

Proposing an Analysis System to Monitoring Weightlifting Based on Training (Snatch and Clean and Jerk)

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Abstract:

Analysis system of sports players is very important for individuals in weightlifting. Assessment of player and strength is important for the performance of weightlifting. This paper proposes an analytical method for weightlifters with check-by-frame video. This analysis system can compute the major steps of seven positions in both snatch and clean and jerk methods in frame-video weightlifting monitoring of movements. Each user can compute the major steps of the seven positions of Hu moments among two frames in the video during training, and the Euclidian distance can be computed for the Hu moment values and lifting moment values in the snatch and clean and jerk methods during training. The outcome of the proposed system shows on efficient, accurate results in monitoring movement analysis in weightlifting for players during training in this area.

Keywords: Movement analysis, behaviour tracking, weightlifting, Hu moment, Euclidean *distance*.

Introduction:

Object tracking is an important operation in frame video to detect the movement of objects in videos. For automated analysis in video, the output is the location of the movement based on the frame video (1).

The movements of weightlifting are jerk and snatch – each movement methods generates force to move the barbell off the ground for successful operation (2).

Snatch a one-step motion for raising the barbell to the final location. However, clean and jerk demands a two-step movement to raise the barbell to the final location. The first motion, takes the barbell from the floor, and known as clean, (pressure status) in the barbell interesting, for collarbone. The barbell has thrust overhead in the end locked-out location, and known as jerk (3).

The lifter runs through that motions effects moving the weight higher through the withdraw/leadership stages and lowering the barbell, using the barbell's heaviness to the lifters (3), (4).

Human action in video frames is a strong research field that offers some applications in the computer visions, such as netting-based control, contents-based video analyses, etc., which are used with the increasing number of cameras (3), (5).

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Weightlift Training:

The alternative side of sports training, comprising psychic distance of performance ("motive, set dynamics, and health"), which affects youthfulness therefore the scale of an athlete, has received substantial scholarly interest regarding weightlifting training and trainers who can uses training to craftsmanship technicality of the shape. It can add up to granularity to compute footwork in which the interacting distance of training shape public amounts (6).

• **Type of training:** Coaches provide training at several key steps. The first is when the weightlifter is positioned to the barbell on floor. The second is stand up preferably can a 45 grad corner to assess the overall stance, and the final when a weightlifter is concentrating before beginning to lift.

• **Definition of Movements:**

1. Ground Reaction Force (GRF): The three components vector at the perpendicular, front, backward, and median airplanes at relevance from the land.

2. Snatch Lifting: A barbell in the ground for arm's length in continuous one movement. Though this introduction can be used for the force snatch, a significant variance among the two players is that final or 'taking' status. The force of snatch is know you taking status, where the leg is over 90 grad corner compared to the perpendicular (6).

3. First pull: The first drag happen from the moment of separation (MOS) from the strip of the

floor and continues until the bar reaches the maximum from the knee or, to some sportsman, only over the knee.

4. Power: The neuromuscular system is the ability of implementing an action in a given time or, instead, for production in a pose, it may be a given exerted in speed of motion.

5. Triple Extension: Indicates the motion where the ankle is dorsiflexed; the knee and hip are inflected in a static position; and can be movement fast the ankle, and flexed the knee and hip are extended.

6. Speed Strength: Any ability that contains force, strength, and speed complex to muscular work.

7. Relative Intensity: This is the rate of the 1RM into a specific exercise (raise).

8. Load: This is an indication to the entire weighting from the barbell.

9. Stretch: Shortest stretches and movements inverse, of a muscle short instantly stretches the and strength increase movements the resulting, where energy cost reducing (6).

10. LEARNING AND TEACHING THE LIFTS

There is no single perfect learning advancement for the snatch and clean and jerk methods. Methods vary according to technical pattern variance, imitation, available time, resources, and needs of the individual. There is a wide variety of coaching methods for the substantial number of successful weightlifters worldwide. There are two groups of Olympic bars: training and competition, as shown in Fig. 1 (6).

Step-by-step technicality is illustrated as follows: behind expansion, cable line, veal raise, lock-calf seat journalism, chew abdominal work, curl, deadlift (bow-legged), drop seat journalism, dumbbell row, finger expansion, handful machine coaching, decline seat journalism, leg journalism, lift strip work, and L-fly (7).

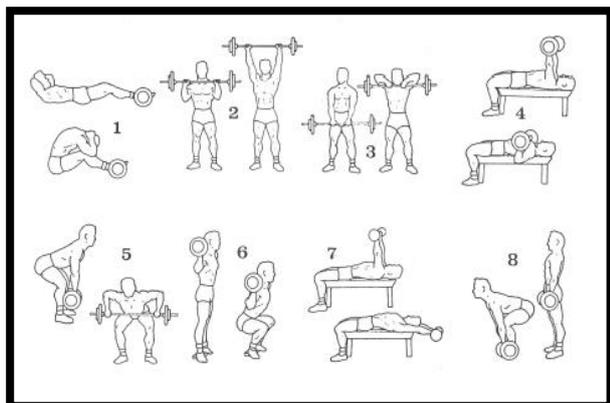


Figure 1. Training for weightlifting.

