PIEZO-BASED INTERACTIVE MUSIC SYSTEM

Che-Yi Hsiao

Master Program of
Sound and Music Innovative Technologies
National Chiao Tung University, Taiwan
E-mail: radiohead10533@gmail.com

Chih-Fang Huang

Department of Information Communications,
Kainan University, Taiwan
Email: jeffh@knu.edu.tw

ABSTRACT

There are lots of discussions about the interactive music in the recent years, including both performance and research. It involves various fields such as the artistic works of video and music, or even the interdisciplinary integration among architecture, biotechnology, and so on, to generate the new species of artistic and technological thinking possibilities. Piezo-based Interactive Music System (PBIMS) is proposed in this paper, to help the artists who use technologies to design their own interactive media system to compose music easily with more flexibility. It provides a powerful sound and music parameter remapping mechanism, with piezoelectric transducer detecting for the pickup of many kinds of music instruments.

1. INTRODUCTION

Interactive music, also known as nonlinear music or adaptive music has been an important topic in performing art. Performers on stage interact each other by instruments or other parameters such as body movement [2]. This paper uses piezoelectric transducer as a kind of vocalization method with sensing of touch and sound vibration to perform the interactive music [1][2]. The well-know electronic music instrument Theremin [3], the first music instrument to generate music performing effects without the need of hand touch, can be treated as a type of media of interactive music [4] in the early times, via the gesture of hand movement. Not only the music pitch change, but also dynamic, rhythm, and many other music parameters can be used for music effect variance to accurately and deliberately control and process of the interactive music system. Our proposed Piezo-based Interactive Music System (PBIMS) is based on touching force and sound vibration, to vocalize for interactive music. In addition to frequency components detect, more detailed dynamic and volume variance sensed by the tactile and sound vibration from piezoelectric transducer provides performers richer emotion-based data with sound and music parameters remapping with other media data output, for an expressive interactive music performance with the proposed system applied. There are some hardware and software devices such as Arduino [7], Max/MSP program, and piezoelectric transducer to be used in this research. Max/MSP is a well-know software program for computer music, which can be integrated with various interfaces to reinforce the communication with other media data rather than music and sound. For instance, Max/MSP is integrated with Arduino board. The proposed Piezo-based Interactive Music System (PBIMS) is a powerful system to incorporate both computer music processing and other input sensing devices, to achieve a complete interactive multimedia system with more creative ideas accordingly.

2. METHOD

An interactive music composing system should be as satisfying as performing music “live”, which means in real time. The proposed PBIMS provides a real-time live performing into the system, allowing composers to explore the interactive musical idea with sonic arts with other media elements in an efficient way. With the piezoelectric sensor input, user can easily and rapidly develop the interaction system with music parameter remapping, therefore such as live performance and even free improvisation using Max/MSP program is becoming feasible with the multimedia works. Fig. 1 shows the flow of PBIMS to generate interactive music in real time. There are several things needed for PBIMS to generate interactive music for the designer and performer as follows:

(1) Real time capability: simultaneous and rapid response, to deal with the varied performing environment.
(2) Interactivity: such as data exchange and mutual influence, via HCI (Human Computer Interface) or GUI (Graphic User’s Interface).
(3) Real Time Interactive Music Generation: with proper HCI/GUI settings and software

programming, to perform the "live" music with parameter mapping.

(4) Remapping Mechanism: sound input – Mapping – sound output between music parameters and other media data.

(5) Input device: microphone, sensor, MIDI controller, and mouse, etc.

(6) Output device: speaker, light, video, robotics, tactile device, etc.

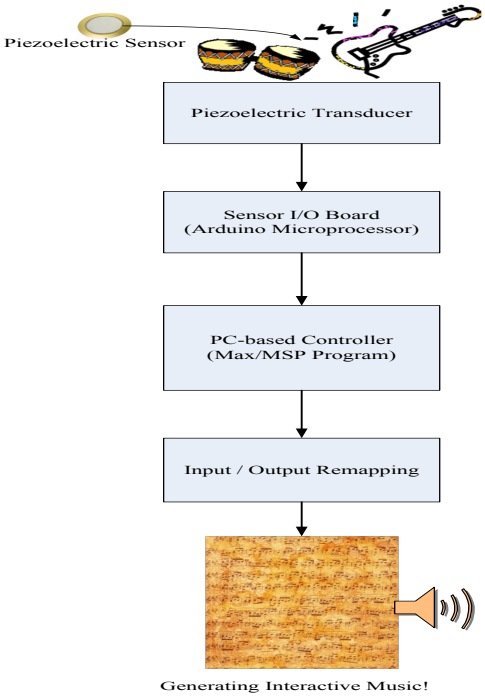

Figure 1. The Interactive Music Generation Flow of Piezo-based Interactive Music System (PBIMS)

3. IMPLEMENTATION

3.1. Arduino

Arduino, developed by ATmega IC series, is an I/O board to connect with peripheral modules, and its code compiling and external hardware integration is simple and convenient. There are six 10-bit Analog-to-Digital Converters [8] for various sensor inputs, providing a powerful integration function for this development board.

