Journal of Theoretical and Applied Information Technology
15th September 2021. Vol.99. No 17

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

PERFORMANCE MEASUREMENT OF VOLLEYBALL PLAYER IN ATTACKER POSITION THROUGH OBJECT DETECTION AND TRACKING TECHNIQUES

BALAJI.S.R[1], S. KARTHIKEYAN[2], R. MANIKANDAN[3]

[1]Research Scholar, Department of ECE, Sathyabama Institute of Science and Technology, Chennai, India
[2]Associate Professor, Department of ECE, Sathyabama Institute of Science and Technology, Chennai, India
[3]Professor, Department of EIE, Panimalar Engineering College, Chennai, India

E-mail: [1]ecebalajisr@gmail.com, [2]skarthi1879@gmail.com, [3]money_kandan2004@yahoo.co.in

ABSTRACT

Individual Performance Measurement of volleyball player is very much essential for the trainers to select the players for the tournaments. Usually, this kind of measurement is carried out by capturing the videos during the test session. But it involves plenty of challenges like occlusion, fast moving videos, complex body actions of players etc. In this paper, we proposed a method to measure the performance of the player when they are in test session. Videos are captured while the players are in test session. The players are detected and tracked from the videos for performance measurement. The work proposed here uses Metaheuristic algorithm for object detection and tracking. Later, we have taken two parameters such as height of jump measurement from ground level when the player leaps to hit the ball and then the arm speed of the player when the player tries to hit the ball. Finally, the average among these parameters for the five attempts is calculated for each player to measure the best performer easily. Based on these two parameters the trainer selects the player for attacker position in the tournament. From the result it was observed that the trainer can select Player 3 as the best player since this player has good average height of jump around 56.1cm and average arm speed of 17.9m/s which is better than the other players.

Keywords: *Metaheuristic algorithm, Height of jump, Arm speed, Attacker position, Player Detection, Player Tracking*

1. INTRODUCTION

Sports are taken to various modifications not only in the field but also virtually. The trainers are the backbone of any sports. The qualified sports persons are taken to the world class tournament only using the training given by the trainers. So trainers play a vital role in the development of skills of players. But many times it is not an easy task for the trainers to measure the accurate performance of the players. It is difficult for the trainer to make live observance to measure the performance of the player during test session.

In order to create a well-qualified player, the trainer used to adopt modern tools to observe the performance of the player. This modern tool helps the trainer to know the strength and weakness of the player. Thus, only way for this is to capture the video of the player and observing their action during the test session. Generally, the height of jump is the important key factor in measuring the performance of the players of volleyball game [1]. When a player tries to hit a ball, the player has to make maximum height of jump to pass the block successfully to the opponent side. The jump that is specific to volleyball such as block jump and attack jump can originally parameter to measure the jumping ability of the player [2]. Thus the arm movement is another important parameter in hitting a ball with greater speed to opponent side.

We found that the video analysis method is the best way to measure the performance of the players as this method could improve the accuracy of measurement and many parameters can be added to measure the performance of the players without using any sensors or accelerators. This video analysis will be useful for the trainers and players to upgrade the performance of the players. In our proposed system, we have captured the video of the player in test session. In this work, we have captured the spike action of the player to hit the ball.

Generally for spike actions, the height of jumping and arm speed of player to hit the ball is important. So, we measured these two parameters to decide the best attacker in volleyball team.

In this work, we used a high resolution Canon 700d 5184 X 3456 pixel video camera. The videos are captured at the rate of 30 Frames/second. The camera is placed in static manner to capture the events of attacker position in volleyball court. The camera is turned on when the player runs and jumps to hit the ball from opponent. Performance measurement is carried out for 5 players and each player is given 5 chances to hit the ball. In this work, the leg movement while jumping and arm speed to hit the ball is measured. The best player is identified based on these two parameters.

2. RELATED WORKS

In this we will discuss the earlier works that are carried out in measuring the performance of the player. A research contains two studies, one is automatic detection of jump method validation and another is to determine Time of Flight (ToF). Each athlete was given a device to wear and they tracked the time of jump. This manual method is used to determine the accuracy of the automatic detection of jump [3]. For every jump, it was located on forced plate. The start and end flight was defined by after and before the centre of flight when the force plate exceeds 5N which is the threshold value.

Another researcher built wearable sensing device to know the talent levels of spikers of volleyball. The players perform various spikers in volleyball court and they classified as three different categories with support vector machine. Based on the categories they were able to identify the skill level differences between good, average and poor players [4]. Another research concludes that the spike jump is important factor that influence the volleyball. They measured the causes for the effective spike jump such as power production in hip, knee power in vertical jump, and take off [5].