Competitiveness and Commitment:

For every competitive sport, successful competitors require specific individual traits that supports training. The sportsman lug competition mostly may be seen out of previous in other sports, 'but this does not always translate completely into weightlifting' (8).

An athlete's obligation to weightlifting and training is a significant element for success. If an athlete is not keen on training, it will be clear in his or her performance, and this will outline the efficiency of the programming. Coaches need to be motivated, but to reach their true potential, athletes need to be driven, and disciplined and aim oriented on their own. If an athlete need(s) to be continually coerced into the training and competing, it's very unlike(ly) that athlete will be successful in reaching his or her physical potential (9).

Previous Weightlifting Work:

In 2010, Crow, and Cook, proposed a new workouts four players man and four women weightlifters offers that games specimen after, and before four exercises through a four weeks coaching time. Coaching included the three workouts: (snatch, clean and jerk), and forward squat with the one repetition maximum' (1RM) computed of all coaching through all exercises. The (($p < 0.05-0.01$)) coaching refinement results into the 1RM range ((4.0%-5.2%)) were observed through snatch and clean and jerk workouts, over Olympic full lifting (10).

In2013,Chatzitofiset *al.* proposed a new workout using three-dimensional (3D) data in coaching weightlifting of athletes. The athletes' weightlifting attempt is monitored, helping coaches to coach athletes as preferred. This reveals extraction data and helpful information in which 3D body movements of the weightlifter are computed. The result obtained the comparison hue moment movement speed between two athletes different in weightlifting, this system gives, any athlete is best among other athletes (11).

In 2016, Onofriet *al.*proposed a new workout and referred that emerging computer monitoring such as knowledge based personal action recognition at the objective for cover in methodology. The approach and methods used in proper weightlifting represented and integrated knowledge in the recognized operation. They can be grouped as "statistic, syntactic, and descript-based methods". The public and private sets of data used in this frame video can be helpful for readers in weightlifting training (5).

Interim Medium Background Subtraction:

Frames make a difference in the calculated efficient progress for each original method. The front is detected by contrasting the sequential images in a video sequence and distinguishing the areas where they vary.

The time-varying background subtraction method (2), after an estimation of the visual background, B_t , is calculated by recursively updated pixel values for all pixel positions. All pixels are classified by contrast variance, D_t , among "the current frame, I_t , and the background, B_t , with the threshold T " illustrated in Equations (1, 2, 3)

$$D_t = |B_t - I_t| \dots\dots\dots 1$$

$$M_t(x, y) = \{0, \quad Dt(x; y) \geq T \dots\dots\dots 2$$

$$\{ 1, \quad Dt(x; y) < T$$

The background example, " B_t , is updated at every interval step by applying the adaptive mean to a learning rate α ".

$$B_{t+1} = \alpha I_t + (1 - \alpha) B_t, \dots\dots\dots 3$$

where I_t as status frame, M_t as generate binary frame, α as learn rate, B_t as generate adaptive frame, and D_t as variance among B_t and I_t (12, 13, 14).

Filter-Based Correlation in Tracking-Frame Videos:

Correlation filter procedures can be used in video frames. The video frame, as a suitable shape or give image, is one of the important problems in computers visions are the object feature is collection of data. Object images can be detected using a correlation filter or some another filter (15, 16, 17).

For calculation efficiency, the spatial frequency region $[u, v]$ is calculated, as in equation (4):

$$C[u; v] = I[u; v]F^*[u; v] \dots\dots\dots 4$$

Efficiency correlation operation is computed by exchanging the convolutions with each other using element-wise multiplication; it uses discrete Fourier transform (DFT). The DFT of a vector is calculated by the efficient fast Fourier transform (FFT) algorithm. Following the correlation process, spatial trust maps or a response map can be obtained using inverse FFT. The placement with a high value in this map is then predicted as the new target state (18, 19).

The major concept backward correlation filters is used to control the feature in the cross correlation output among the image and the filter uses lowering the medium [16]. It is completed as a task relative shift among the form and inquiry images using equation (5) (20).

$$C = \frac{I[u, v]T[u, v]}{|I[u, v]T[u, v]|}, \dots\dots 5$$

"where $I(u, v)$ is the 2D FFT for the query image; $T(u, v)$ is the 2D FFT for the template image; and C is the correlation plane".

To find the peak sharpness, equation (6) is used, and the output value is called the peak-to-correlation energy (PCE) (20):

$$PCE = \frac{\text{Max peak-mean (correlation plan)}}{\text{Standard deviation (correlation plan)}} \dots\dots 6$$

Image Hu Moment Value:

The Hu moment is used to define the likeness among two patterns. There are seven standard types of Hu moments: translation, scaling, and rotation. However, the seventh moment is affected by an inverter (20).

Two corresponding styles can be determined by joining the seven moment values into one vector; for every style and then contrasting the two vectors. However, the vectors together would show a small variation and would look similar in style (20, 21).