Figure 2. The Arduino I/O Board for PBIMS

3.2. Max/MSP

Max/MSP is a software program for computer music composition and audio processing, giving the user to create unique sounds, stunning visuals, and engaging interactive media [9]. The main advantage of his software is to process MIDI data and DSP audio in real time with parameter exchange, which is crucial to the proposed PBIMS design for interactive computer music with much more flexibility.

3.3. Piezoelectric Transducer

As shown in Fig.3 , PBIMS uses piezoelectric transducer as the signal source generator, and its fundamental theory is based on the tiny displacement of the sensing film proportional to the generated analog voltage [10]. The low cost and quiet contact-microphone feature with accurate signal generation is its main advantage.

Figure 3. Piezoelectric Transducer

3.4. Piezoelectric Transducer Circuit for Arduino

As shown in Fig. 4, piezoelectric transducer generates a voltage signal via a resistor load, to accurately provide the pick-up signal for Ardunio. Arduino's ADC can only read 0~5V range, therefore the negative voltage cannot be read, and the ground 0V is raised to 3.3V as the voltage level for the negative voltage read by the piezoelectric transducer.

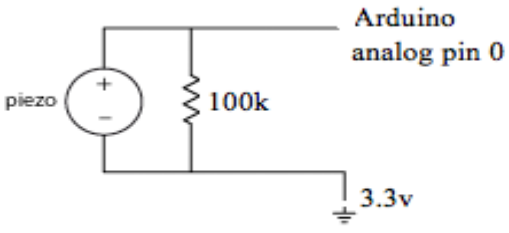

Figure 4. The Piezoelectric Transducer Circuit

3.5. Arduino and Max/MSP Integration

Both Arduino and Max/MSP can be integrated via the standard serial communication protocol, and the following Java-like code segment is for their data change.

3.5.1. Arduino Code

```
#include <SimpleMessageSystem.h>

void setup(){
   Serial.begin(9600);
}
void loop(){
 if (messageBuild() > 0) {
   switch (messageGetChar()) {
   case 'r':
     readpins();
     break;
   case 'w':
     writepin();
   }
 }
}

void readpins(){
switch (messageGetChar()) {
   case 'a':
   messageSendChar('a');
   for (char i=0;i<6;i++) {
     messageSendInt(analogRead(i));
   }
   messageEnd();
}
}

void writepin() {
 int pin;
 int state;
 switch (messageGetChar()) {
   case 'a' :
   pin = messageGetInt();
   state = messageGetInt();
   pinMode(pin, OUTPUT);
   analogWrite(pin, state);
   break;
  }
}
```

Figure 5. Code Segment of Arduino for PBIMS

There are three functions including loop(), writwpin(), and readpin(). writwpin() is responsible to send Max/MSP generated data to Arduino as its parameter control. readpin() function reads Arduino external data such as voltage and discrete states, etc., to send to Max/MSP program for its music parameter mapping and control. loop() repeatedly reads writewpin() and readpin() functions, with 9600 bit/s baud rate setting. Please refer to Fig. 5 for more detailed code.

3.5.2. Max/MSP Code:

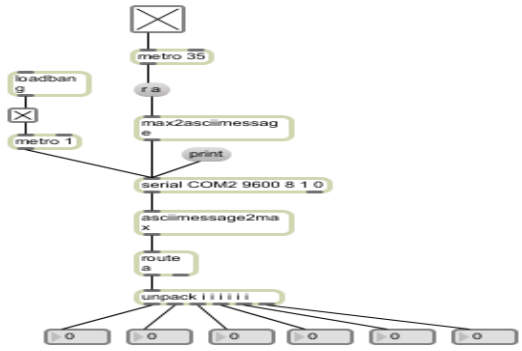

Figure 6. The Max/MSP Communication and Display Program

Fig.6 shows Max/MSP program of data communication, with serial object to select USB com port and baud rate, to perform transmission and receiving function bi-directionally. Both "max2asciimessage" and "asciimessage2max" objects under "serial" object can be used to perform the receiving and transmitting message function between Arduino and Max/MSP, while other objects are responsible for program initiation and data display.

The data received from the six ADCs of Arduino will be displayed uder "unpack" object's outlets in digits. In order to make 10-bit quantization of Arduino's ADC, its readout value is set within 0 ~ 1023, to be correspondently mapped to 0 ~ 5v of Arduino's ADC range. Whenever piezoelectric transducer signal is generated, the related data values will be displayed on the output of Max/MSP program and applied.

4. EXPERIMENT

4.1. Voltage Pickup Test

Voltage pickup test for PBIMS experiment is shown in Fig. 7, with proper connection among the piezoelectric transducer, variant resistor, and Arduino.

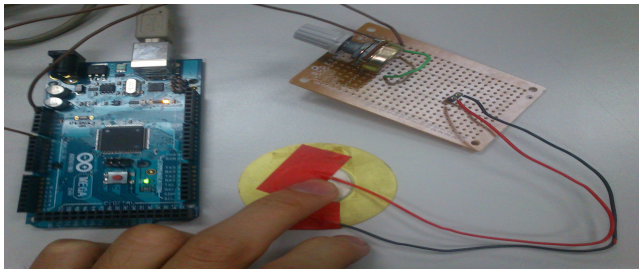

Figure 7. Voltage Pickup Test for PBIMS

Fig. 8 shows the voltage generated by the piezoelectric transducer with finger gently depressed about one second. One unit of X-axis is 1ms, and 0.5V for every 100 units is for Y axis.

