

A NEW SEARCH AND EXTRACTION TECHNIQUE FOR
MOTION CAPTURE DATA

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ABSTRACT

Motion capture is defined as measuring the position and orientation of an object in physical space by triangulating information from multiple cameras which tracks and estimate a number of retro reflective markers over time. This information is later translated into a 3 dimensional digital representation. Motion capture is applied in a wide range of field such as biomechanics, athletic analysis/training, gait analysis, computer animations, gesture recognition, sign language, music and also fine art dance/ performance. In sport science, motion capture data is used for analyzing and perfecting the sequencing mechanics of premiere athletes, as well as monitoring the recovery progress of physical therapies. Existing indexing and extraction technique for motion capture files are based on the whole body motion, where-by motion analysis in sport generally focuses on repeated movements made by specific part of limb such as the arms and legs to measure the effects of a training program. In this research, “Silat Olahraga” movements were used as a case study to apply a new technique for searching and extraction of motion capture files based on different human body segments. “Silat Olahraga” is a type of sport based on “Silat”, a combative art of Malay fighting and survival. A total of sixteen “Silat Olahraga” motion samples simulating four different motion categories were collected and stored as a motion capture database. The process of identification and extraction of logically related motions scattered within the data set called content-based retrieval method was performed to return results to the user. Results from the experiments show that matching motion files were successfully extracted from the motion capture library using the new algorithm based on different human body segments.

ABSTRAK

Definisi perakam pergerakan adalah mengukur kedudukan dan orientasi sesuatu objek di dalam ruang fizikal dan kemudian merakamkan maklumat tersebut ke dalam bentuk gunaan computer. Kegunaan perakam pergerakan meliputi bidang yang luas seperti biomekanik, analisa/latihan ahli sukan, analisa gaya jalan, animasi komputer, pengecaman gerak isyarat, bahasa isyarat, muzik serta seni tarian/persembahan. Masalah yang lazimnya timbul adalah dalam penyimpanan dan kemudiannya mengekstrak fail perakam pergerakan di dalam pangkalan data perakam pergerakan. Pengguna biasanya terpaksa melakukan turutan klip pergerakan secara manual atau membuat carian berdasarkan kata kunci yang memerihal perlakuan sesuatu pergerakan. Penyelidik terdahulu telah memfokuskan terhadap mengindeks dan pertanyaan pangkalan data ini berdasarkan kepada seluruh pergerakan badan. Di dalam penyelidikan ini, pergerakan Silat Olahraga telah digunakan sebagai kajian kes untuk menerapkan sebuah teknik baru di dalam pencarian dan mengekstrak fail perakam pergerakan berdasarkan segmen badan manusia yang berlainan. Silat Olahraga adalah sejenis sukan berdasarkan Silat iaitu satu bentuk seni mempertahankan dan kemandirian Melayu. Pergerakan di dalam bidang sukan biasanya tertumpu kepada gerakan yang dilakukan oleh bahagian-bahagian tertentu tubuh seperti tangan atau kaki. Sebanyak enam belas sampel pergerakan Silat Olahraga yang mewakili empat kategori pergerakan telah dirakam dan disimpan sebagai pangkalan data perakam pergerakan. Kaedah pengekstrakan berdasarkan kandungan telah diterapkan bagi memaparkan hasil pencarian. Hasil daripada uji kaji yang dijalankan menunjukkan fail-fail sepadan telah berjaya diekstrak daripada pangkalan data perakam pergerakan dengan menggunakan sebuah algoritma baru berdasarkan segmen tubuh manusia yang belainan.