The seven moment values are given below:

$$\begin{aligned} \emptyset_1 &= \eta_{20} + \eta_{02} \dots\dots\dots (7) \\ \emptyset_2 &= (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 \dots\dots\dots (8) \\ \emptyset_3 &= (\eta_{30} - 3\eta_{12})^2 + (\eta_{03} - 3\eta_{21})^2 \dots\dots\dots (9) \\ \emptyset_4 &= (\eta_{30} + \eta_{12})^2 + (\eta_{03} + \eta_{21})^2 \dots\dots\dots (10) \\ \emptyset_5 &= (\eta_{30} - 3\eta_{12})(\eta_{30} - \eta_{12}) [(\eta_{30} - \eta_{12})^2 - 3(\eta_{21} - \eta_{03})^2] + (\eta_{03} - 3\eta_{21})(\eta_{03} - \eta_{21}) [(\eta_{30} + \eta_{12})^2 (3\eta_{21} + \eta_{03})^2] \dots\dots\dots (11) \\ \emptyset_6 &= (\eta_{20} - \eta_{02}) [(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \dots\dots\dots (12) \\ \emptyset_7 &= (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12}) [(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03}) [(\eta_{21} + \eta_{03})^2 - 3(\eta_{30} + \eta_{12})^2] \dots\dots\dots (13) \end{aligned}$$

where η_{pq} is the stamping centric moment of system $(p+q)$: $\eta_{pq} = \mu_{pq} / \mu^{\gamma} \sigma^0$, $\gamma = p+q+2/2$, and μ_{pq} is the centric moment of $f(x, y)$ defined by equation (14):

$$\mu_{pq} = \sum_x \sum_y (x-\bar{x})^p (y-\bar{y})^q f(x, \bar{y}) dx dy, \dots\dots (14).$$

where $\bar{x} = m_{10}/m_{00}$ and $\bar{y} = m_{01}/m_{00}$ 'are the centric moments of the image, where x is the row number and y is the column number of pixels in the image (f) ' (22).

Proposed Weightlifting System

This work proposes a method for analysis clean and jerk and snatch workouts for weightlifters represented by the seven main positions of the movements in weightlifting in snatch and clean and jerk methods of a video frame.

The major steps for the analysis system of the lifters' performance of weightlifting are shown in Fig. 2.

