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IMPROVEMENT OF AUTOMATIC GENRE CLASSIFICATION SYSTEM FOR TRADITIONAL MALAYSIAN MUSIC USING BEAT FEATURES

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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Dedicated to my baby who went to heaven peacefully during the last stages of writing this thesis, at age 10 weeks gestational….

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Shyamala Doraisamy, PhD.

Faculty : Computer Science and Information Technology

The increase in processing power and storage of computer has resulted in the growth of digital musical files, which demands some form of organization such as classification of the files. Typically, manual classification is used but it is expensive both in terms of time and money.

One alternative solution is to automate musical genre classification. Existing systems have been developed to classify Western musical genres such as pop, rock and classical. However, adapting these systems for traditional Malay music is difficult due to the differences in musical structures and modes. In general, the musical structure of many genres in traditional Malay music is rhythmic and repetitive, which is different than Western music.

This study investigates the effects of factors and audio feature set combinations towards the classification of traditional Malay musical genres. Ten traditional Malay musical genres are introduced in this study: *Dikir Barat, Etnik Sabah, Gamelan, Ghazal, Inang, Joget, Keroncong, Tumbuk Kalang, Wayang Kulit* and *Zapin*.

The study is conducted in three phases. The first phase investigates the factors affecting classification of traditional Malay music: dataset size, track length, track location, number of cross-validation folds, and classifier. The second phase investigates the effect of feature set combinations on the classification result of traditional Malay music. The combinations are STFT, MFCC, STFT and Beat, MFCC and Beat, and STFT, MFCC and Beat. Following this, an automated classification system is developed and named MAGCLAST (Musical Analysis and Genre CLAssification System for Traditional Malay Music).

The performance of MAGCLAST against three groups human (expert, trained and untrained) is tested in the final phase of the study. Results show that its classification at 66.3% is comparable to MARSYAS (61%) and trained human (70.6%). Interestingly, MAGCLAST also outperforms classification by average Malaysians, suggesting that an automated system for classifying traditional Malay music is certainly needed.

Additionally, a small-scale study on human classification behaviour is also done to understand the factors that affect classification. It is hoped that the information could be exploited to enhance existing automated genre classification system in the near future.

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

PERBAIKAN PENGKELASAN GENRE MUZIK MALAYSIA TRADISIONAL SECARA AUTOMATIK MELALUI FITUR BEAT

Oleh

NORIS MOHD. NOROWI

Mei 2007

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Fakulti : Sains Komputer dan Teknologi Maklumat

Peningkatan dalam kuasa pemprosesan dan ruang storan komputer telah menyebabkan pertumbuhan fail muzik digital dengan pesatnya, yang mana memerlukan satu bentuk organisasi seperti pengkelasan fail. Lazimnya, pengkelasan fail secara manual digunakan, namun ianya memerlukan masa yang lama dan kos yang tinggi.

Satu alternatif kepada permasalahan ini adalah melalui pengkelasan genre muzik secara automatik. Sistem-sistem yang telah sedia ada telah dibangunkan untuk mengkelaskan genre muzik Barat seperti pop, rock dan klasikal. Walau bagaimanapun, mengadaptasikan sistem sebegini untuk pengkelasan muzik traidisonal Melayu adalah sangat sukar disebabkan perbezaan dalam mod dan struktur muziknya. Secara amnya, struktur muzik bagi muzik tradisional Melayu adalah

berirama dan berulang-ulang, yang mana adalah tidak sama dengan kebanyakan muzik Barat.

Kajian ini menyelidik kesan pelbagai faktor-faktor dan kombinasi set-set fitur audio ke atas pengkelasan muzik tradisional Melayu. Sepuluh genre tradisional muzik Melayu diperkenalkan dalam kajian ini: *Dikir Barat, Etnik Sabah, Gamelan, Ghazal, Inang, Joget, Keroncong, Tumbuk Kalang, Wayang Kulit* dan *Zapin*.

Kajian ini telah dijalankan dalam tiga fasa. Fasa pertama mengkaji kesan beberapa faktor ke atas muzik tradisional Melayu, antaranya saiz dataset, panjang trek, lokasi trek, bilangan *cross-validation folds*, dan *classifier* yang digunakan. Fasa kedua melibatkan kajian kesan beberapa set-set fitur audio dan kombinasinya untuk meningkatkan keberkesanan pengkelasan muzik tradisional Melayu. Lima set fitur audio yang dikaji adalah STFT, MFCC, STFT dan Beat, MFCC dan Beat, dan STFT dan MFCC dan Beat. Berdasarkan hasil keputusan ini, satu sistem pengkelasan muzik tradisional Melayu secara automatik telah dibangunkan dan dinamakan MAGCLAST (Musical Analysis and Genre CLAssification System for Traditional Malay Music).

