



## Editors-in-Chief

Mohd Fadzli Bin Abdollah – FKM, UTeM, Malaysia  
Tee Boon Tuan – FKM, UTeM, Malaysia  
Mohd Azli Salim – FKM, UTeM, Malaysia  
Mohd Zaid Akop – FKM, UTeM, Malaysia  
Rainah Ismail – FKM, UTeM, Malaysia  
Haslinda Musa – FPTT, UTeM, Malaysia

### First published 2017

Copyright © 2017 by Centre for Advanced Research on Energy (CARE)

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, electronic, mechanical photocopying, recording or otherwise, without the prior permission of the Publisher.

**ISBN: 978-967-0257-88-4 (online)**

### Published and Printed in Malaysia by:

Centre for Advanced Research on Energy,  
Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka,  
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, MALAYSIA.  
Tel: +606 234 6891 | Fax: +606 234 6884 | E-mail: care@utm.edu.my  
www.utm.edu.my/care

## TABLE OF CONTENTS

FOREWORD BY THE EDITORS-IN-CHIEF	ii
EDITORIAL BOARD	iii
REVIEWERS	iv
TABLE OF CONTENTS	vi

No.	Title	Authors	Page
<b>Theme 1: Automotive and Aeronautics</b>			
001	Tribological behavioural of bio-oil extracted from peel waste of musa aluminata balbisiana	<i>H.A. Hamid, N.A.B. Masripan, R. Hasan, G. Omar, M.F.B. Abdollah</i>	1
002	Pre-charge pressure effects on isothermal and adiabatic energy storage capacity for dual hybrid hydro-pneumatic passenger car driveline	<i>F. Wasbari, R.A. Bakar, L.M. Gan, M.M. Tahir, A.A. Yusof</i>	3
003	Influence of iron oxide on the mechanical and tribological behaviors of brake friction materials	<i>R.J. Talib, M.A. Selamat, M. Hisyam Basri, Koay Mei Hyie, N.I. Ismail</i>	5
065	Optimization of process parameters variation on ION and VTH in n-channel double gate FinFET device	<i>N.K. Norddin, F. Salehuddin, N.R. Mohamad, Norhisham Mansor, A.S.M. Zain, K.E. Kaharudin, A.H. Afifah Maheran, A.R. Hanim, H. Hazura, S.K. Idris</i>	138
066	Reliability testing of inertial measurement units in the analysis of physiological variables in archery	<i>Z. Taha, R.M. Musa, M.R. Abdullah, M.H.A. Hassan, M.A.M. Razman, A.P.P. Abdul Majeed</i>	140
067	Wing design for blended-wing-body aircraft	<i>M.H. Mat Yazik, M.T.H. Sultan, A. Hamdan</i>	142
068	Improving manufacturing facilities design layout for a coffee production company	<i>D. Ibrahim, S.M. Hashim, A.I.S. Yusof, Y. Yaakob, N. Hussin, A.A. Azahari</i>	144
069	Particles influence on breakdown voltage of liquid insulating medium	<i>M.H.S. Zainoddin, H. Zainudin, N. Abu Bakar</i>	146

## Reliability testing of inertial measurement units in the analysis of physiological variables in archery

Z. Taha<sup>1</sup>, R.M. Musa<sup>1,2\*</sup>, M.R. Abdullah<sup>2</sup>, M.H.A. Hassan<sup>1</sup>, M.A.M. Razman<sup>1</sup>, A.P.P. Abdul Majeed<sup>1</sup>

<sup>1</sup>Innovative Manufacturing Mechatronics and Sports Lab, Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, Pekan Campus 26600, Malaysia

<sup>2</sup>Faculty of Applied Social Sciences, Universiti Sultan Zainal Abidin, 21300, Terengganu, Malaysia

\*Corresponding e-mail: rabiumuazu86@gmail.com

**Keywords:** Archery; inertial measurements units; physiological indicators

**ABSTRACT** – Archery is a static sport. Detection of any movement is beneficial in ensuring shooting accuracy. Thus, determining the reliability of any detection instrument is paramount. This study aims to ascertain the postural balance, hand movement, muscular activation as well as heart rate of an archer using Shimmer sensors. An archer was observed over two different tests (A&B). Test A with free movement while B with restricted movement. Kolmogorov/Smirnov test was utilized to measure the reliability of the sensors over test re-test in two different tests. The Kolmogorov/Smirnov test re-test reveals a significant difference between all the indicators in both tests A and B,  $p < 0.001$ . IMUs sensors appear to be reliable in measuring some physiological indicators in the sport of archery.

### 1. INTRODUCTION

Current innovative advances reinforce the utilization of inertial measurement units (IMUs) as a practical alternative for the appraisal and measurement of exercise performance beyond the motion analysis laboratory [1]. These IMUs offer various potential points of interest over conventional marker-based frameworks; they are little, cost-effective, simple to set-up and empower the appraisal of human movement in an unconstrained situation [2]. This implies that these universal advancements may have the capacity to possibly quantify human movement and give feedback with respect to the nature of the movement performed [3].

IMUs have been utilized in various ways from evaluating energy expenditure [4]; to gait analysis [5] to medical observation [6]. These sensors have additionally been utilized in the athletic field and sports such as skiing [7] and golf [8]. Recently, the usage of IMUs as a technique for tracking gym and rehabilitation exercises have been examined. Lin and Kulić assessed data collected from IMUs at the hip, knee and ankle during various lower limb works out. Information from the IMUs were utilized to estimate joint angles; with the authors comparing the IMU-derived joint angles to those quantified via a marker-based motion analysis capture system [9]. Despite, the aforementioned development, however, the reliability of such sensors are often neglected or not reported. The purpose of the present study is to test the reliability of IMUs sensors in

measuring the postural sway, hand movement, muscular activation as well as heart during execution of archery related techniques.

### 2. METHODOLOGY

A total of 4 IMUs Shimmer sensors were used in the present study to determine the postural balance, movement of the bow, muscular activations of the muscle flexor digitorum and extensor digitorum as well as the heart rate of the archer. The experimental protocol was implemented in two parts. In first part (Test A), the archer was instructed to sway from the center of his gravity while holding the bow meanwhile, in the second part (Test B), the archer was permitted to limit the movement so as to enable the researcher to discover whether the sensors have the ability to differentiate the selected physiological indicators in the two types of the postural positions. Two shimmer sensors were attached to the left muscle extensor digitorum and the right muscle flexor digitorum to obtain Electromyography (EMG) signals during the performances of the archery related movements described previously. All the data were streamed in real time at a sampling rate of 51.2Hz using an Android phone and transmitted via Bluetooth for further analysis. The areas of all the sensors attachments on the archer's body are shown in Figure 1.



Figure 1 IMUs sensors' location attachments on the archer's body.