Another work discussed about the dynamic data of limb movement like shoulder, wrist, and elbow during the smash in badminton using wireless inertia sensor system. The work result shows that wrist movement plays a vital role in smashing action of badminton sports than elbow and shoulder [6]. In another research, Vertical jump is measured using Opto jump system. This method uses a dual beam optical device which measures the flight time and contracts for series of jumps. The measurement is carried out in various playing positions for each sex separately [7].

A research aimed to develop a Wearable Sensor System to monitor the arm motion of badminton player during serve and stroke actions. They modelled Hand Wrist Monitoring Module (HWMM) to determine the rotational angle of wrist and they also modelled Elbow Monitoring Module (EMM) to determine the rotational angle of elbow. These tools help the players to improve their skills [8]. In a research, running spike jump were measured and compared with one leg and two legs. The data are collected using six IR Qualysis motion capture camera with reflective markers of about 21. The data for kinetic information are collected using ATMI force platforms. Both these kinetic and kinematic data recorded by Qualysis A/D converter which contains 64 channels [9].

In another research, they used 12 Vicon MX-13 cameras which in turn capture reflective 51 markers to access the spike jump of elite male and female volleyball players. The aim of this research is to investigate the sex difference in performance. In addition to this surface EMG, two AMIT force plates are used. The estimation of segmental movements was done via Visual 3D software [10]. In another study, the difference involved in biomechanical characteristics between 1 leg and 2 legs running vertical jump are measured. Similarly this research also used Six IR Qualysis motion cameras and two ATMI force platforms [11]. This method also used various markers which may be dislocated from the measurement spot and affects the accuracy of measurement.

A work examined differences in release of ball and throwing kinematics between female and male hand ball players in throwing in standing position with run up. They observed the result as motions of trunk, pelvis and throwing arm are key information for coaches in giving the feedback to the players [12]. In a work, they compared the skill of spike with one, two and three steps. For this work, they used a special device known as jump mat. This device measures the kinematic variables during the performance [13]. This mat will be definitely will act as the barrier for the player while making the performance.

In a work, in order to determine the individual performance of a volleyball player, they calculated the weighted individual index of performance (WIP) for each participant by saving the residuals of individual ratio between the total touches. This method is used to control the individual performance inside the team performance [14]. In another work, they analysed technical and tactical behaviour among the various age groups and gender at elite volley ball beach players [15]. For this work they took various tactics to measure by capturing their videos and it was found there is no significant difference in tactics and techniques followed among the various age groups or gender.

A physical performance test was carried out for male and female sitting volleyball players. Five test trials were conducted. The parameters like Modified agility t-test, speed and agility test, handgrip tests are carried out [16]. They used various sensors for each test and the players are asked to tie up in the body. The results show that there is significant difference between the male and female sitting volleyball players in their performance.

In all the above works, for measuring the performance of the players, the sensors and accelerators are used. These sensors are tied to the body of the players and will definitely cause the inconvenient to the players and also this does not yield accurate measurement as the sensors may dislocate out of the measurement region where the performance of the player is to be measured. So in existing systems both the accuracy of measurement and the player inconvenience due to sensors tie up are the major problems. Hence, our research focuses on this area to overcome these problems.

3. PROPOSED SYSTEM

The objective of this research is to identify the best spiker in volleyball sports. For this purpose, we used 5 state level male volley ball players. The players were given a chance to make 5 attempts each in spiking a ball. So, around 25 spikes have been taken for the measurement. The best player is identified based on the height of jump and the arm speed to hit the ball.

From our literature survey, we have identified that the researchers used many sensors to measure the performance of the players especially to measure the performance of the arm swing and height of jump. This use of sensors is generally makes inconvenient for players while playing the match. The players normally will have fast moving and abnormal movement in body action while hitting the ball. So, it is not an easy task to fix the sensors in the body of the players which may leads to misplace of sensors during the hard movements by the players. Hence this may cause inaccurate result while making the measurement. So, in our proposed work, we did not use any sensors to measure the performance of the players. Instead, we used image processing technique to measure the performance of the player so that it can resolve the problem which occurs in sensors.

In our proposed work, the videos are captured at the rate of 30 frames/second with the frame size of 960 X 540 pixels resolution. The camera is placed in static manner to capture the events of attacking position in volleyball court. The camera is turned on when the player runs and jumps to hit the ball from opponent. Performance measurement is carried out for 5 players and each player is given 5 chances to hit the ball. In this work, height of jump and arm speed of the player to hit the ball is measured. Based on these parameters, the trainer can easily identify the best attacker for the team.

