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SENSOR-BASED ASSESSMENT USING MACHINE LEARNING FOR PREDICTIVE MODEL OF BADMINTON SKILLS

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Dedicated to all readers, especially you

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ABSTRACT

Badminton assessment is a process to evaluate the performance of players and it is very important for them to identify their strengths and weaknesses so as to improve their training effectiveness. Several conventional assessment methods, which are the lack of manpower, expertise and objective methods. Besides, standard parameters and assessment model using machine learning for badminton assessment are still at research level. The main objective of this research is to design and develop a novel and effective system for badminton assessment . In this thesis, a total of three assessment modules (Module 1: Badminton Serving Accuracy, Module 2: Badminton Shots Quality, Module 3: Player's Agility) were developed to extract the required measurable parameters of players through their serves, hits and agility. A 9 degree of freedom wireless sensor, an APDM Opal sensor and a badminton feedback sensor, XiaoYu 2.0 were used in this study to collect kinematic parameters such as acceleration , power and rotational speed. All the three modules were tested with 3 strong and 6 normal players and there were totally 46 collected features. A total of 39 out of 46 features have been proved being significantly different using t-test method. The three feature selection methods were named Relief, Principal Component Analysis and Correlation Feature Selection and were used for feature extraction. Then, the acquired datasets were tested by seven machine learning models , namely Random Tree (RT), Random Forest, Artificial Neural Network, K Star, Multiple Linear Regression, Gaussian Process and Support Vector Machine. Total of 21 assessment models had been constructed. The results show that the RT model produces prediction accuracy of 90.84% and correlation value of r=0.86.

ABSTRAK

Penilaian badminton adalah satu proses untuk menilai prestasi pemain dan sangat penting untuk mengenal pasti kekuatan dan kelemahan bagi meningkatkan keberkesanan latihan mereka. Terdapat beberapa masalah dalam kaedah penilaian konvensional, iaitu kekurangan tenaga kerja, kekurangan kepakaran, dan kaedah objektif. Di samping itu, parameter standard dan model penilaian menggunakan pembelajaran mesin untuk penilaian badminton masih di peringkat penyelidikan. Objektif utama penyelidikan ini adalah mereka bentuk dan membangunkan sistem penilaian baru dan berkesan untuk penilaian badminton. Dalam tesis ini, terdapat tiga modul penilaian (Modul 1: Kejituan Badminton Servis, Modul 2: Kualiti Pukulan Badminton, Modul 3: Ketangkasan Pemain) dibangunkan untuk mengekstrak parameter yang boleh diukur pada pemain melalui servis, pukulan dan ketangkasan. Sensor wayarles 9 darjah kebebasan, sensor APDM Opal dan sensor suap balik badminton, XiaoYu 2.0 telah digunakan dalam kajian ini untuk mengumpul parameter kinematik seperti pecutan, kuasa dan kelajuan putaran. Kesemua tiga modul itu diuji dengan 3 pemain yang kuat dan 6 pemain biasa dan terdapat 46 ciri yang dikumpulkan sepenuhnya. Sebanyak 39 daripada 46 ciri telah terbukti berbeza dengan menggunakan kaedah ujian-t. Ketiga-tiga kaedah pemilihan ciri dinamakan *Relief*, *Principal Component Analysis* dan *Correlation Feature Selection* dan mereka digunakan untuk pengekstrakan ciri. Kemudian, kumpulan data yang diperolehi telah diuji oleh tujuh model pembelajaran mesin, iaitu *Random Tree* (RT), Hutan Rawak, Rangkaian Saraf Tiruan, Bintang-K, Regresi Pelbagai Linear, Proses Gaussian dan Mesin Vektor Sokongan. Sejumlah 21 model penilaian telah dibina. Keputusan kami menunjukkan bahawa model RT menghasilkan ketepatan ramalan sebanyak 90.84% dan nilai korelasi r = 0.86.

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LIST OF ABBREVIATION

AI	-	Artificial Intelligence
ANN	-	Artificial Neural Network
CFS	-	Correlation Feature Selection
DOF	-	Degree of Freedom
GP	-	Gaussian Process
K*	-	K Star
MAE	-	Mean Absolute Error
MLR	-	Multiple Linear Regression
PCA	-	Principal Components Analysis
RF	-	Random Forest
RT	-	Random Tree
SVM	-	Support Vector Machine
SPSS	-	Statistical Packages for the Social Science
UTM	-	Universiti Teknologi Malaysia
WEKA	-	Waikato Environment for Knowledge Analysis

LIST OF SYMBOLS

°	-	Degree of angle
F	-	Force
Hz	-	Unit of frequency
mm	-	Millimeter
N	-	Unit of force, Newton
s	-	Unit of time (second)
θ	-	Angle

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Sport assessment is a quality tool to evaluate athletes' sport performance in terms of fitness, strength, agility, stamina, gaming skills and knowledge. There are mainly three benefits in the performance assessment.

