TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol.12, No.6, June 2014, pp. 4274 ~ 4282
DOI: 10.11591/telkomnika.v12i6.5120

Research of Background Segmentation Method in Sports Video

Shen Li*[1], Hou Lihong[2]
[1]Harbin Medical University, Harbin 163316 China
[2]Beihua University, Jilin 132013, China
*Corresponding author, e-mail: shenli_hmu@163.com

Abstract

Human motion image segmentation is the first step in the process of human motion analysis; it is low-level processing part of the visual analysis of human movement. The processing results of the stage of quality directly affects the progress of the follow-up work, the segmentation result has enormous influence on the final results human of movement analysis. Human motion image segmentation research is an important goal similar to the visual perception of the human, which make the computer feel the movement of human body, and make computers easier to understand the feelings of sports behavior. Deviation information based on Gaussian mixture model to join the chroma and brightness of background segmentation method is not only suitable for ordinary static scene, but also it is suitable for the special environment such as reflective of ice, fuzzy shadow, moving object reflection. According to experiments results, it is shown that the proposed algorithm has strong robustness.

Keywords*: image segmentation, motion analysis, sports video, method, research*

1. Introduction

As known that among the environmental information, held very large proportion of visual information, while the dynamic visual information is the main component. And a lot of meaningful visual information is involved in the movement. The research of background of the human body movement image segmentation is to make the computer have the functions which are similar to the visual perception of the person, the computer can feel the view within the human body target, and can understand people's sports behavior of the computer, and also can take the appropriate action.

At the same time, the background segmentation method not only can be used in the human body target, but also it can be widely used in other areas, such as license plate recognition, video surveillance, etc. But due to the nature of the algorithms, they are limited to the application environment, at the current research status and technology level, we still can't find out a general algorithm, which is applicable to any external environment (lighting conditions, cameras, anti-interference ability, etc.) and applicaple to all kinds of motion segmentation under complex background, thus in order to solve some limited conditions or some application under the background of the movement of the image background segmentation problem is still be the main topics of the research in this field [1].

Human motion image segmentation is an indispensable part of human motion analysis, and it plays a very important in kinematic analysis. Based on this, a large number of scholars in the field have done a lot of useful work. The commonly segmentation algorithm includes the following several ways:

1. The finite difference time domain
2. The background difference
3. The segmentation method based on background model
4. The method based on statistical model
5. Other method

Received November 11, 2013; Revised December 31, 2013; Accepted January 24, 2014

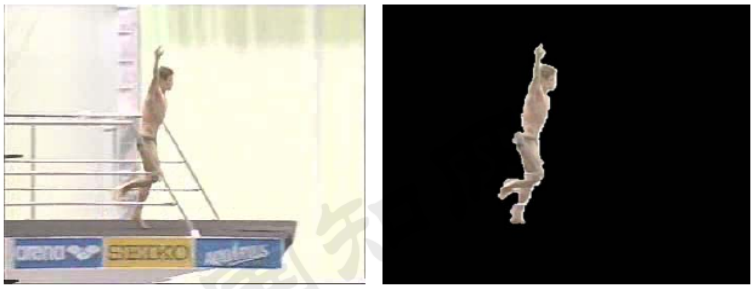


Figure 1. The Background Substraction Result of Movement Emulator

There are many other methods in the motion detection. Such as motion vector method, it is suitable for multidimensional changing circumstances, and can eliminate the background pixels, and can make object in certain direction of motion more prominent, but the motion vector method cannot accurately segment the object. the EM algorithm can establish classification Gaussian mixture model for each pixel, the model can be automatically updated, and can adaptively to classify each pixel as the background, the shadow or sports outlook [2-5].

Although many scholars have conducted a large number of useful research, because of the complexity and irregularity of human movement, make it difficult to study through a unified way. Many methods and models are too simple and not widely used, or too complex to application in practice. The mainexisting problems of background of human motion image segmentation technology research at present are as follows [6]:

a. There are no general methods in the background of the human body movement images segmentation, it is usually carried out under the condition of specific environmental, and so it should design corresponding segmentation method. Such as during the movement of human, it is not obscured, background is relatively simple, stationary camera, etc.

b. The segmentation of human movement, under the complex background, due to the influence on surrounding environment, and it often powerless to outside interference. When pedestrians wear clothes which color is similar to the background color or changes of background light is big, it is difficult to s discern the moving of the human body from the background.

c. The size of human body contour, the color of the clothes and the texture with the dress and appearance characteristics, such as the weather changes, and changes of other external conditions, it has very strong variability.

d. The single image processing is difficult to achieve reliable segmentation of background, and therefore it must be adopted with sequence image processing, but it needs to store and process large amount of data, and real-time performance of the system is difficult to guarantee.

e. The background of the human body movement images segmentation technology involves the knowledge of many subjects, including computer vision, image processing, pattern recognition, artificial intelligence, how to combine them is the research question. In the current research status and the technical level, the realization of general background segmentation system is not reality, so how to solve some limited conditions under the background of application background segmentation problem will still be the main topics of the research in this field.

