

Development of Human Pose Models for Sports Dynamics Analysis using Video Image Processing Techniques

P.Kannan¹, R.Ramakrishnan²

¹ Research Scholar, Tamilnadu Physical Education and Sports University, Chennai, India

² Professor and Head, Tamilnadu Physical Education and Sports University, Chennai, India

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Abstract. Monitoring and detection of human body movements is a very interesting and important research problem in the video based applications. It has gained more importance in the field of computer vision due to its potential applications such as sports, video surveillance, security systems, home care and patient monitoring systems. A thinning algorithm is proposed to find the skeleton of the sports person. The development of human pose modeling plays an important role in the sport analysis. The pose models are constructed using the feature points on the human body. Eleven feature points are tracked and identified from the sports person to construct two dimensional body modeling for analyzing sports dynamics.

Keywords: Human body part movement analysis, Thinning Algorithm, Background subtraction, Human poses modelling.

1. Introduction

Body movement analysis is a current research topic in the field of computer vision and machine vision. In the areas of medicine, sports, and video surveillance, human motion analysis has become an investigative and diagnostic tool [1]. Human motion tracking can be performed in two or three dimensions. Depending on the complexity of analysis, representations of the human body range from basic stick figures to volumetric models. Tracking relies on the correspondence of image features between consecutive frames of video, taking into consideration information such as position, color, shape, and texture. In postural and gait analysis, joint angles are used to track the location and orientation of body parts [2]. Gait analysis is also used in sports to optimize athletic performance or to identify motions that may cause injury or strain [3].

2. Motivation

The sports dynamic analysis is required to extract the information about the background subtraction, location of human body parts and feature points from the body. Even though, the relevant information is difficult to obtain using video/image processing techniques quickly and efficiently, a wide range of research possibilities are present in this application. Marker based human pose modeling and their movement analysis is a simple approach but it needs markers on the human body at every time of sport analysis. So, the marker-less pose modeling is very important in the automated analysis [4]-[5].

3. Challenges of the proposed work

The development of human body models and their motion analysis have a challenging issue that the human body is non-rigid in nature and it has various un-predicted shapes. The fast and accurate background subtraction techniques are important issues in the video based human body segmentation. The computational complexity increases when the entire image is computed by computer vision techniques and more time is needed for extracting the features. The captured videos are influenced by some practical factors such as illumination changes, lighting conditions, camera noise, camera misfocus, camera calibration, reflections, occlusions and shadows which affect the segmentation by changing the shape of the object.

¹ Corresponding author. *tel*; 91-44-26490505, *fax* :91-44-26490101
E mail address; pkannan2003@yahoo.com

4. Aim and Objectives

The aim of this work is to investigate the sports dynamics using human pose models in sports applications. The objectives of this research work are,

- To segment the human body from the video sequences using background subtraction techniques.
- To develop the skeleton of person using Thinning algorithm.
- To develop an approaches for human pose modeling in two dimensional views.

5. Proposed methodology

The objective of the proposal is to analyze the sports dynamics using human pose modeling from the video sequences. Mainly, the three steps are needed for this implementation such as background subtraction, Thinning algorithm and pose modeling. Figure 1 shows the overview of the proposed work. The initial phase of the work includes video acquisition and pre-processing. First, the video sequences are captured using single static video camera from the environment. The video sequence has been taken at the rate of 30 frames/second.

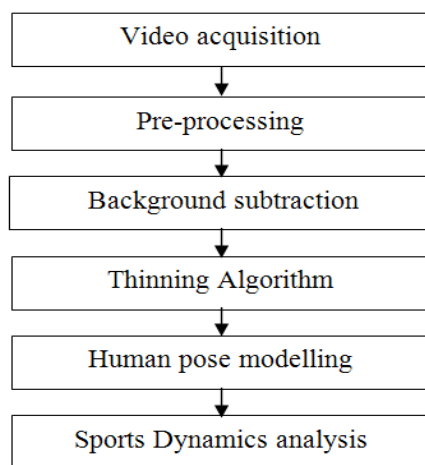


Fig 1: Overview of the proposed work

After the video acquisition, the pre-processing is done on the video frames. The quality of video sequence may depend on lighting and environmental changes. The key function of the pre-processing is to improve the quality of image sequences. In the pre-processing algorithm, initially RGB colour space of an image is converted into YCbCr space as it is easy to perform the normalization process. In YCbCr model, Y represents luminance and CbCr represents chrominance components. Here, luminance correction is performed using the normalization technique. Normalization is a process of scaling the numbers in a data set between [0 1]. In the normalization technique, the lower value of channel Y is mapped to 0 and the highest value to 1. Then, the histogram equalization process is performed to redistribute the intensity values. Finally, the RGB values are restored.

