Knowledge-Based System Framework for Training Long Jump Athletes Using Action Recognition

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Abstract—The long jump is a part of track and field event. Also, it has been a standard event in modern Olympic Games. Athletes have to use their strength, skills and effort to make distance as far as possible from a jumping point. The long jump consists of 4 phases: run phase, take-off phase, flight phase, and landing phase. The actions in each phase affect to the flight distance. If athletes perform right actions in each phase, their performance will be significantly improved prior. In order to have right actions, they need coaching from experts. However, due to the lack of experts in the field, coaching the right actions cannot be proceeded widely. In this paper, we propose a framework of an expert system for training long jump athletes by combining computer vision techniques and knowledge management theory. The expert system will capture and learn the right actions of the long jump experts in each phase. Then it will be able to analyse and coach learner/jumper based on knowledge captured from the experts.

Index Terms—action recognition, expert system, long jump, computer vision, suggestion system, knowledge-based system

I. INTRODUCTION

The long jump was a section of the first Olympics in ancient Greece, circa 708 B.C., It had first become in the Olympic sport since 1896. It has been included in track and field of the athletic sports on the local, national and also international levels. Long jumpers generally practice following the long jump principle techniques such as approach running, taking-off, flighting and landing to achieve in maximum performance. Until, the world record of the long jump distance for man stands at 8.95 m. The record has been broken by Mike Powell of the United States. The world record set held in Tokyo (1991). Furthermore, since 1988 the women record was held by Galina Chistyakova of the Soviet at 7.52 m [1].

The achievement of long jumping is attempt to jump as far as possible. The long jump which comprise 4 phases are the approach run phase, the take-off on the wood board phase, the flight phase and the landing phase. Furthermore, in order to make the flight distance, the biomechanical parameters of the long jump have been determined by Take-off speed, Take-off angle, Take-off height and Aerodynamics [2]. Moreover, Linthorne (2008) addresses that biomechanical principles of the long jump are the run-up, take-off, flight, and landing phases. These principles are behind the successful for the long distance long jumps [3]. Therefore, long jump performance is considerable for constructing the long jump distance.

Performance of a long jumping is depended on not only a fast horizontal velocity at the end of the run-up but also take-off technique and landing in the sand pitch. These phases of the long jump are very importance and effect to the distance of the long jump, especially, the run-up phase which is the first phase of the long jump. Hey (1985) states that in order to make a fast run up, most long jumps athletes use 16-24 running strides (around 35-55 m.) The athlete reached about 95-99 per cent of their maximum sprinting speed at the end of the run-up [4]. Besides, many long jump athletes use a check mark at 4-6 strides before taking-off on the wood board. Therefore, their coach can easily monitor the accumulated error and also solve run-up in the first phase of the long jump. The take-off phase is also one of important phase for the long jump performance. The long jump athletes have to use a suitable take-off technique. For instance, the take-off leg angle at about 60-65 degree to the horizontal [5], [6]. While, the flight and landing phases are a difficult action on the air. Because, after the take-off the athlete is in free flight, so the all angular momentum have to be considered, for example, the forward angular momentum (circling the arms and legs forward). Finally, the end of the flight phase is the landing on the sand pitch. Long jumpers have to prepare their bodies for the landing by lifting their legs up.
and extending them in front of the body [4].

According to the long jump techniques, the existing coaching methods of long jump are monitoring during the jump, and then suggesting the right actions to the long jumpers or as a slow motion video which is a popular method for analysing motion. Nonetheless, they have to rely on many professional coaches for suggestion techniques and also to correct the wrong actions of the long jump. For example, the optimisation performance of the long jump such as the approach run [4],[5], the take-off [5], [6],[7],[8],[9], the flight and landing [10], [4], [11]. These research have been studied in the sports science research in order to improve the long jump techniques for the athlete’s long jump. Therefore, the knowledge of long jump techniques are held in professional coaches and long jumpers. Thus, problems in transferring the skilled knowledge from professional coaches to the new generation long jumpers are to be considered. In order to make robust suggestion techniques. Computer science technology is an alternative way for helping coaches and athletes to practice long jump techniques correctly.