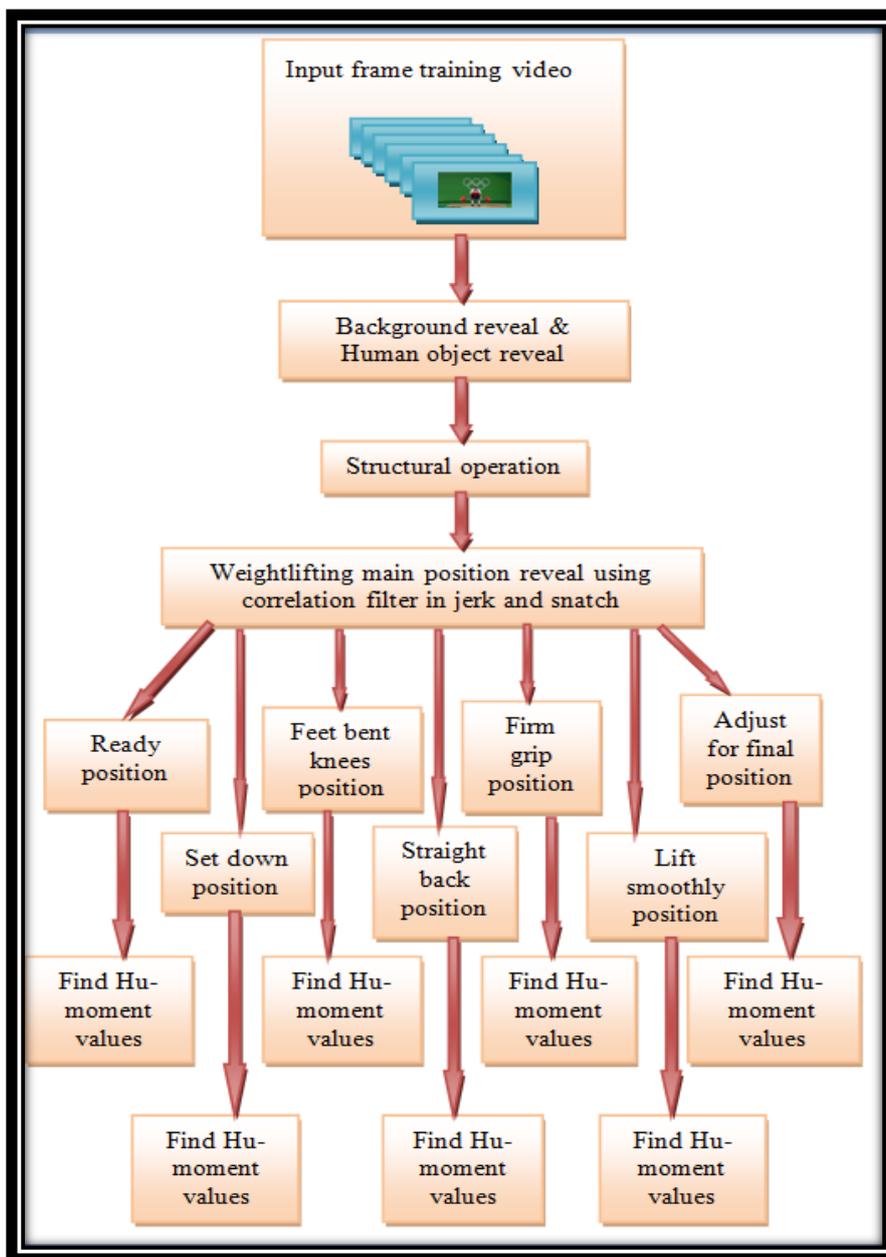


Figure 2. Main steps of proposed system(clean and jerk method).

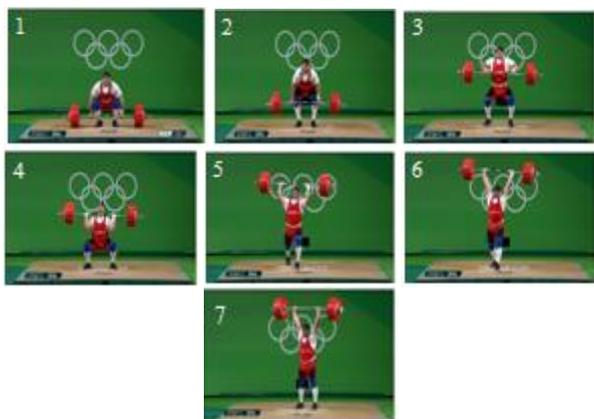


Figure 3. Movement position in weightlifting clean and jerk: 1) ready, 2) set down, 3) feet bent knees, 4) straight back, 5) firm grip, 6) lift smoothly, 7) adjust for final position.

A. Subtract Frames from Background Video

The proposed a analysis system automates the analysis for weightlifters in close-up view using video frame. The system first reveals of individual, then utilises a correlation filter to show the major movement locations in weightlifting (clean and jerk method: ready, set down, feet bent knees, straight back, firm grip, lift smoothly, and adjust for final position), as shown in Fig. 3, then detects the main kinetic positions in weightlifting (snatch method: ready,set down, get into a squat position with back flat, arms straight, hips higher than knees, look forward, and adjust for final position), as shown in Fig. 4.

Fig. 6-a and b show the binary frame video before and after applying the structural process for snatch and clean and jerk methods.

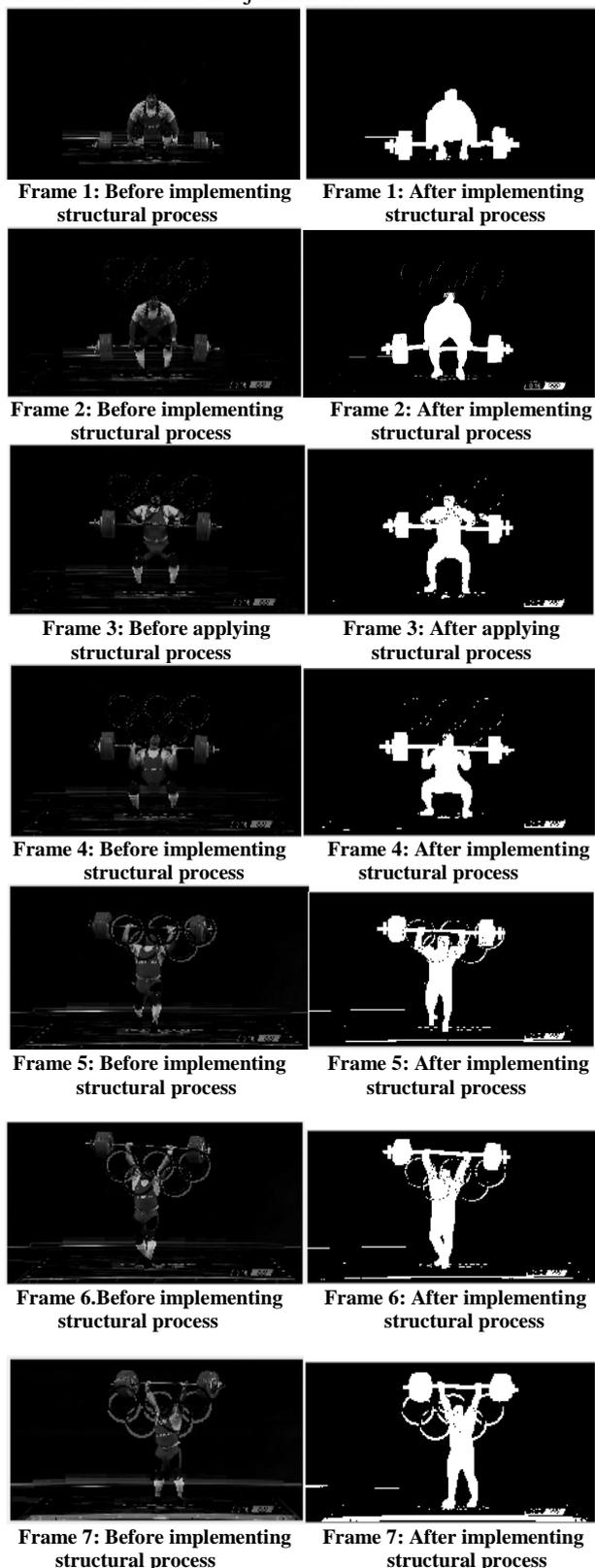


Figure 6a: Result of structural operation in clean and jerk.

