.

12.3.Implications

There was a big gap in responses towards these experiments between the two groups. All adult villagers participated in the experiments perform the roles of singers, dancers, instrument players, teachers or administrators in the dance teams. They learned ethnic dances and music when they were small from their parents and senior people. They practice, teach and earn extra income from the performances. They are very knowledgeable about their dances and songs and this knowledge with the practices are traditionally passed from one generation to another. Thus, they are preoccupied with their own ways of singing, dancing and making music. The performances conducted in the experiments sounded very new and alien to them. They had the difficulty to accommodate this and explore any unique experiences.

The primary students there are undergoing an education system very different from the adult villagers. As reflected by the students participated in the experiments, they learn subjects in Chinese as the major language (Yi is the language of their minority group). Besides, most of them do not know how to play their ethnic musical instruments, but they learn Chinese flute in the music lessons. All students who are senior than primary four need to go to the towns or cities for further education. Hence, they are exposed to modern Chinese culture instead of learning, practicing and passing their culture in their own lands. In this way, they may not be as knowledgeable as their parents with the ethnic dances and music now and even in the future. This however, reduces the preoccupation of ethnic elements in their minds. It is speculated that they will be more likely to accept modern technologies and experiences when they grow up. Talking about the present, the children there, like many other children in the world are curious about new things and technologies. They are open to these and accept without criticisms.

12.4.Limitations

Reviewing the research process, limitations are found in a number of areas. First of all, organizing a field trip for such kind of experiment was not easy, especially in a remote village in China. Being an outsider in Hong Kong, support was needed for connecting local scholars and research personnel in getting access to the village. Thus, it was necessary to make sure that the professors and research students in Kunming were available for the schedule of the experiments. In addition, access to the village was restricted to certain time period that the villagers were not busy. Because of this, the trip had been rescheduled a number of times.

Besides, there was a big difference between experimenting in labs and at the field. People's expectation differed to a great extent and it was much difficult to control the environment at the field. Time was limited for carrying out the experiments, interviews and survey. The adult villagers have to work during daytime, so we could only invite them at night after they had finished dinner. Because of this, training or a pretrial could not be offered. It was only possible to give them a brief introduction, so many of them felt strange and had difficulty to familiarize with the proceeding. There were also problems with controlling the participant size and the environment. In order to invite as many suitable participants as possible, it ended up with more than double the number of people expected. The equipment and the venue did not work so well under this situation. This affected the sound quality of the performances and the way they perceive them

There is an age gap between the adult villagers and the primary students groups. For adult villagers group, age ranges from 28 to 82 while it ranges from 10 to 12 in primary students group. Younger people from 13 to 27 are not available. Comparison was limited to students and mature people, leaving out teenagers or younger people. Students over primary four being required to study in towns or cities is the major reason for this. Besides, younger people may prefer to work in towns or cities after graduation to seek for more job opportunities.

Reviewing the prototyped systems, they are not as interactive as expected. This can be caused by inadequacy of interactive features developed and being tested. In implementing the prototyped systems, a lot of effort and time were spent on building the generative features in resembling Yi ethnic nature. More interactive features can be developed given more time for the implementation and more budgets for incorporating new interfaces. Besides, due to the time limited, only one or two interactive features can be tested in the field.

12.5.Enhanced System Design

The first version of the system prototype had been tested by different groups of people in the experiments designed for the Axi people in the Ke Yi Village. A number of design issues were revealed. Although there are a lot of studies addressing the issues of designing interactions between the machine system and the people, there are special requirements if we design the systems for art and music performances. This section is going to summarize the comments and shortcomings of the first version of the prototype with an attempt to design enhanced version of the system.

Lessons had been learnt after the experiments conducted and the inherit limitations cannot be overlooked. Many experiences are suggesting that users should get involved during the early stage of the prototype development and user-centered approach should be adopted in designing systems and products. The case we selected for the study of Yunnan Yi music was rather special as frequent access to the village was not possible. Besides, we had to rely on some third parties to organize. The experiments conducted demonstrating the features of the first version of the prototype served the purposes of introducing the modern way of making music and collecting the preliminary user comments.

There is no doubt that Axi people enjoy music a lot and they are very knowledgeable about their own way of making music. They inherited the traditional practices from

their ancestors since they were small. They still live on the mountain areas and most of them are farmers and livestock keepers nowadays. Although they also went through changes of the society and technology, but the speed was far slower than the cities. We, as people of modern society, went though rapid changes of technology and living style. Interactive music can be named the product of modern society that people innovate music performances with Internet and information technology. This implies not only cultural conflict, but also adaptation problems between people living in two different worlds.