Nowadays, the development of digital world with the wide spaced digital equipment enable the use of technology to produce huge amount of image and merges the technology into many automatic applications. In the computer science research, computer vision techniques have been employed computer vision techniques for analysing the human movement, called the action recognition. The action recognition aims to automatically analyse and interpret continuity of human movements that made by a human agent during doing a task into actions.

The typical action recognition system consists of the feature extraction, the action learning, the action classification, and the action segmentation [12]. For instance, in Thomas (2001) the long jump technique in the transition from the approach run to the take-off using Time-Continuous kinematic data has been analysed. They classified the complex movement patterns by using the single linkage algorithm. The single linkage algorithm is based on minimising the distance between two objects [13]. Besides, Niebles (2010) presents the framework for recognition complex human activities in the video by using temporal model [14]. Hsu and his colleaques (2006) studied an automatically detect the motion during a standing long jump. First of all the silhouette of the jumper from video sequence were segmented from the background for all frames. Then a GA-based search was used to find the stick model. The stick model points out the essential joints of the person [15]. In addition, Costas et al. (2006), they studied an automatic human detection, tracking and action recognition based on real and dynamic environments of athlete finding. These sports such as pole vault, high jump, long jump, and triple jump were tested in this study [16]. While, in Robin et al. (2012), the use of image processing for measuring swimming biomechanics is demonstrated. They analysed techniques to enhance images for improving clarity and automating detection of both arms and legs segments [17]. These research used computer vision techniques in order to help for analysing human movement and also improving athlete skills.

The review of literatures above has shown feasibility to apply action recognition techniques to long jump biomechanics training jumpers. With respect to construct the high performance smart trainer of the long jump. In this paper of losing knowledge skills, we introduce a new framework of Knowledge-Based System for long jump athlete by using computer vision techniques. The goal of this work is to support the coaching of the long jump athletes and assist for improving their long jump techniques. Also, the system is able to transfer the long jump knowledge to the new generation athletes.

The major contributions of this article are the following: (i) we propose a novel framework of knowledge-based trainer for improving skills of the long jump athletes; (ii) we present a system design of the application of the computer vision techniques for analysing the biomechanics of the long jump. (iii) we suggest the potential of the integrating system design for recommendation athletes in order to prove their skills with knowledge management systems.

The organization of this paper are the background and relate works presented in Section 2. In the flowing, the conceptual frame work of the knowledge-based trainer for long jump athletes is described first in the Section 3. In the Section 4 Knowledge-Based system is designed. Section 5 the preliminary experiment and results are showed at the end of the paper. Finally, Section 6 the conclusion as well as the future work are determined.

II. BACKGROUND AND RELATED WORK

A. Long Jump Biomechanics

Long jump principle has been changed over time to the modern athletics in the mid-nineteenth century. It consists of sprinting on the runway, taking-off on the wooden board, flighting through the air and then landing in a sand pit. An excellence long jumper must be a fast sprinter, strong legs, a good complex take-off, flight and landing. About 6.5-7.5 m is the best female long jumper distances, while the best male distances could be reached around 8.0-9.0 m. [3].

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Fig. 1 shows the long jump biomechanics that consists of the approach run phase, the take-off phase, flight and
landing phase, and the flight distance can be derived from all phases of the long jump.

1) Approach run phase

This phase is an important aspect of the long jumping that lead to a good performance by a fast and accurate run-up. The tasks of the athlete during run-up compose of the acceleration to near-maximum speed, lower the body during almost final step and bring to take-off and take-off foot on the take-off board accurately.