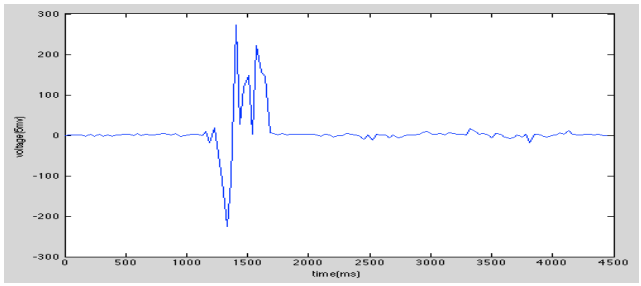

Figure 8. The Piezoelectric Voltage Output with Gently Depressed

Fig. 9 shows the voltage generated by the piezoelectric transducer with finger heavily depressed about one second. Compared to Fig. 8, the heavily depressed case generates 0.5V more peak value.

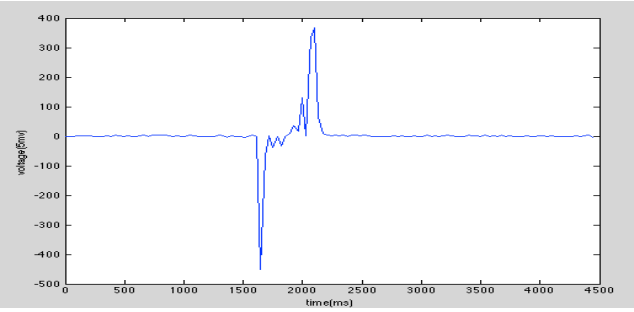

Figure 9. The Piezoelectric Voltage Output with Heavily Depressed

5. CONCLUSION

Using piezoelectric transducer as the media of interactive music is as shown Fig. 10. One case is applied to MIDI Drum. When the finger gently depressed, it can follow the voltage value to change MIDI velocity. The other case is applied to acoustic guitar to be a contact microphone. It is interesting that the value in Max/MSP can be used as the music parameter to map with acoustic guitar sound to perform the interactive music. More interactive music applications will be developed based on PBIMS in the future hopefully.

Figure 10. PBIMS Applied to Interactive Music

Acknowledgement

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract No. NSC101-2410-H-424 -014 -MY3.

6. REFERENCE

[1] Todd Winkler 1995 "Making Motion Musical: Gesture Mapping Strategies for Interactive Computer Music" Procedings of the 1995 International Computer Conference, San Francisco, CA: Computer Music Association, 1995.

[2] Todd Winkler, "Movement-Activated Sound and Video Processing for Multimedia Dance/Theatre. In Proceedings for the 2003 International Computer Music Conference, San Francisco, CA: Computer Music Association, 2003.

[3] Theremin Website, Wiki: http://en.wikipedia.org /wiki/ Theremin, accessed October 11, 2012.

[4] Tsung-Ching Liu,Shu-Hui Chang,Che-Yi Hsiao, "A Modified Quad-Theremin for Interactive Computer Music Control", Conference of International Conference on Multimedia Technology,ICMTS, 2011.

[5] Yih-Young Chen,Tsung-Ching Liu, and Yu-Shiuan Hsieh, "The Control Of Interactive Computer Music Using Android Phone", Master Thesis of Mechanical Engineering Department, Chinese Culture University, 2011.

[6] SimpleMessageSystem,http://www.arduino.cc/play ground/Code/SimpleMessageSystem, accessed October 11, 2012.

[7] Simon Monk, book: "30 Arduino Projects for the Evil Genius", McGraw-Hill/TAB Electronics, 2010.

[8] ADC, Wiki: http://en.wikipedia.org/wiki/Analog-to-digital_converter, accessed October 12, 2012.

[9] Bing-Shr Yan,Tsung-Ching Liu,Che-Yi Hsiao, "A Theremin with Real-time Notation in Interactive Computer Music", Journal of Chinese Culture University Hwa Kang Journal of Engineering, Vol.29, No.20, pp.209-216, 2012.

[10] Han-Chih Chang,"Design and development of a positioning system using piezo-buzzer actuator and inductance sensor, Master Thesis of Mechanical Department, Taiwan University, Taipei, 2012.

7. AUTHOR'S PROFILE

Che-Yi Hsiao studies at master program of Sound and Music Innovative Technologies from National Chiao Tung University in Taiwan.

Chih-Fang Huang received both a Ph.D. in mechanical engineering and a master's degree in music composition in 2001 and 2003 respectively from National Chiao Tung University. He is the Assistant Professor at the Department of Information Communications at Kainan University, Taiwan, and the chairman of TCMA (Taiwan Computer Music Association). His research papers include various fields, such as algorithmic composition, sound synthesis, and automatic control.