UNIVERSITI TEKNOLOGI MARA

BIOMECHANICAL CHARACTERISATION OF SENI SILAT CEKAK USING A NOVEL 3D MOTION CAPTURE-ANALYSIS SYSTEM

GHAZIRAH BINTI MUSTAPHA

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Mechanical Engineering

May 2018

CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 18th January 2018 to conduct the final examination of Ghazirah Binti Mustapha in her **Doctor of Philosophy** thesis entitled "Biomechanical Characterisation of Seni Silat Cekak Using a Novel 3D Motion Capture-Analysis System" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiner recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

Wirachman Wisnoe, PhD
Professor
Faculty of Mechanical Engineering
Universiti Teknologi MARA
(Chairman)

Ir Muhammad Azmi Ayub, PhD
Professor
Faculty of Mechanical Engineering
Universiti Teknologi MARA
(Internal Examiner)

Badrul Omar, PhD
Professor
Fakulti Kejuruteraan Mekanikal &
Pembuatan
Universiti Tun Hussein Onn Malaysia
(External Examiner)

Shin-Ichiroh Yamamoto, PhD
Professor
Department of Bioscience and
Engineering,
Shibaura Institute of Technology
(External Examiner)

PROF SR DR HAJI ABDUL HADI HAJI NAWAWI
Dean
Institute of Graduates Studies
Universiti Teknologi MARA
Date: 16 May 2018

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Ghazirah Binti Mustapha
Student I.D. No	:	2012895992
Programme	:	Doctor of Philosophy – EM 990
Faculty	:	Mechanical Engineering
Thesis Title	:	Biomechanical Characterisation of Seni Silat Cekak Using a Novel 3D Motion Capture-Analysis System
Signature of Student	:	.....
Date	:	May 2018

ABSTRACT

Characterisation of *Kaedah A* is important to ensure its efficacy as one of defensive techniques emphasised in Seni Silat Cekak Malaysia (SSCM). This is because the ability to fend off an attack with bare hands is questionable since the estimated ordinary human reaction time is 0.18s. In addition, achieving this is also challenging as past research related to characterising martial arts technique suggested the use of motion capture system; which is complex (consisting multiple high-speed cameras), expensive, difficult to handle, devoted to the expert use and only available in certain institutions (sports institute, university laboratory). Thus, the main objective of this study is to biomechanically characterise *Kaedah A*. Furthermore, the objective also include developing a reliable and low cost motion capture-analysis system; which can be used to capture the SSCM movement in quasi-training environment for characterisation purposes. The motion capture-analysis system was developed using the integration of MATLAB GUIs and Kinect™ Sensor. The accuracy and reliability (validity) of the system was then statistically observed in comparison with Virtual Sensei Lite and VICON® (gold standard) system to ensure its validity as an alternative motion capture-analysis system. Then, the system was used to capture the *Kaedah A* (fend off technique) execution performed by 20 experienced Seni Silat Cekak Malaysia (SSCM) practitioners. The time of execution (ToE) and kinematic parameter of practitioner's hand movement during *Kaedah A* execution were determined. As a result, an alternative system named Cekak Visual 3D (CV3D) v1.0 was developed. It is a markerless motion capture-analysis system which is capable to track dual martial art practitioner's skeleton motion in a single frame view. The results for the validity test show that CV3D is reliable and in good agreement with VICON® systems (ICC $\geq$0.6, r $\geq$0.800 and % SEM $\leq$2%). A similar trend between CV3D and VICON® at providing elbow angular changes during *Kedah A* executions, has also confirmed the capability of CV3D in assessing rapid movements. The characterisation results show that the maximum impact velocity ($V_{impact\ ave}$) was 5.02 m/s, determined from the root mean square (RMS) velocity profile. The time of execution for *Kaedah A* was identified to be below 0.1s. The velocity profile also demonstrates that the hand motion reaches its target, just before the left hand reaches the maximum velocity. The results presented are important not only for improving the performance of practitioners but also to demonstrate the efficacy of *Kaedah A*. Therefore, it could be concluded that this study has significantly contributed towards enhancing knowledge about Martial Art Biomechanics and motion capture-analysis system.

TABLE OF CONTENTS