Run-up velocity: Most long jumpers take about 16-24 percent for striding over a distance of about 35-55 m. Then the athlete reaches around 95-99 percent of their maximum sprinting speed. Long jumpers avoid run-up all 100 percent of sprinting speed [18].

Run-up accuracy: The long jump run-up consist of two phases which are the acceleration phase and the zeroing-in phase. During the last few strides before take-off on the board, the athletes are adjusting the length of their strides in order to check how far they are from the board. About five strides before the board have been used for high performance long jumpers. In addition to that, long jumpers are able to adjust the stride with a small loss of horizontal velocity. Novice athletes tend to have mistaken their stride adjustment and high accumulated error later than highly skilled jumpers. A check mark 4-6 strides has been used for many long jumpers before the board [19].

Run-up to Take-off: Hay and Nohara (1990) states that skilled long jumper prepared about two to three strides before take-off with lower their centre of mass (COM). A low position into take-off is vital to provide a large vertical range of motion (ROM). Most long jumpers spend more time for practicing to lower their COM while, minimizing any reduction in run up velocity [19].

2) Take-off phase

In order to perform an appropriate take-off technique at the end of run-up and take-off foot well ahead of COM at touchdown to produce low position at the beginning of the take-off. Later a body of jumper pivots up and over the take-off foot, in at the same time the take-off leg quickly flexes as well as extends. Bridgett and Linthorne, (2006) states that a projectile event is principally for long jumping [5]. Additional, the long jumper desires to maximise the flight distance of the human projectile by optimising take-off velocity and take-off angle. In 2000, Seyfarth and his colleagues revealed that in the long jumping, the optimum take-off technique will run up as fast as possible [6]. On the other hand, planting the take-off leg should be approximately 60-65° to the horizontal [5].

3) Flight and landing phase

The majority of long jumpers employ either ‘hang’ position or execute a ‘hitch-kick’ movement. The athlete actions are considered to control the forward rotation. It is informed by the body at take-off and also to reach an effective landing position [10]. Linthorne (2008) describes the athlete is free flight in the air, so the total angular momentum of athletes must be preserved. The forward angular momentum is produced by swinging the arms and legs. The long jumpers select their technique depend on the angular momentum of they take during take-off as well as the available time on the air before landing on the sand pitch. Many coaches recommend the ‘hang’ technique for the novice athletes because they produce a lower angular momentum and also have less available time on the air. Whereas, the ‘hitch kick’ technique is appropriate for the better athlete. Long jump styles comprise hang style, stride jump and hitch kick are shown in Fig 2 [3].

4) Flight distance equation

Fig 3 shows the jump distance that can be calculated by the summation of the take-off distance, the flight distance, and the landing distance [20].

Equation (1) is the total of jump distance. Wakai (2005) states that 90 percent of the total jump distance is the flight distance. Hence, the biomechanical factors of the long jumpers flight distance are essential in long jumping. The effects of gravity are much more than aerodynamic forces during the flight phase of the long jump. Therefore, the jumper may be determined as a projectile in feet [20]. The trajectory of the COM is defined by the conditions at take-off as well as the flight distance is given by

\[ d_{\text{jump}} = d_{\text{take-off}} + d_{\text{landing}} \]  

\[ \text{(1)} \]

Figure 2. Long jump style: (a) Hang style, (b) Stride jump, and (c) Hitch kick.

Figure 3. Diagram of the total jump distance.
And
\[
d_{\text{flight}} = \frac{v^2 \sin 2\theta}{2g} \left[ 1 + \left( 1 + \frac{2gh}{v^2 \sin^2 \theta} \right)^{\frac{1}{2}} \right]
\]

where \(v\) is the take-off velocity, \(\theta\) is the take-off angle, and \(g\) is the acceleration due to gravity. \(h\) is the relative take-off height, which is given by:
\[
h = h_{\text{take-off}} - h_{\text{landing}}
\]

where \(h_{\text{take-off}}\) is the take-off height and \(h_{\text{landing}}\) is the landing height, the range of a projectile launched from the ground level over a horizontal plane can be derived from
\[
d_{\text{flight}} = \frac{v^2 \sin 2\theta}{g}
\]

B. Long Jump Analysis

Long jump can be distinguished into two parts, sprinting and jumping. The first part is the sprinting which comprises of two phases, the driving phases when the leg is in touching the ground and the recovery phases. Another part is the jumping movement of the long jump, which very similar to sprinting and involves the hip knee and ankle [21].