To give a brief account, people in the village had dispersed opinions towards the system being experimented. Children(primary school students aged 10 to 12) in general were very excited and interested in experiencing and interacting with new products or objects. In the adult group, the age gap was big from 28 to 85. It ended up with groups of people being interested, not interested and not used to. Details can refer to the results chapter. To summarize, there are a number of areas where improvements are needed:

12.6.Areas to Improve

12.6.1. Interactivity

In the existing version, although there is an interactive module for people to interact with and the system can make response, but the interactivity can be increased to make it more responsive and cohesive. In view of this, more features can be introduced to motivate people to interact more. It will be a good start to make the system respond in a humane and a friendly manner.

12.6.2. Interface Design

Max/MSP was the development tool and it provided the main user interface. It is a graphical screen interface and the people interact with the system through a laptop computer. As it was an experiment, so the setup was basic and primitive. If time and

budget allow, an enhanced version will make use of more interfaces as mediated devices between the system and the users in multiple modalities. More state-of-the-art interfaces will be utilized to provide more enjoyable experiences not limited to audio and visual formats.

12.6.3. Ethnic Elements

Yi ethnic elements are very important in Yi songs. They preferred the system design can have more ethnic elements that they are familiar with. Besides the Yi songs and rhythmic patterns being referenced and imported into the system, more other types of ethnic elements can be studied and incorporated.

Musicians enjoy music for its harmony and coherence. Harmony can be found when different musical instruments are played in coherence with the rhythm, melody and the emotion of the music piece. It is not a difficult task for interactive music. It can achieve same or alternate kind of coherence by synchronizing different sounds with images, videos and other media forms. The system itself becomes the central unit coordinating and manipulating the digital contents and finally projecting them to different media forms. Axi people enjoy their music for its ability to communicate affection and share happiness among them. They inevitably sing and dance to the music. That is why dance songs are so popular in their regions. Interactive music should not overlook this kind of integrity and Yi ethnic culture is taken into consideration.

After summarizing the shortcomings and comments for future improvement from the villagers, a number of new requirements are expected to be achieved. Although they cannot be attained with a single version, but can be achieved in a series of coming versions. They prefer the system to be:

- More interesting
- More enjoyable
- More interactive

- More Yi ethnic elements
- Integration with dances
- More adaptive

12.7.New Adaptation Model

The theoretical framework proposed in the proposition section features a dragging force between interactive and generative capabilities of the system. It deals with architectural design of interactive music performance systems. When ethnic minority culture is being studied, we need to consider a lot of issues other than design. First of all, an in-depth and thorough understanding of the ethnic culture is inevitable. Its characteristics are so unique and different from the system, relevant elements should be extracted and translated to be understood by the system; the folk people have been inheriting their own culture and get exposed to their practices. It is not so easy for them to accept something out of their knowledge. Like those villagers who had participated in the experiments, a lot of them could not get used to the system and the way it was making music. They preferred something they were familiar with, especially the ethnic elements. Thus, there should be an adaptation process for the system to learn the ethnic style of making music and the minority people to get used to the system.

12.8.Adaptation Process:

I would divide the adaptation process in four stages:

Stage 1	Stage 2
Familiarity of ethnic styles Easiness to interact	Enhancement of existing version Introduction of new unique features

Stage 3	Stage 4
Interaction with dances Familiarity of ethnic dance forms	Enhancement of existing version Introduction of unique dancing features

Figure 13-1. Adaptation process in enhancing the system for the ethnic minority

Stage 1:

Familiarity of the ethnic music elements

Easiness to interact

For most villagers, it was the first time they encountered such performance and system. Easiness to use helped reduce any difficulties of using the system for the first time. Familiarity helped them get acquaintance. Thus, we made use of the elements and the styles familiar to them. We also made the sound similar to their musical instruments.

Stage 2:

Enhancement of existing version of the system

Introduction of unique features not found in existing music performances

Although familiarity to the ethnic elements made the system easier to be accepted by the villagers, but it inevitably induce them to make harsh comparison between the music performed by their own musical instruments and the system. However, it is not a "apples to apples" comparison. The system did not evolve from their culture. They cannot be expected to produce the same quality of music and the same kind of affection that they are achieving now. Introduction of some unique features that cannot be found in their existing music performances can be a remedy.

Stage 3:

Interaction with dances

Familiarity to folk dances

In the first version of the prototype, the interactive features were rather limited that people interacted to change the melody, tempo and rhythmic patterns. As dances are indispensable to the music in Yi minority, new features are recommended to make the system interactive with the dances as well. Familiarity to the folk dances such as relevant steps and movements can enrich the system to make the music responsive to the dances.

Stage 4:

Enhancement of the existing version of the system

Introduction of unique features not found in existing folk dances

Enhancement of the system is expected to solve the problems and improve the quality. New unique features that cannot be found in their existing folk dances are highly recommended to encourage them to dance in a new way. It is also possible to

induce them to dance in a different way so as to achieve various results projected that the music or the visuals can respond differently directed by the dance movements.