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CHAPTER 1

INTRODUCTION

1.1 Background

The study of human locomotion and its applications have changed since it began from the cave drawings of the Paleolithic Era. The reason for human locomotion studies during its early days were driven by the need to survive by efficiently moving from place to place, escaping from predators and hunting for food (Thomas & Eugene, 2000). Modern-day human locomotion studies have contributed to a wide range of applications ranging from military use, sport, ergonomics, and health care. In locomotion studies, according to Susan (1991) the term *biomechanics* became accepted during the early 1970s as the internationally recognized descriptor of the field of study concerned with the mechanical analysis of living organism. In sport, human locomotion studies are made to stretch the limits of an athlete when even the smallest improvement in performance is pursued eagerly (Atha, 1984). However, the advancement of human locomotion studies remains dependent on the development of new tools for observation. According to Thomas & Eugene (2000) more recently, instrumentation and computer technology have provided opportunities for the advancement of the study of human locomotion. Atha (1984) described numerous techniques for measuring motion and

mentioned the co-ordinate analyzer (*motion capture* device) as a significant advance in movement analysis.

According to Maureen (2000) *Motion capture* or also known as *mocap* was originally created for military use before it was adapted into the entertainment industry since the mid 1980's. Dyer, Martin and Zulauf (1995) define *motion capture* as measuring an objects position and orientation in physical space, then recording that information into a computer usable form. According to Kovar and Gleicher, 2003; Suddha, Shrinath and Sharat, 2005 *motion capture* is the fastest way to generate rich, realistic animation data. James *et al.* (2000) describes that *Mocap* can also be applied in several other fields such as music, fine art dance/performance, sign language, gesture recognition, rehabilitation/medicine, biomechanics, special effects for live-action films and computer animation of all types as well as in defense and athletic analysis/training.

There are basically three types of motion capture systems available such as mechanical, electromagnetic and optical based system. All three systems go through the same basic process shown in **Figure 1.1**. The first step is the input where the movement of live actors either human or animal is recorded using various method depending on the type of the motion capture system used. Next, the information is processed to identify the corresponding markers of the live actor and then transferred into virtual space using specialized computer software. Finally the output is where the information is translated into a 3D trajectory computer data that contains translation and rotation information known as *motion capture* file.

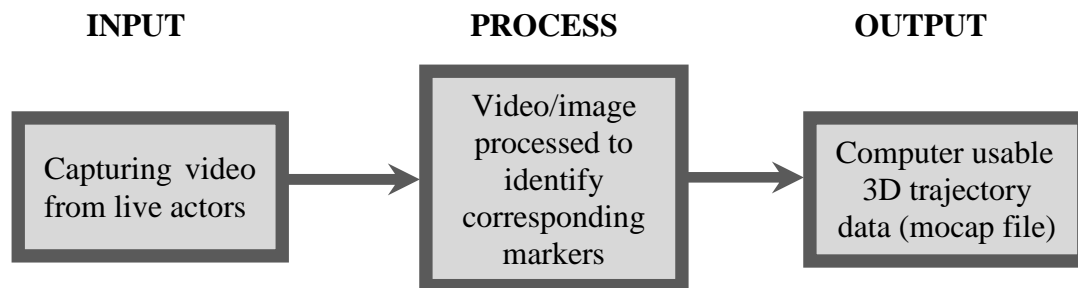


Figure 1.1 Basic Motion Capture Process.

Training or coaching sport activities such as *martial art* have been traditionally exercised by means of observations and visual assessment. This trend however is fast becoming obsolete with the rapid growth of research and developments in sports science. According to Atha (1984) visual assessment is commonly practiced because of the fact that it is low cost but not without its significant drawbacks. It is relatively slow, it has to sort what it wants from a great variety of visual information, and its usefulness is limited by the small capacity short term memory to which it has access.

Scientists at National Geographic employ state of the art mocap system to measure and map the speed, force, range and impact of *martial art* fighter techniques (Yancey, 2006). This is a practical step to take *martial art* to the next level since most of the popular self-defense techniques such as *Tae Kwon Do*, *Karate* and also '*Silat Olahraga*' have been adapted to become a new form of sport which raises the issue of safety and competitiveness in term of training and coaching. The goal of this research is to apply scientific method towards '*silat olahraga*' training and coaching technique.