Sebagai fasa terakhir dalam kajian ini, hasil pengkelasan MAGCLAST telah dibandingkan dengan hasil pengkelasan manual oleh tiga kumpulan manusia: pakar, terlatih dan tidak terlatih. Kajian mendapati hasil pengkelasan MAGCLAST pada 66.3% adalah setanding dengan MARSYAS (61%) dan manusia terlatih (70.6%). Tambahan pula, hasil pengkelasan MAGCLAST telah menandingi hasil pengkelasan yang dilakukan oleh rakyat Malaysia kebanyakan, menegaskan bahawa satu sistem automatik untuk pengkelasan muzik tradisional Melayu adalah diperlukan.

Sebagai tambahan, kajian pada skala kecil-kecilan telah dilakukan ke atas tabiat manusia dalam pengkelasan muzik. Ini adalah untuk lebih mendalami faktor-faktor yang mempengaruhi pengkelasan muzik secara manual. Adalah diharapkan maklumat hasil kajian ini dapat dieksploitasikan dengan tujuan menambah baik sistem pengkelasan muzik secara automatik pada masa hadapan.

ACKNOWLEDGEMENTS

This thesis would not be possible (nor very useful) without the help and support of several important people listed below.

First of all, I wish to express my gratitude towards my supervisor, Dr. Shyamala Doraisamy, for being such a great supervisor, simply the best any postgraduate student could have asked for, period. Dr. Shyamala took me right under her wings and it was with her that I learned how to do research and how to write. She has always been supportive of my work and a constant source of new and interesting ideas. Throughout the entire course of my study, she was always there and available for discussions. Thank you, Dr. Shyamala, I am continually grateful. In addition, I would also like to thank my co-supervisor, Dr. Rahmita Wirza, for all the advice and support especially during the last difficult months of completing my Master.

I would like to take this opportunity to thank various individuals and organizations that helped me obtained the very few, but precious, traditional Malaysian music data. My thanks go to Dr. Ariff Ahmad of Universiti Malaya, Mr. Fauzi Abdul Rais of PKKSSAAS, UPM, Mr. Arif Zain Yusof Ali of Music Department, UPM, and the staffs and students at the National Arts Academy, Malaysia, especially to Mr. Kamrul Bahri Husin.

I also want to thank all of my colleagues at FSKTM who, in one way or another, have helped me again and again. Thank you, for listening to me go on and on trying to clear my brains out when I thought I was stuck, for discussing the possible

solutions, for helping here and there with my programming and for having to listen to nothing else than traditional Malay music playing on my laptop in the office.

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I was fortunate enough to have my studies funded by JPA and UPM during my first five semesters of study. I am eternally grateful for the scholarship offered.

Special thanks go to everyone in my family, especially Ayah and Umi, for their love and encouragement during this difficult journey. You have been my icons in life and I hope I have made you proud. To my husband, Saiful, I could not thank you more for being constantly understanding, supportive, and most of all – patient. He is the semantics behind all that I do.

Last but certainly not least, I thank God Al-Mighty for giving me the strength to complete this study. There were certainly moments where I had thought that this study would not have succeeded, but, as always, He guided me through it. Alhamdulillah…

APPROVAL

I certify that an Examination Committee has met on 25 May 2007 to conduct the final examination of Noris Mohd Norowi on her Master of Science thesis entitled "Improving Automatic Musical Genre Classification of Traditional Malay Music Using Beat Features" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Associate Professor Dr. Ramlan Mahmod, PhD
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Associate Professor Dr. Hj. Md. Nasir Sulaiman, PhD
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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date:

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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NORIS MOHD NOROWI

Date:

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LIST OF ABBREVIATIONS

ARFF	Attribute Related File Format
DWT	Discrete Wavelet Transform
FT	Fourier Transform
FFT	Fast Fourier Transform
GMM	Gaussian Mixture Model
LDA	Linear Discriminate Analysis
MAGCLAST	Musical Analysis and Genre Classification System for Traditional Malaysian Music
MARSYAS	Musical Research System for Analysis and Synthesis
MFCC	Mel-Frequency Cepstral Coefficients
MIDI	Musical Instrument Digital Interface
MUGRAT	Music Genre Recognition by Art of Texture
RMS	Root Mean Square
STFT	Short Time Fourier Transform
SVM	Support Vector Machine
WEKA	Waikato Environment for Knowledge Analysis
WT	Wavelet Transform
ZCR	Zero Crossing Rate

CHAPTER 1

INTRODUCTION

1.1 Introduction

Improvements in audio compression along with increasing amounts of processing power, hard disk capacity and network bandwidth have resulted in large number of digital musical files. Easier distribution of digital music through peer-to-peer file sharing has also made possible the creation of large, digital personal musical collection, typically containing thousands of popular songs. It is very likely in the future that every single piece of recorded music by human will be available in the digital format.

The rise in number has made some form of organization of these musical files a necessity, i.e. search, classification and retrieval. At present, metadata such as filename, author, date created and genres are commonly used to classify and retrieve these documents. The most common approach to address classification and retrieval of documents is through a semi-automatic solution: manually annotating audio signals with these metadata.

Such manual classification is highly labor-intensive and costly, both in terms of time and money (Dannenberg *et. al*, 2001). For instance, Microsoft's MSN attempt to manually label a few thousand songs required musicologists to be brought as full time employees and took about thirty man-years (Dannenberg *et. al*, 2001).

Its categorization is also limited to specific information provided, e.g. music genre, mood, or energy level. It also requires constant maintenance to ensure that the annotation results are consistent and accurate.

Another problem that surfaced from manual labeling was that it was too subjective. A study by Pachet (2000) on the taxonomy of musical genres ascertained that there were more than 378 genres of western music alone which could be determined based on their genealogy, geographical location, historical period, etc. It is therefore apparent that an automated musical genre classification system is needed.

An example of possible use of an automated analysis and retrieval system is an automated DJ, where a radio station that usually plays songs of a particular genre would have lists of songs automatically generated and ready to be played from its station. Another example is where a user hears a music he finds interesting and would like to hear more songs of similar texture, he could easily record it and requests the automatic audio retrieval system to search and return other similar songs.

In addition to the entertainment industry, automatic audio classification system also has potential areas such as Bioacoustics. This is an example where an automated audio similarity system is used to compare the sound similarity produced by the birds in the wild and that of endangered birds species, which had been identified and stored on the database so that the endangered birds in the wild could be located and preserved.

These few abovementioned examples portray the need for such system, which has opened up a path towards an area known as content-based search, classification and retrieval of audio.

One approach to music classification that is currently being widely studied is classification by musical genres. The term genre comes from the Latin word *genus*, which means kind or class. Specifically, musical genres are categories of pieces of music that share a certain style or 'basic musical language' (van der Merwe, 1989). Simplified, it refers to labels created and used by humans for categorizing and describing music (Tzanetakis and Cook, 2002). Examples of a few Western musical genres are such as Pop, Rock, Classical, Hip-hop and Jazz. Humans are able to recognize and analyze sound immediately based on instrumentation, the rhythm and general tone. Furthermore, human are able draw connections to other songs that have a similar sound and feel. These commonalities make it possible for humans to classify music into different genres.

In spite of this, replicating automated musical genre classification in machine is a process that is not as trivial as it appears in human. An automatic musical genre classification system needs to be able to analyze and extract implicit knowledge of the musical files into a comprehensible form. Several systems for automated genre classification and retrieval of musical files have been researched and developed (Tzanetakis and Cook, 2002; Wold, Blum, Keislar and Wheaton, 1996; Aucoturier and Pachet, 2002). However, most of these studies were conducted using only Western dataset, with little incorporation of other non-western music, including traditional Malay music.

Adapting these existing systems for the classification of traditional Malay music is a challenge due to the differences in musical structures and modes. Traditional Malay music encompasses all traditional music from Malaysia, both West Malaysia and Sabah and Sarawak (Mohd Ghouse, 1992), e.g. *Dikir Barat*, *Etnik Sabah*, *Inang*, *Joget*, *Wayang Kulit* and *Gamelan*. In general, these musical genres have strong sense of rhythm (Musical Malaysia 2005), partly due to the fact that traditional Malay music is traditionally played by ear as opposed to reading from written musical scores. Having the beat or rhythm clearly audible helps when the musical piece is being passed down orally through generations in the villages, i.e. having clear gong hits. Traditional Malay music is further discussed in Chapter Two.