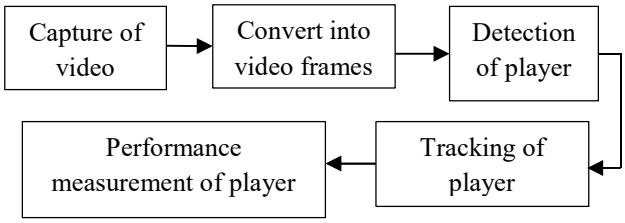


Figure 1: Proposed System for performance measurement of players

The Figure 1, represents the sequence of our proposed work. After capturing the video of test session of the players, the videos are converted into frames. Then we used metaheuristic algorithm to detect and track the players in the frames. After detecting and tracking the players, the performance metrics of the players are done by measuring the height of jump and speed of arm to hit the ball.

Object detection and tracking from video frames are still thrust area of research due to its challenging nature. Many tracking algorithms involve complex computational complexity. This task can be made simpler by using Metaheuristic algorithm. This algorithm can be applied to larger problems. This algorithm is a frame work which can be used for

different optimization problems. It uses to obtain an optimal solution for the complex problems in a shorter and also in reasonable time [17]. This algorithm can solve the problem by considering some assumptions and this is the reason it can solve many problems.

In this paper we used Cuckoo Search Algorithm (CSA) for detection of player in the frame and Bat Algorithm (BA) for tracking the player in video. In our previous researches while we are making object detection and tracking we have measured the performance using various parameters and against other Metaheuristic algorithms. We found the above algorithms are best suited for this application [18]. So we have chosen these algorithms for our work.

4. OBJECT DETECTION

As mentioned earlier, we used CSA for detecting the players from the frames, as this algorithm best suited for player detection. In our video we have challenge like shadows and complex background objects. The background objects like trees, lamp post, pedestrians are all acted as barrier for detecting the players accurately. But we overcame all these barriers and given a better accuracy in detecting the players.

CSA was proposed by Yang [19], and it is based on behaviour of species of cuckoo bird. For hatching the eggs, some species depends on other birds. These are called brood parasites. This cuckoo bird mainly targets the nest of other birds to lay the eggs. The eggs are hatched earlier by the cuckoo than host bird. To increase the food sharing, the new cuckoo babies will throw out from the nest. This is the parasitic behaviour which is used for this algorithm.

In most of the studies it was observed that flight pattern of insects and animals are taken as Levy Flight property. Step length in random walk is based on probability distribution. This nature is useful to make an optimal search [20]. For the new solution x (t +1), search ability is controlled by levy flight. The following are the steps of CSA.

1. 'n' nests are initialized randomly
2. Use levy flight for selecting a cuckoo randomly using the equation 1.

$$X_{i(t+1)} = X_i(t) + \alpha * L \quad (1)$$

where, i=1, 2, …..n

n= Number of nests
α = size of the step
L = value of Levy distribution

3. f(x) is the fitness function Fc which can be calculated using equation 2.

$$f(x) = \sum_{k=1}^{k} \sum_{i=1}^{n_k} (X_i - C_k)^2 \quad (2)$$

where, K = Number of clusters
Xi = Cluster pattern
C_k = Centre for K^{th} cluster.

4. Random nests are selected and fitness function fn are calculated.
5. Replace the nest with cuckoo a fraction Pa of nest replaced by new nest if fc is less than fn
6. Fitness values are calculated and the best nests are retained.

$$f(x) = \sum_{i=1}^{k} \sum_{j=1}^{L+N} ||\alpha(X_j) - \alpha(W_i)||^2 \quad (3)$$

where, K = Number of clusters
L= Normal data
N= Negative data
$\alpha(X_j)$ = Mapping of non-linear function
$\alpha(W_i)$= Cluster centre

7. Best value is stored which the optimal fitness value.
8. Best nest solution is the cluster centre.

4.1 Detection of Player using Adaptive Thresholding based CSA

Generally, thresholding will be decreasing for the intensity of pixels lower than a definite value to zero (black) but the pixels higher than the value selected are specified as one (white). Thresholding method is useful for fast evaluation in segmentation of an image because, this could be a quick and ease processing method. There will be lighting conditions variations in different regions but using the value of threshold globally may not be a good option, in such situation, the adaptive thresholding method is preferred. In our work also we had taken this video in early morning sunlight. So lighting conditions is not stable in all the moment. So we used this technique for the detection of player.

In our work, we took the grey scale image has input for this method. The value of threshold is calculated for each pixel of the image. If the value of threshold is higher than the pixel value then the image is called as foreground image otherwise it is said to background image. This is an optimal threshold value. This threshold value is obtained using CSA. Group fitness is carried out and the optimal value of threshold is calculated using this algorithm. As per this work, the players are foreground objects. So, they are segmented using level set method. This level set method is used for segmentation in the particularly selected region. Later, the morphological operations are performed for the segmentation refinement.