1) The optimisation performance of physical fitness

The long jump can be separated into four phases: the approach running, taking-off, flighting and landing. Each of these requires many fitness components. First of all, approach running is essential in order to execute a good jump that requires the speed fitness component. In this phase it has been studied and found that the most influential factors of the jump distance is approach running. The second phase, take-off with power, needs to be explosive and fast. The third phase, flight phase, requires the balance due to the good balance affect to flight actions in order to perform appropriate landing. The last phase, landing, is very vital for avoiding athletes from muscle tissue and joints injury. Muscular strength and flexibility are also essential. They help protecting the body of athletes to control and change the direction shows in Fig 4 [21].

![Figure 4. Optimization performance of physical fitness in the long jump.](image)

2) Methods of assessing the components of fitness

Tanya (2010) addresses the methods for improving skill, as well as the performance of the long jump. The components of fitness consist of speed, power, balance, flexibility, motion, and force. These components are considerable factors in order to improve their long jump skill. On the other hand, the long jump distance will be increased. Each of the fitness components are described below:

- **Speed**: Athlete sprints 50 metres, an excellent time is under 7.6 seconds for a male and under 8.1 seconds for a female. The sprint test is an essential component to execute the suitable jump at high speed. A good indicator of speed is ten stride test to monitor athletes’ ability and construct efficiently accelerate from a standing start point. Running 6x20 m from a standing start point that works for the individual measures the time and distance covered in ten strides.

- **Power**: The standing long jump or vertical long jump is the measurement of power. The outstanding result is over 2.5 metres for males, and over 2 metres for females. Power is also important in the long jump. Hence, the competitors require dedicating a maximum power in the rapid time.

- **Balance**: The stork stand test is used for testing that excellent reading for both males and females is over 50 seconds. Balance is extremely importance in the flight stage of the long jump. It aims to gaining the longest distance possibly from takeoff to landing by smoothly glide and in one ahead direction in the air.

- **Muscular Strength**: Leg Strength Test in which area of 25 metres is the measurement test. It is constructed by cones in a straight line. The steps start jogging ten metres, and then proceed to hop on the dominant leg until it reaches the end of the cone.

- **Flexibility**: Sit and reach test is a measurement that excellent reading for males would be over 10 cm, and 15 cm for females. Flexibility is vital for helping athletes to protect their joints, connective tissue and muscle. Additionally, it is very importance in assisting the athletes to reach maximum speed, and power levels in the long jump. Motion: In order to complete an excellent jump, the approach run is vital to construct the maximum speed that influences to the jump. Moreover, momentum is also important especially angular momentum such as on arm and leg rotation. In addition, take-off and flight stages of the jump which are parts of momentum, are very necessary for a high jump as well as carry forward. The higher jump makes athletes stay longer in the air, the longer momentum can carry forward. The arms and legs in flight are also significant factors by swinging forward, as it generates further momentum.

- **Force**: is importance in the take-off stage of the long jump. Take-off on the board with the athlete body can be applied force in order to push off it and increase the height and length of jump. Moreover, the force can be absorbed by bending knees, ankles and hips when the body land [21].

C. Action Recognition

In the computer vision, an action recognition is become a very importance research topic including motion...
recognition [22], [23], facial recognition [24], and movement behavior recognition [25].

