UNIVERSITI PUTRA MALAYSIA

SAMPLING SYNTHESIS TECHNIQUE APPLIED FOR THE DIGITAL GENERATION OF MUSICAL TONES OF MALAY FOLK INSTRUMENTS

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By

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Chairman: **Minni Ang Kim Huai, Ph.D.**

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A random survey of commercial synthesisers available shows that sampled sounds of Malay folk instruments such as the rebab, seruling and others are lacking in both forms of software or hardware, in sharp contrast to Western classical instrument sounds where similar materials are in abundance. This study attempts to create original sound banks of selected Malay folk instruments in two formats, SoundFonts (SFs) and the Downloadable Sounds (DLS) formats by application of the sampling synthesis method and analysis of the waveforms of selected instruments. The recorded sound samples of individual selected Malay folk instruments are organised

and sequentially edited according to established procedures of trimming, normalisation, conversion and pitch shifting. The identification of the ADSR envelope and frequency components of specific instruments' waveform is also carried out. Finally, the creation of SoundFonts and DLS instruments is undertaken. As a result of this study, the following have been achieved: a) The production of high quality and realistic soft sound banks of selected Malay folk instruments in the SoundFonts (SFs) and the Downloadable Sounds (DLS) formats. b) A detailed analysis of waveforms and frequency components produced by selected Malay folk instruments. It is hoped that these sound banks would be useful as a source of musical tones, applicable for playback of MIDI sequences orchestrated utilising Malay folk instruments, for use by composers as well as commercial products such as synthesisers, samplers and keyboards.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

TEKNIK SINTESIS PERSAMPELAN UNTUK PENJANAAN SECARA DIGITAL NADA ALAT MUZIK TRADISI MELAYU

Oleh

ANG YAW FENG

April 2001

Pengerusi: **Minni Ang Kim Huai, Ph.D.**

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Satu kajian semasa secara rawak ke atas sintesiser komersial menunjukkan ketiadaan sampel bunyi alat muzik tradisi Melayu seperti rebab, seruling dan lain-lain, mahupun dalam bentuk perisian atau perkakasan. Ini amat berbeza dengan sampel bunyi alat muzik Barat yang mudah diperolehi dalam konteks perisian dan perkakasan yang sama. Kajian ini bertujuan mencipta arkib digital alat muzik tradisi Melayu dalam dua format, *SoundFonts (SFs)* dan *Downloadable Sounds (DLS)*, secara aplikasi teknik sintesis persampelan termasuk analisis gelombang. Bunyi alat muzik tradisi Melayu yang dirakamkan disunting, diikuti dengan prosedur

pemerosesan berikut: 'trimming', 'normalisation', 'conversion' dan perubahan pic. Langkah ini diikuti dengan prosedur analisis gelombang yang merangkumi pengenalpastian komponen frekuensi yang hadir di dalam spektrum alat muzik tradisi Melayu yang terpilih serta sampul ADSR untuk setiap gelombang. Proses ini berakhiri dengan penciptaan *SoundFonts* and alat-alat *DLS*. Kajian ini telah berjaya mencapai: a) Arkib digital nada alat muzik tradisi Melayu dalam format *SFs* serta *DLS*; b) Analisis gelombang serta komponen frekuensi yang wujud di dalam spektrum alat muzik tradisi Melayu. Hasil projek ini boleh digunakan oleh pencipta muzik serta produk komersil seperti sintesiser, sampler dan alat kibod.

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LIST OF ABBREVIATIONS

12-ET	12-tone equal-tempered
ADC	A/D converter or analogue to digital converter
ADR	attack decay release
ADSR	attack, decay, sustain, release
AR	attack release
CD-ROM	compact disc read only memory
DAT	digital audio tape
DAW	digital audio workstations
DB	decibel
DCA	digitally controlled amplifier
DFS	digital full scale
DLS	downloadable sounds specification.
DVD	digital video disc or digital versatile disc
Egs	envelope generators
FM	frequency modulation
GM	general MIDI
KHz	kilohertz/ thousands of cycles per second
LD	laser disc
LFO	low frequency oscillator
LSB	least significant byte
MB	megabytes
Mbps	megabits per second
MD	mini disc
MDM	multi track digital multi-tracks
MIDI	musical instrument digital interface
MMA	MIDI Manufacturer's Association
MSB	most significant byte
PC	personal computer
PCM	pulse code modulation
RIFF	resource interchange file format
SNR	signal-to-noise ratio
STFT	short-time Fourier transform

CHAPTER ONE

INTRODUCTION

Sampling is a process where sound [an analogue signal] is recorded digitally. When sound is recorded into a sampler, it turns the audio waveform into a series of binary numbers or bits [0s and 1s], that can easily be shuffled around and reassembled. This process is achieved with an electronic circuit called an analogue-to-digital converter (A/D converter or ADC for short). In contrast, analogue recording is based on the voltage recorded as patterns of magnetisation in the oxide particles of the recording tape. (Snyder, 1999). For instance, individual musical instrument tones once recorded, can then be played back on a keyboard. These individual tones, commonly referred to as "samples", could be stored on a CD-ROM (Compact Disc-Read Only Memory) or hard disk, but are read in RAM memory for speedy access.