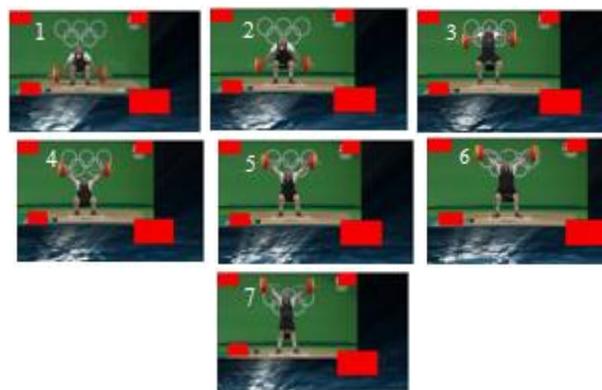


Figure 4. Movement position in weightlifting snatch: 1) ready, 2) set down, 3) get into a squat position with back flat, 4) arms straight, 5) hips higher than knees, 6) look forward, 7) adjust for final position.

Finally, the system would analyze these locations and compared them in the stored idle locations to determine the improved performance.

B. Binary Image in Frames

In this step, the analysis system subtracts the video background from the video frame. It depends on an adaptive interim medium method. This step can provide a constant background video frame seven movement that have no movable objects, as shown into Fig. 5.

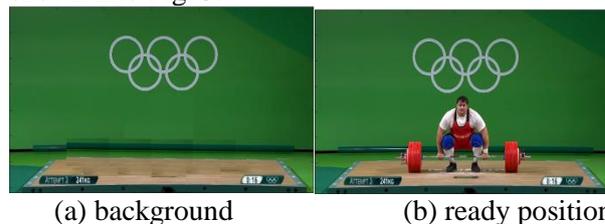


Figure 5. Stationary background.

Even with a fixed background, this picture changes with different lighting conditions. The subtraction process of the background image cannot remove all the illumination effects.

The goal is to show a white object in a black background; it is the big body into the frame, so the closing structural process is applied in all frames to removes the small white objects. The structural operation is applied for thresholding values, and defy is choosing the specific function to computation.

The correct threshold values can be lower enough for eliminating background noise, and higher enough to view the centric body and reveal the border of the lifter in the front. The operation would generate an acceptable user feature at the image, as the threshold values remove the white bodies that are less than 150 points, and would not affect the analysis system execution at the next steps.

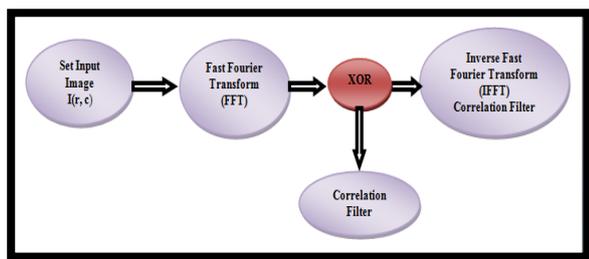


Figure 7. Operation of the correlation filter.

The analysis system needs a collection of an inactive position which appears to the seven major lifting locations at the snatch and clean and jerk methods. These locations are binary images that can be utilised by "correlation filter". The correlation filter has been used in all video frames in the seven major lifting positions in clean and jerk and snatch methods.

To obtain the best results, the approach is applied only on a square region that aligns with the user feature (area of advantage) into the video frame. Using "thresholding" value, the square feature and central distance to the lifter are determined, the square area can be created and found the central pixel of the individual (centre of the binary objects uses at the structure-centring process).

This defy selects the limited function to calculates. The right threshold values are low enough to narrow the likely area, yet, are higher enough for allowing their complete image of the individual in the frame video. Area is configured to be the same size as the stock binaries images for seven positions. This operation can reduce inaccuracy.

The first step in the correlation filter procedure for both the snatch and clean and jerk methods uses FFT for the binary image to represent the seven positions (inactive and stock positions) in a matrix in 2D. Then, the correlation filter is used on all frame videos, using the convoluted method and storing the outcome in a 2D matrix to create images from the 2D correlation outline. The combined high peak is determined, such as the reveal position in weightlifting clean and jerk and snatch methods, as shown in Fig.8 a and b.