5.1. Pre-processing Algorithm

- Step0: Read the original frame from the video sequence.
- Step1: Convert RGB colour space to YCbCr colour space.
- Step2: Separate Y, Cb and Cr components individually for the easy
- Computation.
- Step3: Apply Normalization technique to improve the accuracy of the frame.
- Step4: Compute histogram equalization process to distribute the intensity
- Values.
- Step5: Restore the RGB values after the computation of values.

The primary step in the proposed work is to extract the foreground objects from the video frame. This technique is used to separate a video image into foreground image and background image. In order to focus on the desired human body object for better understanding. This technique is useful in reducing the computational complexity and time since it is concentrating only foreground objects. Thinning algorithm plays a vital role in finding the skeleton of human body [6]-[9]. The thinning operation is performed by

transforming the origin of the structuring element to each pixel in the image. Then it is compared with the corresponding image pixels. When the background and foreground pixels of the structuring element and images are matched then the origin of the structuring element is considered as background, Otherwise it is left unchanged. Here, the structuring element determines the use of the thinning operation. The structuring element determines the number of pixels added or deleted from the objects in an image. It is a matrix that has ones and zeros only with any arbitrary shape and size. In the proposed research work, strel ('line', 6, 90) function is used as a structuring element. The flat, linear structuring element is considered for this application. Here, six specifies the length and 90 specify the angle (in degrees) of the line. And the length is approximately the distance between the centers of the structuring element members at opposite ends of the line. Figure 2 shows the structuring elements for skeletonization by morphological thinning. At each iteration, the image is first thinned by the left hand structuring element, and then by the right hand one, and then with the remaining six 90° rotations of the two elements. The thinning operation is achieved by the hit-and-miss transform. The thinning of an image A by a structuring element B is given by equation (1).

$$\text{thin}(A, B) = A - \text{hit and miss}(A - B) \quad (1)$$

0	0	0
	1	
1	1	1

	0	0
1	1	0
	1	

Fig 2: Structuring element for thinning operation

This process is repeated in a cyclic fashion until none of the thinning produce any further change. Normally, the origin of the structuring element is at the center. The steps of the thinning algorithm are given by [10]

- Step0: Partitioning the video frame into two distinct subfields in a checkerboard pattern.
- Step1: Delete the pixel p from the first subfield if and only if the conditions (2), (3), and (4) are satisfied.

$$X_H(p) = 1 \quad (2)$$

where

$$X_H(p) = \sum_{i=1}^4 b_i$$

$$b_i = \begin{cases} 1 & \text{if } X_2 i - 1 = 0 \text{ and } (X_2 i = 1 \text{ or } X_2 i + 1 = 1) \\ 0 & \text{otherwise} \end{cases}$$

x_1, x_2, \dots, x_8 are the values of the eight neighbours of p , starting with the east neighbor and are numbered in counter-clockwise order.

$$2 \leq \min\{n_1(p), n_2(p)\} \leq 3 \quad (3)$$

where

$$n_1(p) = \sum_{i=1}^4 X_{2k-1} \vee X_{2k}$$

$$n_2(p) = \sum_{i=1}^4 X_{2k} \vee X_{2k+1}$$

$$(X_2 \vee X_3 \vee \overline{X_8}) \wedge X_1 = 0 \quad (4)$$

Step2: Deleting the pixel p from the second subfield if and only if the conditions (2), (3), and (5) are satisfied.

$$(X6 \vee X7 \vee \overline{X4}) \wedge X5 = 0 \quad (5)$$

The step 1 and step 2 together make-up one iteration of the thinning algorithm here, an infinite number of iterations ($n=\infty$) have been specified to get the thinned image. Figure 3 shows the results of the thinned algorithm for different poses.