5. OBJECT TRACKING

Object tracking is an important part of this work because; we have made the performance of the player while making the spike in the test session only after this tracking. So the accuracy of tracking is very much essential in this algorithm. In our previous studies, we have analysed the performance of Bat algorithm for tracking of volleyball players. We found that Bat algorithm was found to be good in accuracy in terms of Track Matching Error (TME). So we used Bat algorithm in this work.

Bat algorithm was proposed in the year 2010 by Yang [21]. This algorithm was based on echolocation nature of micro-bats. This can be given by the following steps:

1. Echolocation is the method which was based by the bats generally to know the distance. They can also able to identify the distance between the prey and the background barriers in a magical way.
2. Bats can fly randomly from the position Xi with a velocity V_i in searching for the prey. Bats can adjust the frequency of wavelength of pulse emitted depending on the proximity of the target.
3. It is assumed that loudness vary from A0 (large positive) to a constant value Amin (minimum).
4. Position X_i^{t-1} and velocity V_i^{t-1} of each bat was defined in a search space of d dimension and during the iterations the position and velocity of bat was updated. The new position X_i^t and Velocity V_i^t can be calculated in global search strategy using the following equations 4-7.

$$f_i = f_{min} + (f_{max} - f_{min})\,\beta \quad (4)$$

$$V_i^t = V_i^{t-1} + (X_i^t + X^*)f_i \quad (5)$$

$$X_i^t = X_i^{t-1} + V_i^t \quad (6)$$

Where X* is comparatively current best solution than all the n bats in the current iteration. The size of the problem can decide the value of fmin and fmax. $\beta \varepsilon (0,1)$ is the random vector. The local search is done by selecting the best solution from the current best solution and random walk is used to generate the new solution as shown in equation 7.

$$X_{new} = X_{old} + \varepsilon A^t \quad (7)$$

The pulse rate is increase and loudness is decreased by the bats if they found the target prey.

$$A_i^{t+1} = r_i^0[1 - \exp\exp(-\gamma t)] = r_i^{t+1}\omega A_i^t \quad (8)$$

Where, ω is the frequency of pulse and r_i^0 is the pulse rate and γ is the amplitude attenuation co-efficient.

5.1 Tracking of Player using Bat Algorithm

The video contains the test session of the player and in the background of the court; there are trees, lamp tower and the pedestrians who walk in the lane. Now, Bat algorithm has to identify the player correctly from the frames. At the first frame, the player is detected. Later, initialize the state vector. The state vector can be given as X=(x, y, s). Where (x, y) are defined as the location of target in pixel co-ordinates. The size of the object can be controlled by the parameter s. After selecting the target and initialized the state vector, then the dynamic model is used to generate the state vector. The frequency values of the state vector $f_{min} = [-16, -16, 0.8]$ and f_{min}= [18, 20, 1.7]. The termination iteration condition was taken as 200. Population size is taken as 10 to 40 with each space 5.

6. PERFORMANCE METRICS OF PLAYERS

As discussed earlier, the objective of this work to measure the performance of the player

while making spike, we hereby focused on the measuring the height of jump and arm speed of the player to hit the ball in test session. Each player was given five attempts to hit the ball. In each attempt, the height of jump and the arm speed of the player are measured. Based on this, the best player to perform attacker in the team was selected by the trainer.

6.1 Height of Jump Measurement

Height of jump measurement is an important parameter in volleyball sports. This is a primary skill of any volleyball player to hit the ball. So we have chosen this parameter for measuring the spike action. The height of jump is determined by converting the colour image into grey scale image to increase the intensity of pixel. To increase the accuracy, the frame has to be calibrated first. The calibration is the method for updating the known distance. Now, the pixels get divided among the known height and hence each pixel value is allotted the measurement value close to the original distance of the image. The calibration can be made using the equation (9).

$$Calibration = \frac{Real\ world\ numerical\ value}{Distance\ in\ pixels} \quad (9)$$

Real World Numerical Value is the value of the known distance. Here we consider the height of the bottom of the net to the ground. After calibration, to measure the distance between the two pixels, two points are assigned in the images. Between these points the distance has to be calculated. The distance between the pixels can be determined by using the equation (10). The height of jump (real world distance) is measured by calculating the distance between the pixels based on Euclidean distance and multiplying it with the calibrated value to get the original height of jump (Real world distance (RWD)) as shown in equation (11).

$$Dist.between\ pixel = \sqrt{[X2 - X1]^2} + \sqrt{[Y2 - Y1]^2} \quad (10)$$

$$RWD = Distances\ in\ pixels\ of\ unknown\ height * Calibration \quad (11)$$

6.2 Arm Speed Measurement

The speed of arm can be determined by calculating the distance travelled by the arm to hit the ball with respect to time [22]. For this, the frames taken for the measurement is the frame from which the player started his arm action to the frame which the player hit the ball. This movement by the arm is calculated with respect to time. The movement of arm is taken as distance travelled by the arm. Later, this distance is calculated by Euclidian distance formula which is given in equation (10). Here we took the time as frame rate. Therefore, the speed can be calculated using the equation (12).