There are several areas in which musical genre classification can be integrated into, such as Signal Processing, Machine Learning, Human-Computer Interaction, Information Retrieval and Perception. It can be seen that these areas are interwoven with each other closely throughout this study of analysis and classification of musical genres.

In general, the process of music genre recognition includes two main steps – feature extraction and classification (Aucoturier and Pachet, 2002; McKinney and Breebart, 2003). Feature extraction is a process where a segment of an audio is characterized into a compact numerical representation. Examples of audio features are Short Time Fourier Transform (STFT), Mel-Frequency Cepstral Coefficients (MFCC), Low Energy, Zero Crossing Rate, etc.

Once the features are extracted, standard machine learning techniques such as K-Nearest Neighbor (KNN) or Gaussian Mixture Model (GMM) can be applied to initiate classification. Classification is the process whereby unlabeled instances are mapped unto different set of categories by making accurate predictions based on past observations. Examples of classifiers are ZeroR, Naïve Bayes, J48 and IB1 (Witten and Frank, 1999). Hence, features utilized during extraction and classification parameters applied jointly determine the outcome of every classification. The general model for an automatic musical genre classification system is portrayed in Figure 1.1 below.

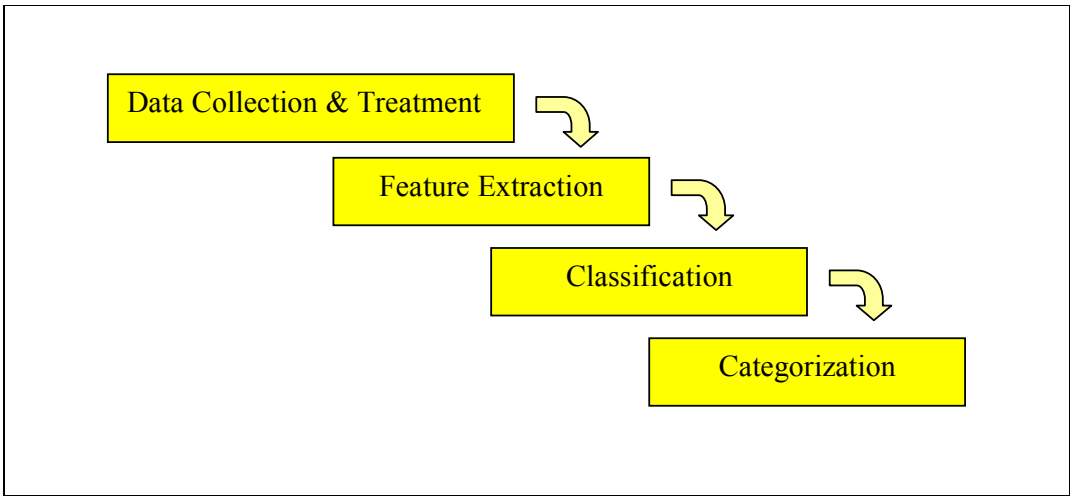

Figure 1.1: General Model for Automatic Genre Classification System

1.2 Problem Statement

Existing classification of musical genres has several limitations: it requires significant user time, costly in terms of hiring professionals or commercial companies to perform annotations and maintenance, and sometimes return inconsistent and inaccurate classification results. This directly points the importance of a system that can automatically perform such task.

The main challenge in music genre classification is the ability to differentiate between musical styles. For this, it is important that the appropriate audio features and classification parameters are utilized. Numerous audio features have been identified by various studies (Aucouturier and Pachet, 1993; Tzanetakis and Cook, 2002; Wold, Blum, Keislar and Wheaton, 1996).

A classification algorithm may return some kind of result, but a poor feature representation will only yield results that do not reflect the real nature of the underlying data. For instance, MFCC has been shown to be the feature set that works best in classifying speech. There might be certain features or combinations of features that are better suited for classification between music and speech, between noise and music, male or female identification, or even musical genre recognition.

Hence, features such as STFT and MFCC that are utilized and performed well for classification of Western musical genres will not necessarily produce the same effect for traditional Malay music genres. This study will focus on the selection of the appropriate or 'right' features and investigate the factors that would improve the classification of traditional Malay music.