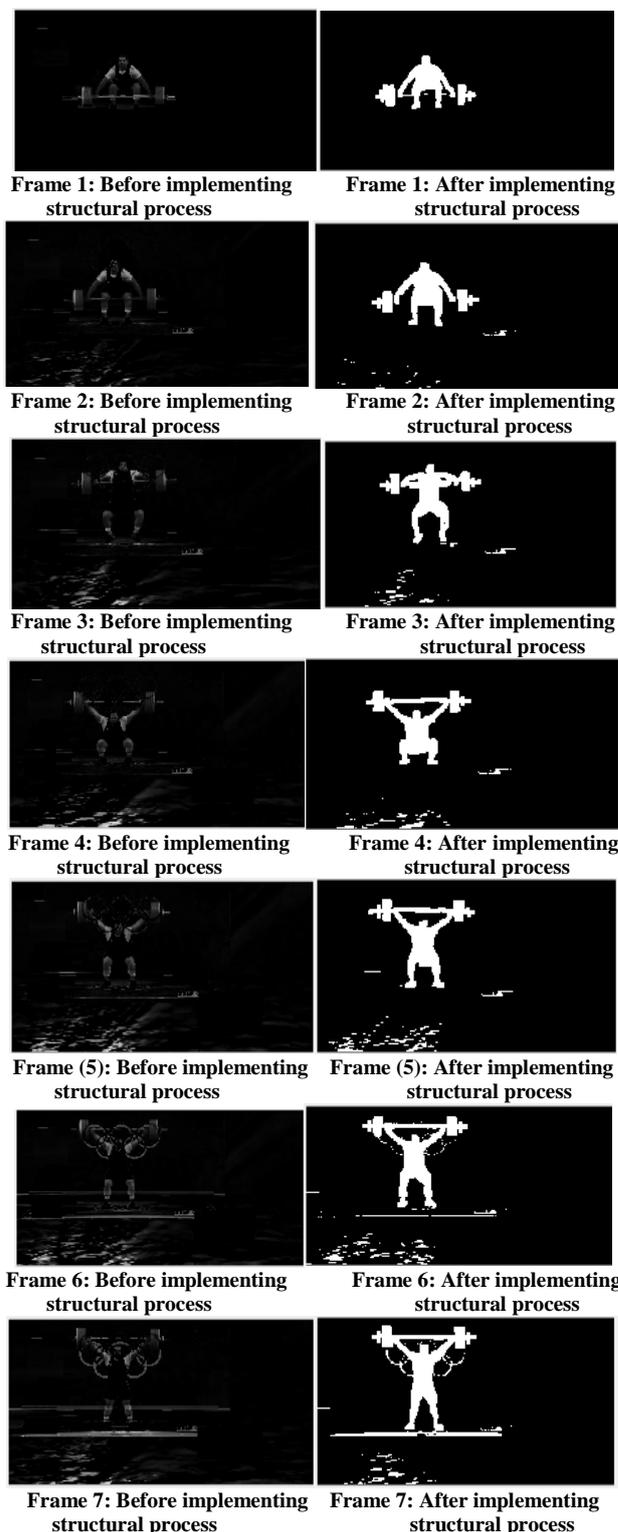


Figure 6b. Result of structural operation in snatch.

C. Correlation Filters in the Analysis System

The correlation filter in the analysis system describes the operations to input images and convert to Fast Fourier Transform (FFT) and applied of correlation filter in seven movements, and the output is used Inverse Fast Fourier Transform (IFFT), as shown in Fig. 7.

positions in weightlifting (clean and jerk and snatch).

Table 1. Correlation filter PCE

Weightlifting Jerk	
Position	PCE
Ready	0.3006
Set Down	0.4441
Feet Bent Knees	0.8163
Straight Back	0.2639
Firm Grip	0.3318
Lift Smoothly	0.4491
Adjust for Final	0.4287

Table 2. Correlation filter PCE.

Weightlifting Snatch	
Position	PCE
Ready	0.7174
Set Down	0.5984
Get into a Squat with	0.1168
Back Flat	
Arms Straight	0.2413
Hips Higher Than Knees	0.1295
Look Forward	0.2070
Adjust for Final	0.9155

- The correlation filter PCE values in all seven positions range from 0.3 to 0.8 for clean and jerk, and from 0.1 to 0.9 for snatch. This range is interesting to measure lifters in the seven positions of weightlifting for snatch and clean and jerk. The binary image after correlation filter can make this clear.

D. Calculate Hu Moment Values in Frames

The Hu moment values are computed in all seven positions in snatch and clean and jerk methods, and computed using the equations in Section VIII, and the calculated Hu moments are compared with the formerly computed Hu moments to the inactive locations.

The weightlifting can change the data with any other data depending on vocational selection. There are inactive positions for performing weightlifting (snatch and clean and jerk) based on many factors, such as a lifter's weight, which is an important factor in the weightlifting in snatch and clean and jerk, and the lifter's position in the stadium. Many factors are considered by the lifter in weightlifting. In the seven major positions the lifter must control any movement to effect to not access to fail. Thus, the operation of selecting references must cover the selected individuals within the video frame of successful weightlifting.

Tables 3 and 4 show the computed Hu moment values for all positions in Figures 8a and 8b and the stock Hu moment values to the matrix. Table 5 shows the similar measures to the seven locations based on the Euclidian distance method.