$$Arm\ Speed = \frac{Distance\ travelled\ by\ the\ arm\ to\ hit\ the\ ball}{Frame\ rate} \quad (12)$$

7. RESULTS AND DISCUSSION

As discussed earlier in proposed system, we captured the video of the player doing the spike action to hit the ball and we measured the performance of the player based on the height of jump and speed of arm to hit the ball. We have followed sequences of steps like detection of player, tracking of player and then we started measuring the player performance. In this section we discussed the results of the work carried out.

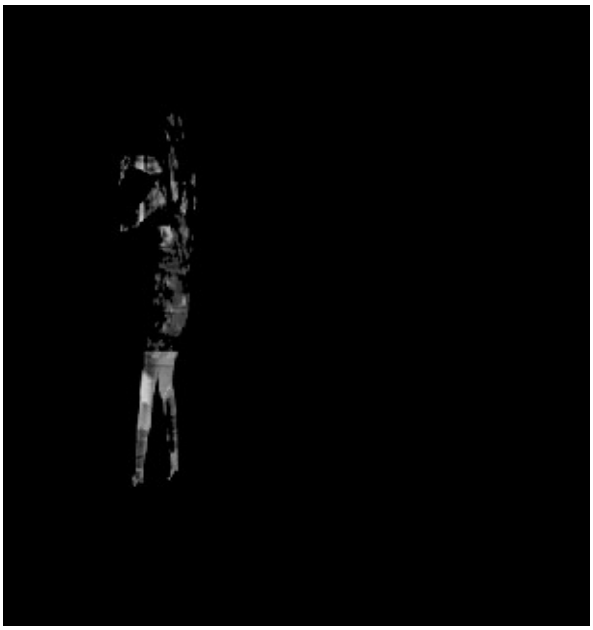
The detection of the player is the primary step of this work. In this work, we used Cuckoo Search Algorithm to detect the player from the video frames. The detection of the player includes certain challenges in our work especially the shadow the player, net and light lamp. This shadow in frames can cause in misdetection of shadow instead of player. Because, the shadows in frame will be detected as foreground object instead of player. So, in this work, we first focused on segregating the shadow pixel and the object pixel. Later, RGB value is normalized and multiplied with matrix [23]. The value of the threshold is compared with the output value. If the output value of the threshold is greater than the value of the output then this output value is taken to determine the value of L using the equation (13).

$$L = GTx(116xY^3 - 16) + (\sim GT)\ X\ (903.3\ x\ Y) \quad (13)$$

If the value of L is lesser than the determined threshold value, then the output will be set to 0 and this is said to be shadowy region otherwise it is said to be foreground object and then the output will be set to 1.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

(a) Input frames for the detection of player



(b) Output frames of the detected player

Figure 2: Detection of player using Cuckoo Search Algorithm

The second step is to track the player in the video frames. We started tracking the player as soon as the player enters into the video frames. We tracked the player from the initiation of running to the hitting of the ball by the player. So almost we have tracked 90 frames for each player. This work uses Bat algorithm for tracking of the players.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Figure 3: Tracking of Player in different frames

7.1 Procedure to measure Height of Jump

1. The pixel values of the starting and ending point of the known distance from the image is found using imtool in MATLAB.
2. Calibrate the pixel value using equation 9.
3. Determine distance between the pixels using the equation 10.
4. Now after calibrating the pixel values and the distance between the pixels, the real world distance can be calculated using the equation (11).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

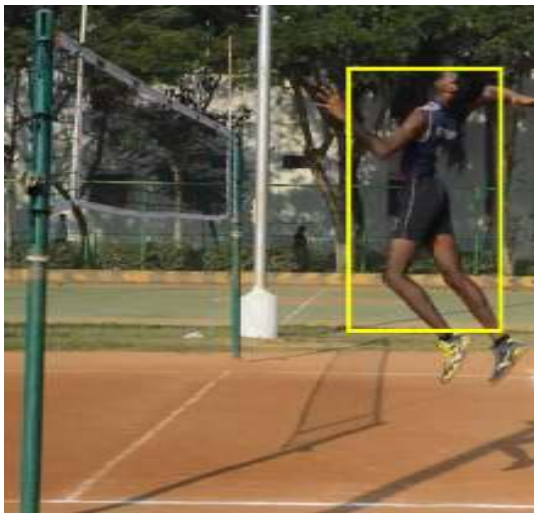
Figure 4: Height of Jump measurement

7.2 Procedure to measure Arm Speed

1. Starting and ending of the arm action frames are taken to calculate.
2. The distance travelled by the arm within these frames are calculated based on equation (10).
3. This distance is measured with respect to frame rate.
4. Speed of the arm is determined using the equation (11).