2. Segmentation Algorithm Research

In the study, the main content of the background of the human body movement image segmentation algorithms, including interframe difference and background difference, online single Gaussian model and method of the Gaussian mixture model are introduced. The online single Gaussian model and the basic idea of the Gaussian mixture model and realization method are also the presented. After analysis of algorithm and the experimental results, the conclusions are obtained through comparison.

Human motion image background segmentation in recent years has been got more attention and it is one of the forefront of the direction, it is the combination of modern biological mechanics and computer vision technology, it has a very broad and important field of application of it in the smart surveillance, human computer interaction, motion analysis and virtual reality, and other fields.

Although in the past ten years, people have done a lot of work on the problem; however, so far, there is no effective algorithm can be applied to movement image segmentation under various environments. The research work of the human body movement image background segmentation is proposed for some specific application problem, the further study of algorithm remains to be needed [7].

In the practical application system and interested target motion in the scene can be divided into four combinations, the first combination is actually a static scene with static of camera-target, the processing method is the static image processing method, which is widely applied in face recognition, iris recognition, the second is the combination of stationary camera and moving target, this is a very important dynamic scenes, the process generally includes moving target detection, classification, tracking and behavior understanding, it is mainly used for early warning, security monitoring events. The third is the combination of moving camera and static target, it is mainly used in robot vision navigation, electronic maps generated automatically, and 3D scene understanding, etc. the fourth combination is with the moving camera and moving target, it can be used in moving target detection in the complex circumstance, such as monitoring and control system in satellite or on the plane. In the study, it mainly discusses the target movement under the condition of stationary camera and how to realize the researches on the division of human movement on the particular scene [8].

The probability density model and online single Gaussian background model and Gaussian mixture models are introduced. Interfaced difference method is through the current image with adjacent frame difference to get moving target prospects. Background difference method is usually selected empty scene image as a background image of moving targets.

Background model method is the key to the background image description model of background model; it is the basis of the background motion segmentation prospects.

Background model mainly includes single-mode state and multimodal two kinds, the former model each background pixel color distribution is concentrated, it can use a single distribution probability model to describe the distribution, while the latter model is more dispersed, and need to use more distribution probability model to describe.

In many application scenarios, such as ripples on the surface of the water, the swaying branches and waving flags, pixel values of them presents the multimodal features. The most commonly used probability density model in describing the scene background color distribution probability density function is Gaussian distribution, [9], as described in below online single Gaussian background model and Gaussian mixture model are both belong to the model.

3. Improved GMM Background Segmentation Algorithm

There is no general method on background segmentation of the human body movement images, it is usually carried out under the limited condition, and greatly influenced by the surrounding environment, usually it is powerless to interference, and only can design the corresponding segmentation method for a particular environment.

In the study, the road speed skating training grounds under the scenario of the human body after the character motion object detection and segmentation, on the basis of the classic of the Gaussian mixture model, brightness deviation and the information such as color deviation are improved, and the new improved algorithm can be applied to the special scene, shadow, reflection and glare and it can get good segmentation effect [10-13].

3.1. Characteristic Analysis of the Ice Environment

Under complex scene background segmentation, the important prerequisite is to know the characteristics of the scene. Only in this way, it can eliminate or reduce the impact of background segmentation of static state and other factors. Therefore, although many of sequence image of moving target detection are studied under static background, but as the complex background scene segmentation, it is necessary to consider the dynamic background. The video is taken by the monocular camera which is the training video of skater with high

speed in the static road, namely that the camera position on the road outside bend alignment of speed skating athletes. Through the comparison of the image video of different environments, due to the characteristic of the ice road, this scenario has the following features restricts the segmentation effect:

1. The change of background illumination
2. The static objects in the background
3. The shaded area
4. Reflection area
5. Strong reflective ice
6. The interference of ice area
7. Other noise