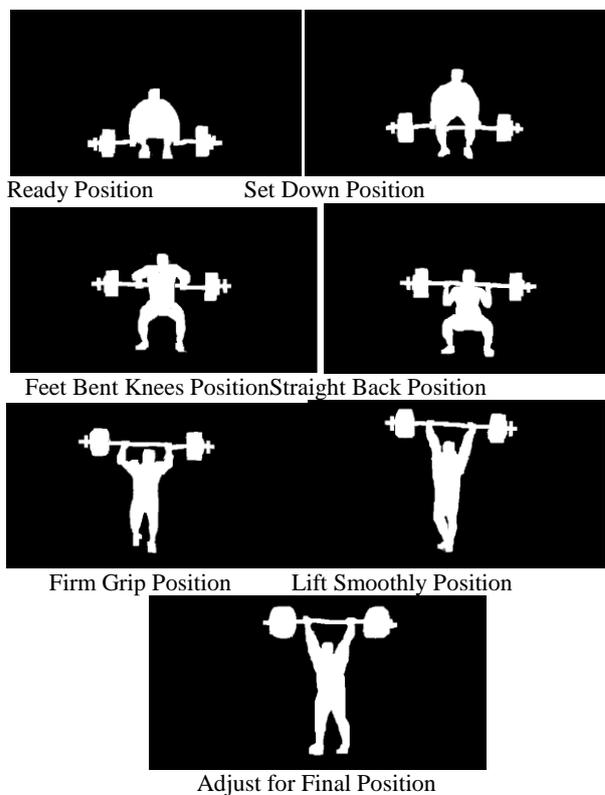


Figure 8a. Reveal main position of weightlifting(clean and jerk).

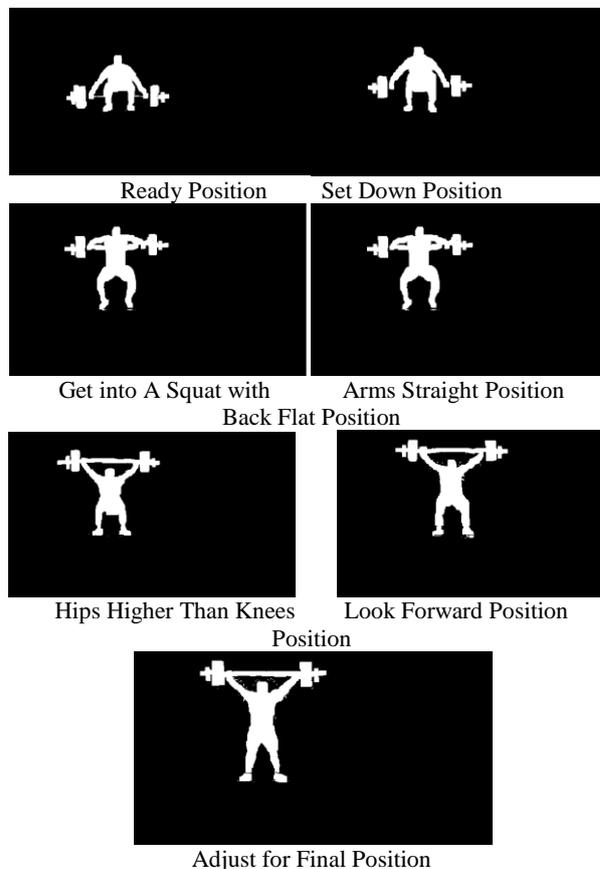


Figure 8b. Reveal main position of weightlifting (snatch).

- In Tables 1 and 2, as shown, the correlation filter PCE values for each of the seven

Table 3. Hu moment values for reveal position in frame video (clean and jerk).

Φ	Ready	Set Down	Feet Bent Knees	Straight Back	Firm Grip	Lift Smoothly	Adjust for Final
1	0.3612	0.4570	0.4899	0.5084	0.6792	0.7039	0.7519
2	0.0525	0.0730	0.0495	0.0656	0.0200	0.0145	0.0018
3	0.0234	0.1034	0.0369	0.0221	0.0532	0.0348	0.2199
4	0.0066	0.0681	0.0987	0.0807	0.2457	0.2780	0.1669
5	-0.0000	0.0021	0.0010	0.0010	-0.0030	-0.0029	-0.0054
6	-0.0004	0.0074	0.0088	0.0076	0.0094	0.0088	0.0020
7	0.0000	0.0004	0.0008	0.0000	0.0052	0.0040	-0.0028

Table 4. Hu moment values for reveal position in frame video (snatch).

Φ	Ready	Set Down	Get into A Squat with Your Back Flat	Arms Straight	Hips Higher Than Your Knees	Look Forward	Adjust for Final
1	0.3810	0.4438	0.5941	0.7113	0.8809	0.8725	0.6729
2	0.0560	0.0156	0.0306	0.0617	0.1417	0.1417	0.0458
3	0.0247	0.0281	0.1504	0.2080	0.0909	0.0909	0.0215
4	0.0076	0.0733	0.3138	0.4008	0.4177	0.4177	0.2064
5	-0.0000	-0.0002	0.0232	0.0376	0.0126	0.0126	0.0006
6	-0.0005	-0.0045	0.0257	0.0465	0.0772	0.0772	0.0096
7	0.0000	-0.0012	-0.0062	-0.0024	-0.0239	-0.0239	-0.0014

method after testing consists of the values from high to low for the seven Hu moments, and the values are positive and negative. These tests are interesting to check the speed of lifters compared to other lifters in weightlifting.