Journal of Theoretical and Applied Information Technology
15th September 2021. Vol.99. No 17

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195



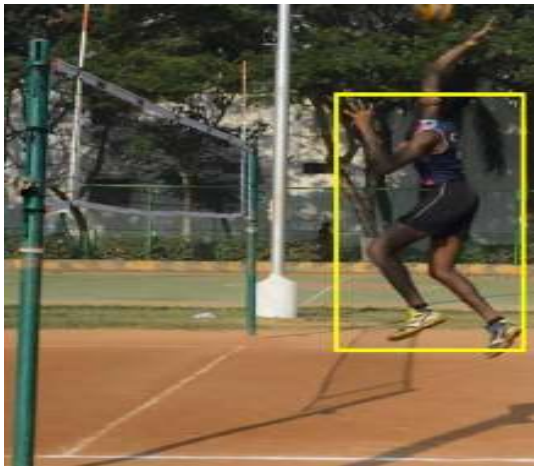


Figure 5: Frames taken for arm speed measurement

Table 1: Comparison of players against of height of jump

Player 1 Height of Player: 189 cm (in cm)	Player 2 Height of Player: 196 cm (in cm)	Player 3 Height of Player: 188 cm (in cm)	Player 4 Height of Player: 187 cm (in cm)	Player 5 Height of Player: 188 cm (in cm)
55.9	48.7	56.9	54.7	52.9
53.2	48.2	55.7	54.4	50.4
54.8	49.1	56	52.3	52.2
53.4	49	55.7	53.9	51.7
53.1	48.5	56.2	54.1	52.6
Average = 54cm	**Average = 48.7cm**	**Average = 56.1cm**	**Average = 53.8cm**	**Average = 51.9cm**

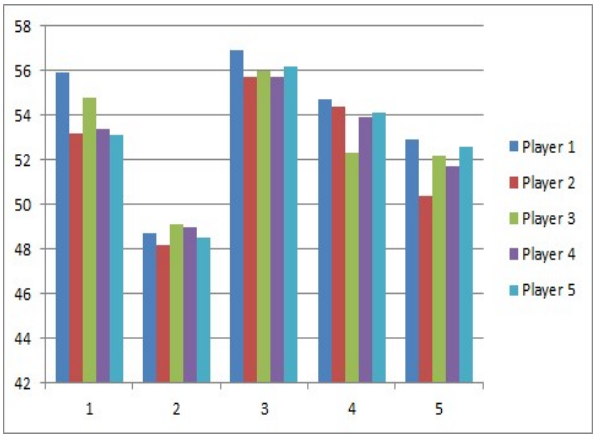


Figure 6: Comparison of Height of jump of Players against various attempts

Table 2: Comparison of players against arm speed (m/s) to hit the ball

Player 1 (in m/s)	Player 2 (in m/s)	Player 3 (in m/s)	Player 4 (in m/s)	Player 5 (in m/s)
15.8	15.4	18.2	16.4	17.5
16.1	15.3	17.6	17.5	16.8
15.8	15.8	18.2	16.8	15.9
14.9	16.1	17.5	18.2	16.7
15.1	16.4	18.1	17.3	17.9
Average = 15.5m/s	**Average = 15.8m/s**	**Average = 17.9m/s**	**Average = 17.2m/s**	**Average = 16.9m/s**