12.9.Enhanced System Model

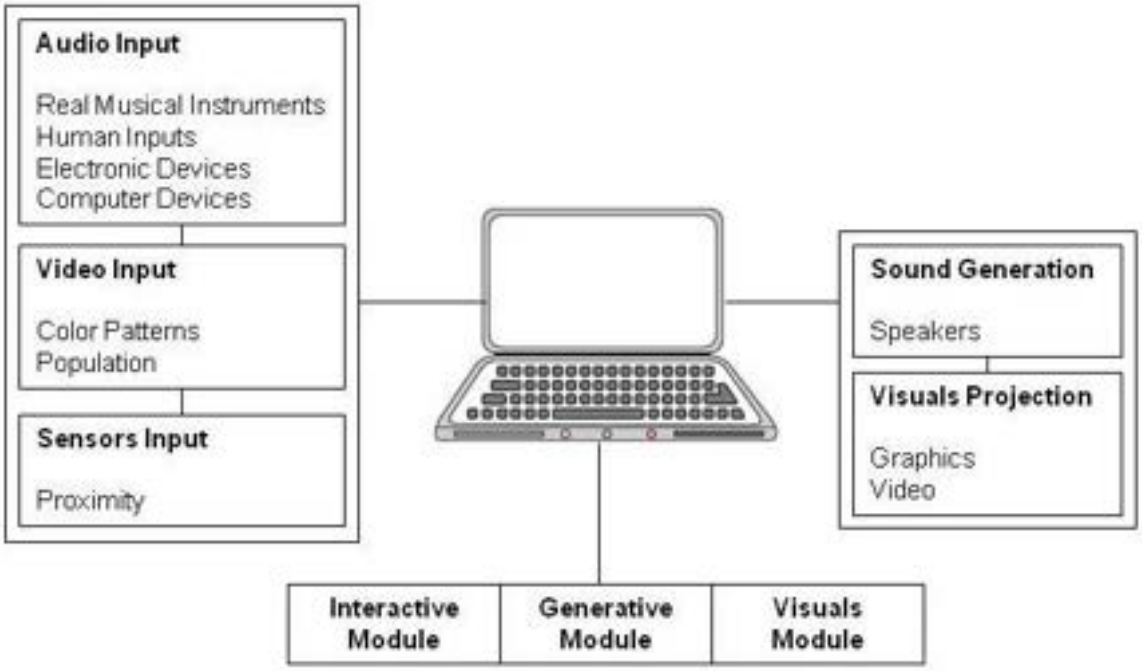

Figure 13-2. Enhanced system components model

In the first version, there were only audio input and output components. The system was mainly responsible for music composition and manipulation. The enhanced version will include more features interacting with folk dances. To do this, a video camera system is needed to capture the dance movement of the people. The graphics analysis unit within the visuals module can make interpretations of color patterns, population or density data. The visuals module will also make use of the analyzed data to generate graphics and videos to be projected. The proximity sensors are needed to measure the distance between dancers and wearable sensors can be placed on the body of the dancers such as legs or waist.

Each minority group in Yunnan has its own costume. The colors of their clothes and the accessories are so vivid that can provide useful and interesting data to the system. In most cases, Yi men and women dance in circles or in two lines facing each other. Proximity sensing can be a method to reflect the changes of the relative distance by making changes to the music and the visuals performed. People may be induced to dance closer or farther if they are in favor of the changes. This may yield interesting observations especially during courtship when young men and women are dancing to each other in public places to choose their future husbands and wives.

12.10. Future Directions

If time and budget allow, additional experiments can be conducted in cities of China to make comparison between people in cities and villages towards music performance with innovative technology. Also, multiple cases can be extended to other minority groups to explicate the uniqueness, similarities and differences among different groups.

In view of the feedback and comments from the participants, there are a number of ways to improve the system. Although there is richness in Yi performances and culture, most of the villagers there are still conventional to their traditional practices and ethnic elements. In this condition, it is not easy for them to accept new practices that they are not used to. If there are any future performances or products that will bring changes or variations to their traditional practices, a close resemblance to their culture is easier to get acceptance. In addition, more interesting interactive features can be developed with innovative interfaces to attract attention as well as enlarging the interactive intensity.

From the experiments conducted with the primary school students, most of them were in favor of this kind of interactive system or performance. It can be concluded that children and younger generation in the villages or the cities may prefer it as a new excitement or experience. There is potential to have future development of the

products of this kind for educational purpose so as to inspire exploration and creativity.

Finally, this work contributed to the generative and interactive design by proposing a new framework in which computer generated music is integrated with the changing elements of performers' input and established a platform for responsive music contents to be generated with the initiative input by the users. In such a way, it is possible to control a generative system by users in real time performances. Much effort is still needed to achieve this objective with more powerful features of the system, and with more studies on users in order to enable the system to be really intelligent and comparable with human performers. This is a promising research direction for further studies in this area.

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