The term sampling is derived from established notions of digital samples and sampling rates. "Sampling Rates" in turn, refers to the number of samples that are taken of an analogue signal per second. The more regularly samples are taken, the better the result will be when the sample is played back (Roads, 1996). This is due to the mechanics of recording devices capable of capturing tiny variations in the sound waves more accurately. As a result, this produces higher fidelity recordings with less distortions (Rubin, 1995).

Sampling thus has an edge over multiple wave cycling, in that it applies a longer wavetable containing thousands of individual cycles - several seconds of pre-recorded sounds, permitting the use of pointers within a sample to define internal looping. It creates samples from live and pre-recorded materials. Recorded sound can be stored in disks, or in the internal memory (Roads, 1996; Dodge & Jerse, 1997). The sample later can be spliced, copied, reversed, enveloped, cross-faded, looped, sped up or manipulated in any combination of the above in order to change the duration, pitch and timbre. Effects such as reverberation or flanging can also be introduced in the wave-shaping process. As a result, it is usually used to create sonorities and effects that would normally not be possible to achieve acoustically. (Moore, 1996; Miranda, 1998). In effect, sampling synthesis permits the production of rich, natural, and time-varying sounds useful for composition, live performance and sound effects purposes. It has minimal flexibility since only few transformations are possible at this level. (De Poli, 1996). The input signal is always the same, as it is recorded. The input signal is a recorded sound resulting in the absence of the control over life-like qualities of sounds that help enhance the perception of music.

Today, there are many different formats or arrangements of data used for describing samples. Two of the most common are the SoundFonts (SFs) 2.0 format patented by Creative Technology Limited, and the Downloaded Sounds (DLS) format standardized by the MIDI Manufacturers Association (MMA). (Scheirer, 1999). The primary objective of this study is to obtain original banks of sound samples of selected Malay folk instruments in the form of these two formats. All the sound

samples can either be uploaded onto the internet or recorded into a CD-ROM for further usage, as well as loaded into commercial synthesisers.

Malay folk instruments that have been chosen for this study are categorised according to instrument families as follows: a) String instruments or chordophones[1]: *gambus* and *rebab* [Malay violin]; b) Wind instruments or aerophones[2]: *seruling* [flute] and *serunai*; c) Percussion instruments: i) Membranophones[3]: *gedombak*, *geduk*, *gendang* [bigger drums], *kompang* and *rebana* and ii) Idiophones[4]: *angklung*, *canang*, *kesi*, and *tetawak* or *gong*.

Statement of the Problem

A random survey of commercial synthesisers available shows that sampled sounds of Malay folk instruments such as the *rebab*, *seruling* and others have yet to be found in any of these products whether in the form of software or hardware. On the other hand, Western classical instruments sounds and other variety of other sounds have long been sampled in those products. Also, no study has been carried out on analysing the waveform of the sound produced by Malay folk instruments to date.

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[1] Chordophones refers to instruments using a stretched string as sound generator.
[2] Aerophones are instruments producesing sound with a column of air.
[3]Membranophones refers to instruments with stretched skin or other membrane for sound generation.
[4]Idiophones refers to instruments made up of material with self-generating sounds.

Objective of the Study

The primary objective of this study aims at obtaining a high quality sound bank of Malay folk instruments in the SoundFonts (SFs) formats and the Downloadable Sounds (DLS) by applying the sampling synthesis method, besides obtaining an analysis of waveforms produced by each of the Malay folk instruments.

Significance of the Study

This study is primarily targeted towards the musician in the field of music technology and manufacturers of musical instruments. By producing the sampled sound of Malay folk instruments, it is hoped that composers will be able to utilise these sound fonts, with Compact Disc (CD) quality sound of MIDI (Musical Instrument Digital Interface) playback for their own compositions, particularly for those who attempt to compose music using Malay folk instruments. In doing so, they will be able to hear the immediate effects of the Malay folk instruments when they use these instruments in their compositions, whilst manufacturers of commercial musical instruments such as synthesisers, samplers and keyboards could hopefully incorporate these realistic representations of eastern instruments into their products in future.