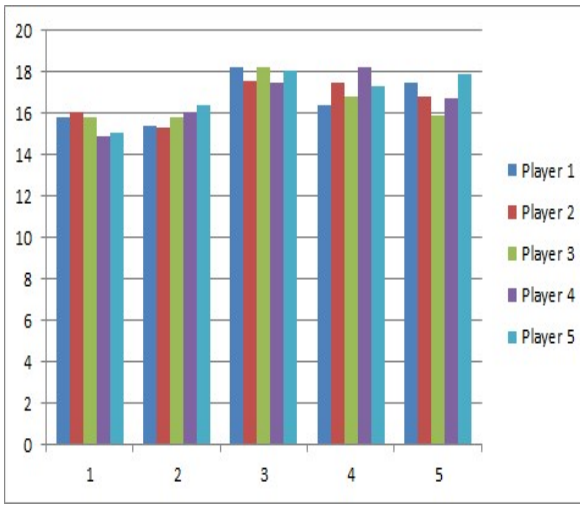


Figure 6: Comparison of Arm Speed of Players against various attempts

As discussed earlier, we have measured the height of jump and arm speed for each player. Each player had made five attempts. We measured the parameters in all the attempts and the results of which are shown in Table 1 and Table 2. From Table 1, the Player 3 has an average height of jump of around 56.1cm inspite of his height 188cm. Table 2 describe the arm speed measurement to hit the ball by the player. The arm speed is started calculated from the frames from which the player started his arm action to hit the ball to the frames which the player hit the ball. From the table 2, it was observed that player 3, has the good average speed of 17.9m/s of arm movement to hit the ball than the other players. The Figure 5 and Figure 6 are the graphical representation of the Table 1 and Table 2. The figure 5 shows the comparison of height of jump of all the five players for each attempt (five attempts). Similarly, the figure 6 shows the comparison of each arm speed of the all the five players for each attempt.

In both the height measurement and arm speed measurement player 3 shows the good performance. In highest measurement, average in height of jump is higher compared with the other players. In arm speed measurement, the player 3 has good average in arm speed to hit the ball. Thus, we concluded that player 3 as the best attacker among the other players taken for this examination.

This work had taken the video analysis of performance of the players instead of sensors or accelerators. This work helps for the volleyball players especially for the players at attacker position in the volleyball court. The detection and tracking techniques is base for the measurement of performance of the players from the video sequences. Since the sensor or accelerators are not fixed to the body in our methods, the accuracy of measurement is high through this method and also this analysis did not cause any inconvenience for the players as the performance is measured purely through video analysis.

8. CONTRIBUTION TO RESEARCH

Our research focuses on measurement of performance of the players through video analysis. As discussed earlier, the detection and tracking of player through Metaheuristic algorithm contributed in measuring the performance of the players. The Metaheuristic algorithms can give optimum solution and involves only less computation than the conventional detection and tracking algorithms. Since our research uses the video analysis to measure the performance of the players, this method can yield better result than using a sensor and accelerators. This method is also cost effective because the sensors or accelerators may not found at market at cheaper cost. This method is suitable for measuring the various parameters of the volleyball player and also can be used to measure the player performance in various positions of the volleyball court.

9. CONCLUSION

This research focussed on the performance metrics of volleyball player in attacker position. This performance metrics will be useful for the trainer to choose the best attacker for the team. The trainer can take necessary actions and can give suitable suggestions to improve the performance of the player based on this performance metrics. In this work, we used image processing techniques to measure the instead of sensors used in conventional methods. We have taken 5 players for this work and each player has been allowed to make 5 attempts to hit the ball. We have taken the average of height measurement and the average arm speed of the player to hit the ball. This research used object detection and tracking technique to detect and track the player from the video frames. Here we have limited our work as the measurement of performance in test session alone. Our research focused only to measure the height of jump and arm speed of the player in

attacker position alone. In future, the arm angle, hip movement and other complex actions of the players can also be taken as the parameters for measuring the attacking performance of the player. This work also can be enhanced to measure the performance of the players in various other positions at the volleyball court using the same methodology. Hence, researchers can focuses on different parameters measurement in different positions of the volleyball court using this technique.

REFERENCES

[1] Thomas Jaitner, Georg Ebker, Marcus Schmidt, "Estimation of jump height for the volleyball spike by a mobile IMU unit", *35th Conference of the International Society of Biomechanics in Sports*, 2017, pp. 222-225.

[2] Damian Pawlik, Adam Kawczy´ nski, Jan Chmura, Krzysztof Ma´ckała, Marcin Kutrzy nski and Dariusz Mroczek, "Jumping Flying Distance and Jump Performance of Elite Male Volleyball Players at FIVB Volleyball Men's World Championship", *Applied Science*, 10, 2045, 2020, pp. 1- 10.

[3] William H. Gageler, Scott Wearing, Daniel A. James, "Automatic jump detection method for athlete monitoring and performance in volleyball", *International Journal of Performance Analysis in Sport*, Volume 15, Issue 1, 2015, pp. 284-296.

[4] Yufan Wang, Yuliang Zhao1, Rosa H. M. Chan3 , Wen J. Li, "Volleyball Skill Assessment Using a Single Wearable Micro Inertial Measurement Unit at Wrist", *IEEE Access, Special Section on Big Data Analytics In Internet Of Things and Cyber-Physical Systems*, Volume 6, 2018, pp. 13758 – 13765.

[5] Ikeda Y, Sasaki Y, Hamano R "Factors Influencing Spike Jump Height in Female College Volleyball Players", *Journal of Strength and Conditioning Research*, 32(1), 2018, pp. 267-273.

[6] C. Z. Shan, E. S. L. Ming, H. A. Rahman, and Y. C. Fai, ''Investigation of upper limb movement during badminton smash,'' *in Proc. ASCC*, 2015, pp. 1–6.