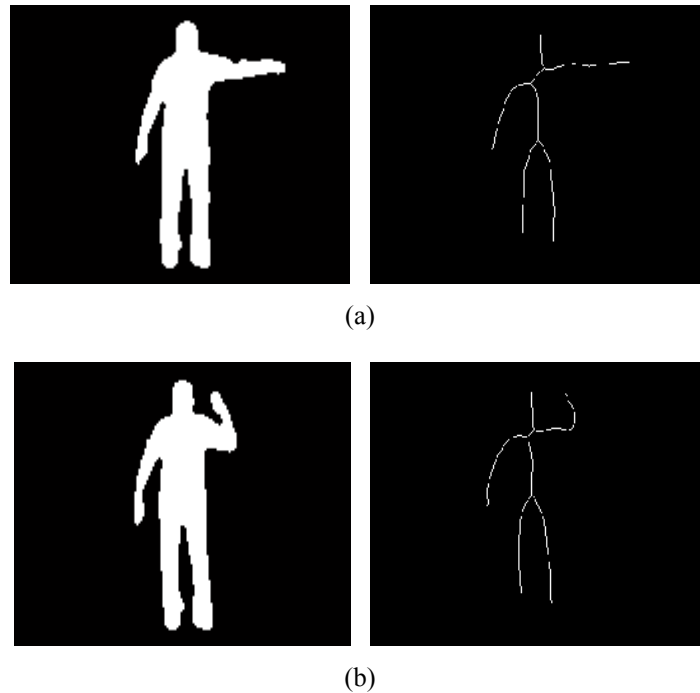
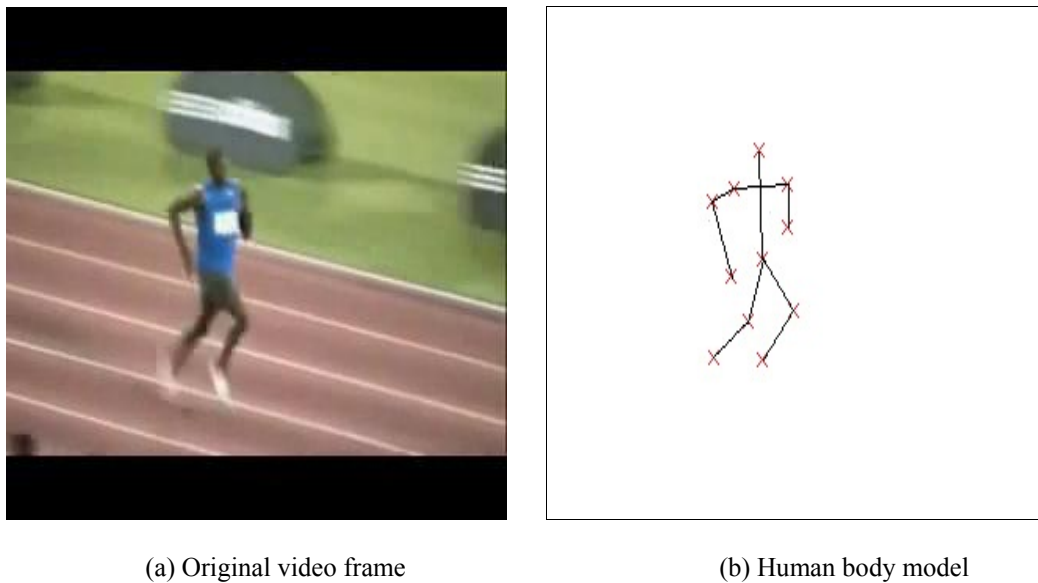


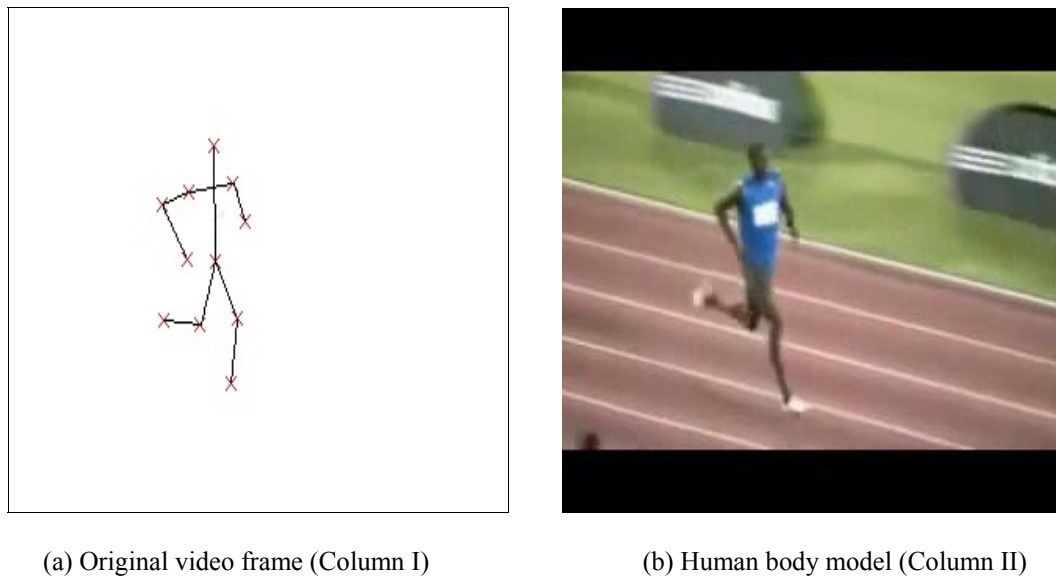
Fig 3: Results of Thinning Algorithm

The next step is to develop the pose models for the human postures. After the human body parts are detected, the human pose models are constructed using the feature points in two dimensional (2D) views. The feature point is a point on the human body which is used to represent the body segments. The feature points that are derived from the human pose models plays an important role in analyzing the activities.