Deniel et al. (2011) addresses the action recognition which is a sequence of human movements that constructed by a human agent during the doing of a task. The task of action recognition will be named actions, for instance, define the action label for describing an action case when acted by unlike agents under unlike perspective. The action recognition system will be done by sending instructions to the actor then using simple action verb imperative and comparing with the recognized action names. It comprises the feature extraction, the action learning, the action classification, and the action segmentation. First of all, feature extraction is extracting postures and motions from video to distinguishable features between human actions. Secondly, action learning is the learning statistical model after features extraction is be done. This model is used to classify a new feature observation. Thirdly, action segmentation is cutting motion streams into a single action for example, initial training sequences that use to learn models. Finally, action classification is a reasonable comparison of dataset with a different amount of training and testing, for instance; different subjects such as size, shape, speed, and style is shown in Fig. 5 [12]. Moreover, Ke et al. (2013) demonstrates human activity recognition on video data. There are three aspects for human activity recognition such as core technology, human activity recognition system, and applications from low level to high level representation [26]. On the other hand, the Fig. 6 shows typography of video-based human activity recognition system.

D. Expert System

The Oxford dictionaries (2010) give the meaning of the expert system as “A piece of software which uses databases of expert knowledge to offer advice or make decisions in such areas as medical diagnosis” [27]. Besides, business dictionary (2015) describes that the knowledge of an expert in a particular subject in an artificial intelligence based system (expert system) is converted into a source code. This source code can be combined with other such source codes (based on the other experts knowledge) and also used for responding questions (queries) submitted through a computer. Generally, expert systems consist of three parts. The first, is the knowledge-based component which contains the information of experts and as well as logical rules. The second part, is an inference engine that is an interpreting of the submitted problem against the rules and logic with the knowledge-based. Finally, the last part is an interface that allows the user to show the problem in a human language such as English language [28].

E. Related Works

In the literature review, the human activity recognition
in the video with respect to the sports are considered to study. In this section we present an overview of some related works as well as refer the readers to [26], [12], [29] for the more completed survey. There are several researchers have studied about analysing the movement of the long jump. They proposed the long jump techniques in order to improve the performance of long jump athletes. For instance, approach run techniques, take-off techniques, flight and landing techniques jump [18], [10], [5], [6], [8], [30], [7], [9].