The Hu moment values in Table 3 in each of the seven positions (clean and jerk) after testing consist of the values from high to low in the seven Hu moments, and the values consist of positive and negative values in weightlifting (clean and jerk). In addition, in Table 4, each position in the snatch

Table 5. Euclidian distance among computed moment values and stock moment values in the clean and jerk method.

Φ	Ready	Set Down	Feet Bent Knees	Straight Back	Firm Grip	Lift Smoothly	Adjust for Final
1	0.1998	0.2096	0.1710	0.1287	0.1162	0.1068	0.1074
2	0.0138	0.0120	0.0145	0.0080	0.0062	0.0035	0.0509
3	0.0167	0.0230	0.0481	0.0461	0.0451	0.0435	0.0422
4	0.0236	0.0351	0.0467	0.0031	0.0020	0.0019	0.0010
5	0.0007	0.0033	0.0021	0.0019	0.0015	0.0007	0.0002
6	0.0003	0.0017	0.0015	0.0011	0.0010	0.0012	0.0007
7	0.0002	0.0003	0.0002	0.0001	0.0000	0.0002	0.0001

Table 6. Euclidian distance among computed moment values and stock moment values in the snatch method.

Φ	Ready	Set Down	Get into A Squat with Your Back Flat	Arms Straight	Hips Higher Than Your Knees	Look Forward	Adjust for Final
1	0.1197	0.2080	0.1815	0.1481	0.1052	0.1040	0.1033
2	0.0168	0.0130	0.0142	0.0066	0.0052	0.0045	0.0401
3	0.0157	0.0368	0.0471	0.0451	0.430	0.0420	0.0418
4	0.0216	0.0243	0.0435	0.0028	0.0021	0.0017	0.0011
5	0.0009	0.0030	0.0024	0.0020	0.0018	0.0012	0.0010
6	0.0002	0.0014	0.0012	0.0009	0.0008	0.0007	0.0005
7	0.0001	0.0002	0.0001	0.0003	0.0000	0.0003	0.0002

Conclusion:

The analysis system uses a temporary medium backward subtract method to show the personal into the video frame. The analysis system reveals the seven positions using a correlation filter, making the video frame clearer, and the analysis system uses Hu moments for evaluating the lifter implementation time through the frame video for the seven positions.

The Euclidian distance among each of the seven positions in the Hu moments for the clean and jerk and snatch methods are shown in Tables 5 and 6. The computed values for both the clean and jerk and snatch methods is in range from 0.1 to 0.00. These values are approximated between the seven positions.

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The analysis system shows 75% revealing to the seven major positions using the correlation filter on each seven positions utilizing video. Moreover, it is a great relief for the sport staff to have analysis.

This analysis system is method that might be monitoring further advances by utilizing other methods and exercises of other sports in this domain.

In the same time the analysis system faces a problem of failing during implementation for weightlifters, as the outcome can be confusing in recording the video for analysis for a weightlifting.

Another problem is that, during recording, because the background is not exact, the process for extracting weightlifter images from the camera view can result in losing part of background image through the subtraction method for the binary image, which, in this analysis system, can result in an error, it can treat this problem by using analysis system after another addition.

The outcome obtains competitive between woman's players and man's players through the Hu moments and speed of movements between them in the analysis system.

The seven standard in Hu moments in clean and jerk and snatch in Table 3, and Table 4 the values in the seven moments is decreased, when applying the Hu moments equations.

The Euclidian distance in the seven position in Table 5, and Table 6 the values is decreased, between each position and another position in clean and jerk and snatch.

Conflicts of Interest: None.

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اقتراح نظام تحليل لمراقبة رفع الاثقال بالاعتماد على التدريب (الخطف والهزة والتنظيف)

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الخلاصة:

تحليل النظام لاعبي الالعاب الرياضية مهم جدا للافراد في رفع الاثقال. القوة والتطور مهمة في اداء رفع الاثقال. يقدم هذا البحث طريقة تحليل لرفع الاثقال مع فحصها بواسطة اطار الفيديو. تحليل النظام يمكنه حساب الخطوات الرئيسية السبعة في اطار الفيديو ومراقبة الحركات لطريقتي الخطف والهزة والتنظيف اثناء التدريب. وحساب الخطوات السبعة الرئيسية لكل شخص من خلال لحظات Hu ما بين اطارين في الفيديو اثناء التدريب. وكذلك حساب المسافة الاقليدية لقيمة الحظاظ Hu وقيم لحظة الرفع في طريقتي الخطف والهزة والتنظيف. ان نتائج نظام التحليل تعطي كفاءة ودقة في مراقبة تحليل حركات رفع الاثقال للاعبين اثناء التدريب في هذا المجال.

الكلمات المفتاحية: تحليل الحركة، سلوك المسار، رفع الاثقال، لحظة Hu، المسافة الاقليدية.