6. Results and Discussion



Frame No: 1230



Frame No: 1240

Fig 4: Results of human body modelling using Thinning algorithm

The proposed work has been developed using MATLAB 7.6(2008a) on Intel dual core processor, 2GB RAM and Windows XP SP2. The video sequences are acquired at the rate of 30 frames/second with the frame size of 320×240 pixels resolution. Figure 4 shows the simulation results of proposed work in which Column I indicates the original input video frame whereas Column II shows the two dimensional model of sports person.

The pixel and line values are extracted using the proposed algorithm and it is shown in Table I and Figure 5.

Table I Pixel and line values of feature points

Feature points	Pixel	Line
1	290	200
2	289	209
3	260	230
4	305	220
5	267	212
6	290	200
7	278	208
8	279	250
9	290	245
10	260	250
11	300	280

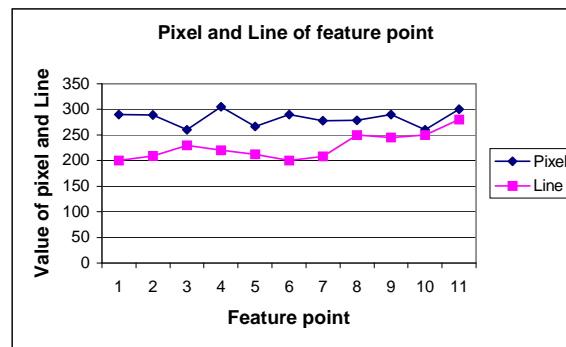


Fig. 5: Pixel and line value of feature points

The mechanical energy and impulsive force can be analyzed from the video sequences using the equation (6) and (7).

$$\text{Mechanical energy} = \text{Potential energy}(mgh) + \text{Kinetic energy}(mv^2/2) \quad (6)$$

$$\text{Impulsive force} = \text{Newton's second law of motion}(ma) \quad (7)$$

Where m- mass, v- velocity, g- Acceleration of gravity, h- height, a- acceleration.

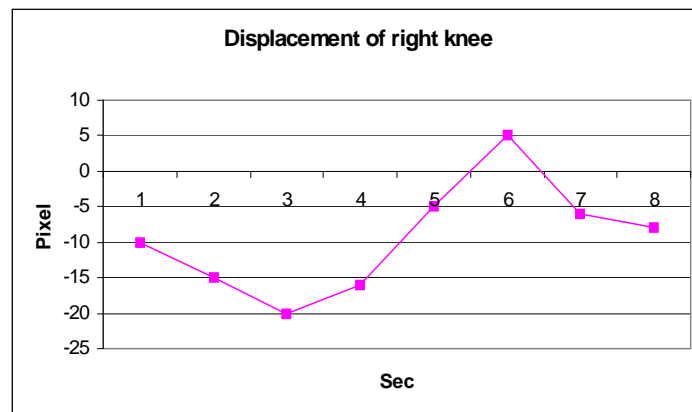


Fig. 6: Displacement of right knee

Figure 6 shows the simulation results of the horizontal displacement of right knee. This graph shows the motion from right foot push off to the next right foot pushes. This pose explains the activity of running. In this figure, pixel(Y axis) represents the horizontal displacement from the pixel at the top of the head to that at the right knee. A value below zero indicates that the right knee is located behind the top of the head whereas values above zero represents the right knee is ahead of the top of the head. And at a pixel value of zero, the opposite leg is just crossing. It is observed that at six seconds it has maximum pixel value and gets large displacement. The large displacement of the right knee gives the maximum velocity, kinetic energy and impulsive force.

7. Conclusion

The human pose models based sports dynamics analysis has been proposed in this work. The image and video processing techniques are used to find the feature points on the person in the video sequences. The efficient background subtraction technique is implemented to segment the human body. The skeleton of human is identified using thinning algorithm. The human pose models are constructed in two dimensional views. From the pose models, the mechanical energy and impulsive force can be calculated.

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9. References

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