Furthermore, in the computer science research, some researchers employed computer vision techniques for analysing the human movements. Thomas has analysed the long jump technique in the transition from the approach run to the take-off using Time-Continuous kinematic data, in 2001. They classified the complex movement patterns by using the single linkage algorithm with 57 trials (4.45-6.84 m) of time-continuous data. The single linkage algorithm is based on minimising the distance between two objects. In the results, it allows to identify structural changes of movement during a singular and individual movement styles within the same movement type, as well as remarkable specifically concerning the flight phases [13]. On the other hand, Niebles (2010) presents the framework for recognition complex human activities in the video by using a temporal model. 3-D Harris corner detector was used for extracting the features [14]. In addition, the library for Support Vector Machines (LIBSVM) of Chang (2001) was employed. This library was used to classify the activities with KTH Human action dataset, Weizmann action database, and Olympic Sports dataset [31]. Besides, Hsu and his colleagues (2006) studied an automatic motion detection during a standing long jump. The silhouettes of the jumper from video sequence was segmented from the background for all frames. Pose estimation for an individual silhouette and Hue-Saturation-Value (HSV) space were also considered to extract the features. Then the GA-based search was used to find the stick model. The stick model points out the essential joints of the person. 20 frames of a standing long jump video sequence have been used for analysing data. The result shows that silhouettes and computer can be generated stick model of the second and the third frames [15]. Moreover, Costas et al (2006) presents an automatic human detection, tracking and action recognition based on real and dynamic environments of athlete finding. They used the Temporal Signal for segmentation the athlete videos. Additional, the Human Points Detection algorithm has been employed for the extracting features. Besides, these sports such as pole vault, high jump, long jump, and triple jump were classified by using Silhouette analysis algorithm. 39 video data set (12 pole vault, 9 high jump, 8 triple jumps and 10 long jumps) were used for analysing. The result shows that the correct classification rates were (100%) for the pole vault, (88.9 %) for the high jump, (87.5%) for the triple jump, and (80%) for the long jump. And also, if some frames the silhouette estimation algorithm ran failed, the system will not lose its stability [32]. While, Robin and his colleagues used image processing for measuring swimming biomechanics. They analysed techniques to enhance images for improving clarity and automating detection of both arms and legs segments. The Normalized Cuts techniques were used in the segmentation. Then Global Probability of Boundary was considered for the extracting feature. Moreover, a freestyle swimming video footage has been analysed in this study. The results found that the Normalized Cut algorithm provides reasonable super pixel maps. And also the boundary detector can precisely detect the body and draws an almost closed contour around swimmer [17]. On the other hand, some researchers employed the expert system in order to construct the application for keeping knowledge from experts. Such as in 2011, Rueangsirarak used Motion Capture Technology to diagnose falling patterns in elderly people with a Knowledge-Based System in order to determine serious falling risks for them and recommended guidelines for medical treatment [33]. Besides, Oliveira (2014) presents the framework of a knowledge-based system in order to support the creation of e-learning materials. It would be easily adapted for an effective generation of custom-made e-learning courses or programmes [34]. In addition, Welter et al., (2011) developed the concept of image-based case retrieval for radiological education using content-based. It is called Content-based image retrieval (CBIR). This paradigm incorporates a novel combination with aspects of diagnostic learning in radiology: (i) Experiences in a training environment combined with the radiologists working context; (ii) The training cases is up-to-date cause they are stored routine by electronic medical records; (iii) Support adults learning that appropriate for the patient and problem-oriented [35].

III. THE CONCEPTUAL FRAMEWORK OF KNOWLEDGE-BASED SYSTEM FOR TRAINING LONG JUMP ATHLETES

The Fig. 7 illustrates the conceptual framework of the introduced Knowledge-Based System for Training Long Jump Athletes. The framework aims at capturing the knowledge of the expert long jump athletes and also the suggestion in order to correcting the right movement of novice long jumpers. Besides, it will improve their skills and performances of athletes. The system is separated into four sections as (i) Domain Experts, (ii) Action Recognition, (iii) Expert System, and (iv) Action Suggestion.

A. Domain Experts Section

In this section, we firstly prepare for exploiting information from long jump experts both the primary and the secondary resources. The primary information is to be collected from experts such as trainers, coaches, and skilled long jumpers. Thereby, the capturing knowledge either of interviews or captures their movements of long jump athletes. Besides, the secondary information is the
collected data that have been analysed in empirical research for example theory of long jump [3], long jump analysis [36],[21], optimisation of take-off [20], approach run research [37], [38], long jump professionals articles [39], [40], textbooks [2], trainer programs [41], etc. Then analysis both information primary and secondary in order to precisely suggestion, as well as recommendation the right movement of the long jump.

B. Action Recognition Section

This section includes about action recognition techniques for recognising the long jump. We will employ the computer vision technique in order to analysis the athlete image sequence while acting long jump processes. It is called the action recognition [12]. There are 4 steps of action recognition. First of all, object segmentation will use the static camera configuration with a camera for capturing the phase of the long jumping of taking-off and flight phase. Secondly, the long jump feature extraction is to extract characteristics of the segmented objects for example, shape, silhouette, colours, and motion. Thirdly, detection and classification algorithm will be used for recognising the long jump movements. It is based on the represented features. Finally, if the data is accepted by experts, it will be used to train the knowledge-based system in order to make the master pattern of the long jump.