[7] Sattler T, Hadzic V, Dervisevic E, Markovic G, "Vertical Jump Performance of Professional Male and Female Volleyball Players: Effects of playing position and competition level", *Journal of Strength and Conditioning Research,* 29 (6), 2015, pp. 1486 – 1493.

[8] V Stephen, Alvin Jacob, "Quantification of arm join motion for monitoring badminton performance using MEMS based wearable sensor*", Computer Science, 2017.*

[9] Wei-Hsun Tai, Hsien-Te Peng, Chen-Yi Song, Jian-Zhi Lin, Hai-Bin Yu, Li-I Wang, "Dynamic Characteristics of Approach Spike Jump Tasks in Male Volleyball Players", *Appl. Sci.,* 11, 2710, 2021, pp. 1 -8.

[10] Philip X. Fuchs, Hans-Joachim Karl Menzel, Flavia Guidotti, Jeffrey Bell, Serge P. von Duvillard, Herbert Wagner, "Spike jump biomechanics in male versus female elite volleyball players", *Journal of Sports Sciences*, 37:21, 2019, pp. 2411-2419.

[11] Wei-Hsun Tai, Li-I Wang, Hsein – Te Peng, "Biomechanical Comparisons of One-Legged and Two-Legged Running Vertical Jumps", "*Journal of Human Kinematics",* 64, 2018, pp. 71-76.

[12] Ben Serrien, Ron Clijsen, Jonathan Blondeel , Maggy Goossens, Jean-Pierre Baeyens, "Differences in ball speed and three-dimensional kinematics between male and female handball players during a standing throw with run-up", *BMC Sports Science, Medicine and Rehabilitation*, 7: 27, 2015, pp. 1-12.

[13] Qadir, NA, Darweesh, NH, Jalal, NJ., "Comparative analytical study of the approach stage to perform the spike skill of the volleyball game and its relationship to accuracy", *Journal of Physical Education and Sports,* Vol. 20, 2020, pp. 229–234.

[14] Elisa Bisagno, Sergio Morra, Martina Basciano, Carola Rosina, Francesca Vitali "Assessing Individual Performance in Team Sports: A New Method Developed in Youth Volleyball", *Journal of Functional Morphology and Kinesiology*, 4 (3), 53, 2019, pp. 1 - 8.

[15] Jose Antonio Perez-Turpin, Luis Maria Campos-Gutierrez, Carlos Elvira-Aranda, Maria Jose Gomis-Gomis, Concepcion Surarez-Llorca, Eliseo Andreu-Cabrera, "Performance indicators in Young Elite Beach Volleyball Players", *Frontiers in Psychology,* 10: 2712, 2019, pp. 1 - 7.

[16] Shirko Ahmadi, Marco Carlos Uchida, Gustavo Luiz Gutierrez, "Physical Performance Tests in Male and Female Sitting Volleyball Players: Pilot Study of

Brazilian National Team", *Asian Journal of Sports Medicine*, 10 (2), 2019, pp. 1- 6.

[17] Xin-She Yang, "Engineering Optimization: An Introduction with Metaheuristic Applications", *John Willey & Sons, Inc*., 2011, pp. 221-230.

[18] S. R. Balaji, S. Karthikeyan, R. Manikandan, "Object Detection using Metaheuristic algorithm for volley ball sports application", *Journal of Ambient Intelligence and Humanized Computing*, Springer-Verlag GmbH, Germany, Vol 12, Issue 1, 2021, pp. 375-385.

[19] X.-S. Yang and S. Deb, "Cuckoo search via Lévy flights," *in Proc. of World Congress on Nature & Biologically Inspired Computing,* NaBIC 2009, 2009, pp. 210-214.

[20] Ratna Babu, K. and K.V.N. Sunitha, "Enhancing Digital Images Through Cuckoo Search Algorithm in Combination with Morphological Operation", *Journal of Computer Science*, Volume 11, Issue 1, 2015, pp. 7-17.

[21] X. S. Yang, "A New Metaheurisitc Bat-inspired Algorithm in Nature Inspired Cooperative strategies for optimization", *Studies in Computational Intelligence,* Berlin, Springer, Verlag, 2010, pp. 65-74.

[22] R. Manikandan, R. Ramakrishnan, "Human Object Detection and Tracking using Background Subtraction for Sports Applications", *International Journal of Advanced Research in Computer and Communication Engineering,* Vol. 2, Issue 10, 2013, pp. 4077 – 4080.

[23] Adesh Hardas, Dattatray Bade, VibhaWalli, "Moving Object Detection using Back ground Subtraction Shadow Removal and Post Processing", *International Journal of Computer Applications,* Issue 2, 2015, pp1-5.