1.2 Problem Statement

- 1.2.1 Even though motion capture is applied into so many fields by creating physically perfect motions, it has a few significant weaknesses. According to Hyun-Sook & Yilbyung (2004) firstly, it has low flexibility, secondly the captured data can have different data formats depending on the motion capture system which was employed and thirdly, commercially available motion capture libraries are difficult to use as they often include hundreds of examples. Shih-Pin *et al.* (2003), states that motion capture sessions are not only costly but also a labor intensive process thus, promotes the usability of the motion data.
- 1.2.2 In the field of animation and gaming industry, it is common that motion clips are captured to be used for a particular project or stored in a *mocap* library. These clips can either be used as the whole range of motion sequence or as part of a motion synthesis. In sport science, mocap data is used for analyzing and perfecting the sequencing mechanics of premier athletes, as well as monitoring the recovery progress of physical therapies. This simply means that a vast collection of *motion capture* files or *motion capture* library are accumulated. Currently, motion data are often stored in small clips to allow for easy hand sequencing and searches based on keywords describing the behavior (Jernej *et al.*, 2004; Tanco and Hilton, 2000). However, according to Hyun-Sook & Yilbyung (2004), Carlos (2001), Tanco and Hilton, (2000) a *motion capture* library is not good at storing and retrieving *motion capture* files as a database. This calls for an immediate need for tools that index, query, compress, annotate and organize these datasets (Feng *et al.*, 2003)

- 1.2.3 During a biomechanics study for the purpose of performance improvements among athletes such as the one done by Gregory *et al.* (2005), a controlled cohort repeated-measures experimental method was used to study the effects of a specific training program. This involves measuring the before and after effects of such training program and also comparisons among the athletes who participated in the experiment. With a collection of motion sequence in hand, according to Muller, Roder, & Clausen (2005) one has to solve the fundamental problem of *identifying* and *extracting* suitable motion clips from the database on hand. The user usually resorts to describing the motion clips to be retrieved in various ways at different semantic levels. One possible specification could be a rough textual description such as “a kick of the right followed by a punch”. Another query mode would involve a short query motion clip, the task being to retrieve all clips in the database containing parts or aspects similar to the query. Muller, Roder, & Clausen (2005) refer this problem as *content-based retrieval*. This research will attempt to apply automatic *searching* and *extraction* of matching human motion data based on statistical properties as an alternative to hand sequencing.
- 1.2.4 Due to the success of motion capture, many organizations developed their own motion capture file formats which were designed for specific hardware. Because of this, according to Meredith & Maddock (2005), Alexander *et al.* (2007), there are no standard motion capture file formats and according to Carlos (2001) since there are no industry-wide standard for archiving and exchanging of motion capture data, it is hard to predict how different software react with the motion capture files. This is why TRC file format was used to develop the motion search and extraction system for this research since Institut Sukan Negara and Universiti Putra Malaysia both uses Motion Analysis Corporation motion capture system that generates TRC files.

1.2.5 Most of the motion capture file search and retrieval research cited in this research including Kovar and Glicher (2004) are concerned with character animation and motion synthesis where-by according to Bobby *et al.* (1997), in the field of animation, highly abstracted applications of *motion capture data*, analogous to puppetry, are primarily concerned with motion character, and only secondarily concerned with fidelity or accuracy where by additionally, accurate motion analysis is important to the biomechanics community.

1.3 Research Objectives

The research objectives are as follows:-

- 1.3.1 To study and identify a suitable *search* and *extraction* method for biomechanics motion sequence.
- 1.3.2 To develop and to test a motion search and extraction system for biomechanics data.
- 1.3.3 To study the effectiveness of the biomechanics data search and extraction system in a motion capture database.

1.4 Scope of Research

In order to achieve the best possible result from this research, we need to identify the scope in which the research will focus on. The scopes identified are concerning the software, types of data, techniques to be applied and the main topics to be covered related to the research area are as follows:-

1. This research will use the Tracked Row Column (TRC) file format for the system development and sample collection of motion capture files based on Motion Analysis Corporation motion capture System employed by Universiti Putra Malaysia where the motion data/samples were collected. The reason for using the TRC file format is explained on the problem statement 1.2.4.
2. Samples collected on basic 'silat' movements such as punching, kicking and elbowing will be manually segmented to simulate the motion library environment where motion sequences are usually named based on the behavior or the performers.
3. A prototype to apply the motion extraction technique identified from this research will be developed using Microsoft Visual Basic and Microsoft Access Database.