C. Expert System Section

In the expert system section, we aim to integrate the domain experts, the action recognition, knowledge databases and also the action suggestion. In order to suggest good practice to athletes, the expert system will be train for the long jumping [42]. There are 4 sequences of this section are firstly, constructing the recognised pattern (training image data set) and also text suggestion from expert (training text), secondly, generating the rule of each segmented objects with experts suggestion, thirdly, comparing the test movement with the trained pattern by using similarity function, and finally, suggestion text for each action segmentation.

D. Action Suggestion System Section

In this section, an action suggestion system is to give recommendation or suggestion of correct actions for the long jump athletes. The suggestion is an idea that will be accepted or rejected. An action is taken after a decision is required [43]. Some research proposed successfully using of suggestion systems such as recognition of employees for improving their jobs [44], [45], [46]. Thus, we will apply the suggestion system to improve long jump skills. Our suggestion system will be provided summary results that show on the monitor. Moreover, training text for correcting and suggesting the long jump, for example, the approach run, the take-off, the flight, and the landing respectively will be shown as well. In addition, the training programme of the long jump will be provided to improve their skill and also long jump distance. Including the nutrition suggestion for the long jump athletes will be provided as well.

IV. KNOWLEDGE-BASED SYSTEM DESIGN

Fig. 8 shows the system design of Knowledge-Based System for the long jump. The system will be separated into two parts which are the Training process and the Testing process.

The Training process consist of 8 processes: (1) Capturing device, (2) Preprocessing, (3) Segmentation of the video to image sequences, (4) Feature extraction of the captured video, (5) Training of the captured video sets, (6) Discriminative of the Action correlation, (7) Configuration training text suggestion to the image sequences. Finally, keeping to Knowledge Model. The Testing process will be provided the suggestion of the long jump athletes.
jump action. There are 7 processes of the testing process. There are (1) Capturing device, (2) Preprocessing, (3) Segmentation of video to image sequences, (4) Feature extraction, (5) Testing video sets, (6) Similarity measurement, and Finally, Suggestion Actions report. The similarity between the training image sequences from the Knowledge Model and testing image sequences will be compared, after that, the results will be reported on the monitor and also recommended the appropriate practice of the Long Jump Biomechanics.

Figure 8. Knowledge-based system design for the long jump.

V. PRELIMINARY EXPERIMENT

A. Methodology

The purpose of this preliminary experiment was to collect pre-test data and evaluate factor that significant affect the long jump performance. There are two sections including speed performance and long jump performance. To do this, we collected speed, long jump distance, take-off angle, and long jump action. We also recoded action for constructing the action recognition of system.

1) Participants and jumping protocol

Ten male students of Chiang Mai University and a long jump expert are participate in the study (Table I). They are novice long jumpers. The participants were informed about the procedures and the protocol prior to their participation. All jumps were completed in the long jump sand pit. The take-off was performed from the synthetic running track, flat, dry. Besides, the sand landing area was leveled with the take-off surface. Each participant performed one time of 50 metres speed running, and also, three attempts of long jumps at his preferred. They jumped without any knowledge information of the long jump Biomechanics.

<table>
<thead>
<tr>
<th>Participant (E1)</th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
</tr>
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<tbody>
<tr>
<td>Expert (E1)</td>
<td>39</td>
<td>1.80</td>
<td>75</td>
</tr>
<tr>
<td>Novice1 (N1)</td>
<td>19</td>
<td>1.60</td>
<td>55</td>
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<td>70</td>
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<tr>
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<td>18</td>
<td>1.79</td>
<td>69</td>
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<td>Novice6 (N6)</td>
<td>19</td>
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<tr>
<td>Novice10 (N10)</td>
<td>27</td>
<td>1.68</td>
<td>58</td>
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</tbody>
</table>

2) Procedures

Data collection: Data consist of 2 sections including speed performance and long jump performance. First section, speed performance were collected by 50 metres running. While running, time were caught every 10 metres (1-10, 10-20, 20-30, 30-40, and 40-50). Then, velocity were calculated by distance/time. The maximum speed period of each athlete were collected in order to determine
of the check mark stride.