Firstly, the assessment helps to identify the weakness and strength of an athlete [1]. By doing so, athletes have better idea to plan their training schedule with a clear objective such as to improve their balancing ability. Secondly, it provides a very precise measurement on training fitness such as heart rate, lactate threshold, etc. Thirdly, repeating test with assessment provides strong evidence of improved performance enhancing their confidence and proves the potential to improve further more on their performance. Besides that, the assessment also helps to motivate athletes to keep improving themselves during training session before next assessment. Sometimes, the assessment is also used for talent identification and injury prediction.

Selecting appropriate assessment is vital for different sports since different sports require different skill sets. For example, soccer goalies require different skill sets versus the forwards and midfielders while baseball pitcher's demand is much different with the infielders and outfielders. Therefore, sport assessment must be specifically designed for different sports.

Badminton is regarded as the most popular sport in Malaysia based on the positive international performance [2]. Recently, technology innovation has great influence in badminton game. For example, smart badminton racquet sensors that are able to gather important information such as swing speed, acceleration, shots recognition. Wireless sensor is used to track athletes' stamina, heartbeat, temperature, oxygen consumption and a video-based system is used to record athlete's 3D motion and pattern [3].

With the integration of technology in sport assessment, an athlete will receive important information objectively and accurately. A machine can gather information from multiple angles which are not achievable by human with only cognitive observation capabilities. For sport assessment in badminton, a common method to evaluate a player's performance is to observe his/her agility, playing skills (different badminton shots such as smash and clear), and serving skill by an experienced coach with a skill assessment list.

To fully utilize the gathered information, new technology such as artificial intelligence (AI) is a key tool to bring the data analysis to higher level. One of the popular forms of AI is machine learning (ML). It is a method to classify subjects into different groups based on number of inputs. Thus, coaches and athletes are able to plan efficient training strategies for athletes based on multi numbers of factors. The ML is able to provide a better visualization on athlete's performance and evaluate their unique status.

1.2 Problem Statements

Conventionally, a badminton assessment depends on observation by a coach. Thus, evaluation results are very subjective and easily affected by the coach's perception and experience. Sports technology such as sensor-based system and computer can provide more accurate information which is non-observable by a coach [4], such as acceleration and rotational velocity [5].

Badminton player need to be good in variety of fitness capability such as cardiovascular fitness, agility, power and skills to become a strong player. A lot of studies have been carried out to create objective and quantitative methods to assess badminton player's performance. But most badminton assessment modules only focus on specific training types, such as smash, fitness and agility. Therefore, an assessment module that combines all individual evaluation on agility, fitness and strategies will be designed in this study.

This study was conducted to identify measurable parameters that can be used as predictors to assess player's playing ability by using a sensor-based system with carefully designed assessment modules. The selected parameters must be able to significantly differentiate between strong and normal players thus the player may understand about their current performance easily. The strong players in this study is the badminton team representative who actively participate in training and competition, while the normal players in this study is the casual player who rarely do the training and not representative of badminton team.

Then, the selected parameters or predictors will be used to construct a quantitative assessment model using ML. Currently, there are no any assessment models which can differentiate between strong and normal players with high accuracy > 90% for badminton assessment.

1.3 Research Objectives

The objectives are:

1. To design and develop a set of sensor-based assessment modules which is suitable for badminton assessment.
2. To investigate and propose measurable parameters from the designed assessment modules.
3. To design and develop a badminton assessment model based on the proposed parameters by using machine learning.

1.4 Research Scope

There are two tasks in this study, namely the design and implementation of the badminton assessment modules.

The main purpose of the badminton assessment modules is to identify measurable parameters to differentiate between strong and normal players. The modules are tested by both strong players (the university's badminton team player) and normal players (ordinary university students). The player's data are collected using APDM Opal sensor and XiaoYu 2.0 Badminton Sensor. Analysis was accomplished using MATHWORK MATLAB, Waikato Environment for Knowledge Analysis (WEKA) and Statistical Packages for the Social Science (SPSS).

Parameters with significant difference between the two groups are applied as predictors in badminton assessment model. The predictors are pre-processed by using feature selection methods, namely RELIEF, CFS and PCA. Then, assessment models are constructed based on different modelling methods, i.e. RF, K*, NN, RT, MLR, GP and SVM. The designed model will be evaluated and selected based on its model correlation coefficient, model accuracy, and model calculation time.

1.5 Thesis Outline

The thesis consists of six chapters. Chapter 1 gives general introduction of the project which briefly discussed background of the studies, problem statements, research objectives and scopes.

Chapter 2 looks into literature review relevant to the scope of this study. It explains in details about previous study on badminton, badminton assessment methods, and assessment models.

Chapter 3 presents methodology of this study. It elaborates the hardware and software implementation, and conducted experiments.

Chapter 4 presents the proposal of badminton assessment modules. There are 3 badminton assessment modules designed and tested. It also discusses the acquired results and findings of the 3 mentioned badminton assessment modules.

Chapter 5 describes the design of badminton assessment models. The inputs to the network have used significant parameters obtained from experiments of assessment modules 1, 2 and 3.

Lastly, Chapter 6 discusses the overall finding of all experiments, contribution of this study, the limitations and future work arising as a continuation to this study.

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