1.4 Research Contribution

The result of this research has generated two main contributions as far as knowledge is concerned:-

1. In this research, a content-based retrieval method for search and motion data extraction has been identified and applied for sequencing/identifying biomechanics data in a motion capture library or mocap database.
2. An automated content-based retrieval for search and motion data extraction has been developed to speed up the process of identifying and extracting suitable biomechanics data from a motion capture library for the purpose of analyzing and perfecting the sequencing mechanics of premier athletes, in relation to sports science.

1.6 Thesis Structure

The structures of the thesis are as follows. The first chapter will cover the introduction explaining briefly on *motion capture*. Also included in this chapter are the problem statement, research objectives, scopes and finally the research contributions. Chapter 2 will discuss the on the past research done on *motion capture* and other related topics to find the best methodology to address the research objectives mentioned in the first chapter. In Chapter 3 will be on the description of the methodologies of this research. Chapter 4 will explain on the implementation of the system development based on the methodology discussed on Chapter 3. Chapter 5 will cover on the test carried on the motion extraction system developed in this research and finally, Chapter 6 concludes this thesis with future directions. The general flow of the thesis is shown in *figure 1.2* below.

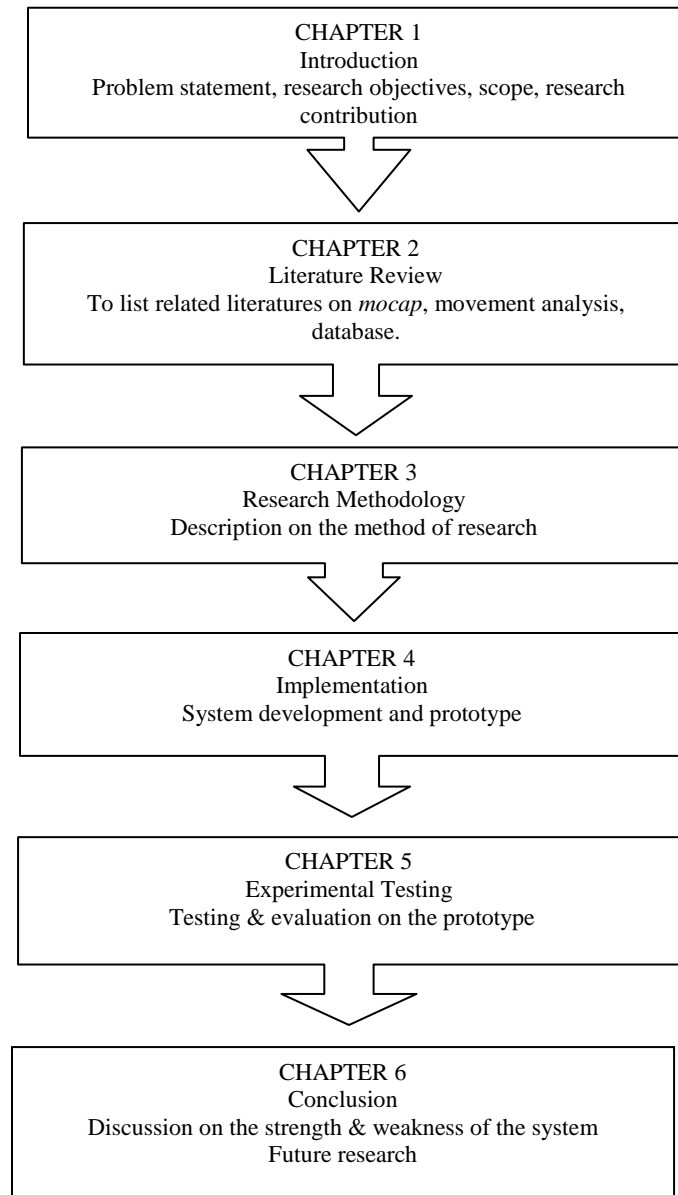


Figure 1.2 Thesis Structure

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