The other section, the long jump performance were collected from the participants, such as, start to take-off distance, time, long jump distance, and take-off angle were noted in the form. In addition, long jump action were captured by a digital camera.

Data analysis: Descriptive statistics were used for calculating the average as well as standard deviation (SD) of start point to the take-off board, velocity, jump distance, and take-off angle.

B. Results

1) Speed performance

Table II shows velocity of all participants with 10m per period of 50m distance. Besides, the Fig. 9 illustrates that almost all velocity of the participants increase slightly to the peak at the 30-40m period, then declines modestly to the end point. The participant N8 is the maximum velocity that rises to 11.90 (m/s). However, it drop rapidly to 8.93 (m/s) at the end point. Therefore, this speed test shows that all of participants should begin running at the point between 30m and 40m far from the take-off board, except for the participant N4, because, he has the peak at the 40-50m period. Hence, his start point should be farther around 40-50m from take-off board.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Velocity of Start to Stop 50m. (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert (E1)</td>
<td>7.46 10.10 9.43 10.75 8.70</td>
</tr>
<tr>
<td>Novice1 (N1)</td>
<td>8.06 8.26 9.35 11.63 8.90</td>
</tr>
<tr>
<td>Novice2 (N2)</td>
<td>8.70 8.40 9.26 10.75 8.93</td>
</tr>
<tr>
<td>Novice3 (N3)</td>
<td>9.52 8.00 9.35 10.64 8.43</td>
</tr>
<tr>
<td>Novice4 (N4)</td>
<td>8.00 9.35 8.85 10.09 10.20</td>
</tr>
<tr>
<td>Novice5 (N5)</td>
<td>9.55 8.52 9.77 10.31 10.00</td>
</tr>
<tr>
<td>Novice6 (N6)</td>
<td>6.80 8.62 9.80 9.90 8.62</td>
</tr>
<tr>
<td>Novice7 (N7)</td>
<td>8.47 8.62 10.00 10.75 8.55</td>
</tr>
<tr>
<td>Novice8 (N8)</td>
<td>7.58 9.01 10.31 11.90 8.93</td>
</tr>
<tr>
<td>Novice10 (N10)</td>
<td>7.19 7.87 9.43 10.42 8.06</td>
</tr>
</tbody>
</table>

2) The long jump performance

Due to the fact that some participants left from this study after speed performance experiment. Eight of participants (one expert and seven novices) cooperated for the long jump pretest. Table III lists the average values of the start distance, velocity, jump distance, and take-off angle.

3) The relationship between velocity and take-off angle effected the long jump distance

Fig. 10 illustrates the scatter plot of the relationship between velocity and take-off angle that effect to the long jump distance of all participants. The result was separated into three groups by the long jump distance which are 3m-4.5m, 4.6m-5.5m, and 5.5m-6.5m respectively. It shows the majority of the long jump distance is around 4.6m-5.5m. Among the plots, we noticed the similar values of velocity and takeoff angle of 2 long jumpers, where the different long jump distances are significant. For instance, two long jumpers tried to jump, the first one was velocity of 6.96 (m/s) with the take-off angle of 21.49° and the other one was at velocity of 6.93 (m/s) with the take-off angle of 22.28°. Both of the long jumpers have similar values of velocity and the takeoff angle. The result revealed that the long jump distances these two participants are considerably different or around 1.18m (6.20m and 5.02m respectively). Therefore, we need to know why the long jump distances are quite different. What alternative factor that influence the long jump distance are performance.
or trainers thereby both interviewing and also capturing long jump motions using video capturing device. Besides, action recognition is to be implemented to analysing data then collect the knowledge dataset not only training image dataset for recognising action but also training text for suggestion actions. In addition, the expert system will be developed for training long jump athletes. One challenging extension is the capability of the system to provide the suggestion, such as approach run, mark points, long jump techniques, as well as training programmes for practices long jump performance.

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