Design of the Study

This study is divided into five main sections. The sections are, accordingly: sample recording, sample organisation, sound editing, waveform analysis succeeeded by SoundFonts and DLS intruments creation.

Initally, the sound samples of the selected Malay folk instruments are recorded onto Digital Audio Tape (DAT). After that, the sound samples are transferred to computer hard disk, organised systematically into different catogories and stored using descriptive file names. The wave files are then edited with the trimming, normalisation, conversion and pitch shifting processes done at this stage[5]. Later, the waveform of each different Malay folks instruments' sound sample is analysed from two points of view: the ADSR envelope and the frequency components. Finally, the SoundFonts and DLS instruments are created using the software Vienna 2.3 and Direct Music Producer respectively.

Organisation of the Thesis

This thesis is organised into five chapters. Chapter two deals with the research literature review, commencing with a discussion on the preservation of Malay folk instruments culture, followed by an explanation of the theory of sampling synthesis, the digital sampling process and critical factors in producing a good sample. This is

[5] These terms will be explained in Chapter Three, when the methodology is described in detail

followed by a review of sampling synthesis from a historical and developmental perspective, as well as current research trends. The chapter concludes with a discussion on the two soft sound bank formats used in this research, SoundFonts (SFs) and Downloadable Sounds (DLS).

Chapter Three deals in detail with the methodology of the whole study. This chapter contains five main sections: sample recording methodology, sample organisation, sound editing methodology, waveform analysis methodology and finally, SoundFonts and DLS instruments creation methodology.

The fourth chapter contains results and discussions, including results of the waveform analysis performed on the various samples. The SoundFonts and DLS instruments created through this research are appended to this thesis in the form of a CD-ROM. Background information on each of the Malay folk instruments selected is presented as an appendix to the main text.

Conclusions of the research are presented in the last chapter, along with suggestions for further studies. The following chapter presents the review of related literature.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents the literature review related to this study. It begins with a discussion on the preservation of Musical instruments culture, followed by the theory of sampling synthesis. This section is further subdivided into the digital sampling process and critical factors involved in creating good samples. After that, sampling synthesis research is considered. Finally, the chapter ends with a discussion on SoundFonts (SFs) and Downloadable Sounds (DLS).

Preservation of Musical Instruments Culture

From the end of 19th century, efforts have been made by ethnomusicologists to preserve culture through assembling primary sources from target fieldwork in various ways: observation in fieldwork, music recordings and interviews, photographs, film and video taping. In this regard, documentary recording has been vital in preserving traditional music. Ethnomusicologists have used sound recording as an integral part of their scholarly texts, instead of being limited to the written word, such as for musicology work. Recording technology has provided the ethnomusicologist and musicologist the means to preserve, duplicate and reshape raw data using the latest technology. In the early days of culture preservation, the recording technology employed was mainly analogue. Magnetic tape, open-reel, videotape and cassette were utilised in order to capture the sound of traditional instruments (Malm, 1992; Myers, 1990). The cassette

restricted signal-to-noise ratio (SNR) (Refer page 17) and limited frequency response, both resulting from the narrow track width and slow tape speed, and these cumulate in noisy recordings with background hiss.

In retrospect, it is little wonder that digital recording has dominated the recording scene since the 1990s. One major advantage of digital recording is generally providing high quality sound recording. Besides, recorded signals do not degenerate with repeated playing. Furthermore, it is possible to generate copies from the original with equal fidelity to the original. The emergence of attainable standards in digital recording overcomes major problems prevalent in the days of analogue recording, such as tape noise and distortion. In this respect, a vast majority of digital recording systems are capable of detecting and eliminating interfering signals. Digital techniques also offer wide possibilities for the ethnomusicologist, who can apply computerised and synthesised digital recordings in their research. For instance, Simha Arom adapted a Yamaha synthesiser to simulate a traditional xylophone, recording the results on a Macintosh SE/30 computer. (Myers, 1992). Also, musicians managed to correct the tunings to reflect authentic African scales by utilising the computer (Myers, 1992).

The most frequently used media for digital recording use the PCM (Pulse Code Modulation) system, including computer, Digital Audio Tape (DAT), compact disc (CD), Mini Disc (MD) and digital videodisc (DVD). (Refer page 12). According to Helen Myers (1992), among the DAT tape, videotape and the compact disc, the latter is said to be the most stable and likely to be the most permanent. In terms of