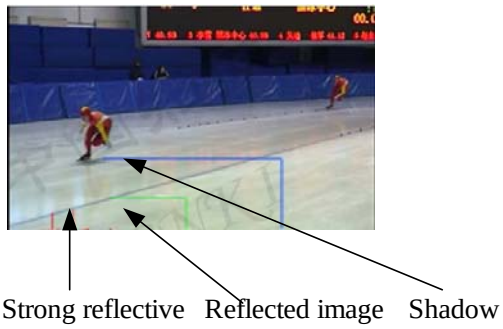


Figure 2. Color Image in the Environment of Skating Rink

In this environment, through the background segmentation algorithms, it can segment the moving targets, remove the static background, but the segmentation results are not satisfactory, shadow, reflection and reflective region have not got the correct processing, they seriously affect segmentation. Based on the particularity, scenario, it makes the improvement on the existing algorithms. Through the study, it can be found that athletes on ice reflection area, the color value change is bigger than the ice color values, but it has smaller values of the color deviation. The athlete's shadow region color is deeper than the surface color, the brightness of the two larger deviation degrees. So we can add the two kind of information to the algorithm based on mixture Gaussian model to distinguish shaded area, reflection area, and thus improve the segmentation as shown in Figure 2.

3.2. Related Definitions

The model is proposed under the RGB color space, as shown in Figure 3, as to the single pixel in the image I, $\mu_i = [\mu_i(R), \mu_i(G), \mu_i(B)]$ represent prime spot of back In RGB space. $X_i = [X_i(R), X_i(G), X_i(B)]$ represent value of the current image pixels. X_i and μ_i represents brightness deviation and colors deviation. The linear pass through the origin and the line $o\mu_i$ is called chroma line, color deviation CD_i is the minimum distance from point X_i to chroma line $o\mu_i$.

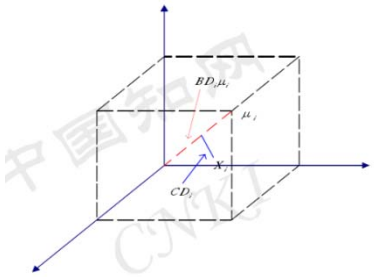


Figure 3. Mathematical Model of Brightness Distortion and Chromaticity Distortion in the RGB Color Space

Brightness deviation BD is a scalar value, we define $\phi(BD_i) = \|X_i - BD\mu_i\|^2$, when the value of $\phi(BD_i)$ is minimum, the BD_i is the deviation of the color, when the background pixel is same as the current pixel, $BD_i = 1$ when background pixel is less bright than current pixel $BD_i > 1$, when background pixel is bright than current pixel, $BD_i < 1$.

Color deviation CD is defined the distance from the point X_i to a straight line $o\mu_i$,that is the distance between the point X_i and $o\mu_i$, Color deviation is given by formula (1):

$$CD_i = \|X_i - BD_i\mu_i\| \tag{1}$$

Color deviation CD_i and the Brightness deviation BD can be calculated through:

$$BD_i = \min\left\{(X_i(R) - BD_i\mu_i(R)^2 + (X_i(G) - BD_i\mu_i(G)^2 + X_i(B) - BD_i\mu_i(B)^2)\right\} \tag{2}$$

$$CD_i = \sqrt{\min\left\{(X_i(R) - BD_i\mu_i(R)^2 + (X_i(G) - BD_i\mu_i(G)^2 + X_i(B) - BD_i\mu_i(B)^2)\right\}} \tag{3}$$

The following two cases chroma deviation (3-4) instead of using the following formula:

a) If you mix, die type B points higher value for the black color of the cloth $\mu_i(R) = \mu_i(G) = \mu_i(B) = 0$ as $BD_i = \inf$ in order to avoid this problem $\mu_i(R) = \mu_i(G) = \mu_i(B) = 0$

$$CD_i = \sqrt{(X_i(R)^2 + X_i(G)^2 + X_i(B)^2} \tag{5}$$

b) When the moving targets in the current image pixel is close to the origin, it always is divided into background pixels. Because all of the color line pass through the origin, close to the origin of pixels is close to any a color line, through the color deviation it will be wrong pixel points. In order to avoid this problem, the line color deviation and the deviation brightness can validate pixel deviation of the size of the chromaticity and brightness. Among them, under the environment of an ice rink, the chroma deviation value can reflect the variation of chromaticity on ice, the athletes' reflection region on the ice usually has smaller values of the pixel color deviation, the introduction of chromatic deviation compared to reflection reaction can inhibit the light changes. Shadow is gray, degree of brightness is low, through calculating it can detect whether change region is the shadow. Therefore, based on this idea, segmentation of chromaticity and brightness deviation under the human body image background environment is good.

3.3. Gaussian Mixture Model Algorithm

Through a lot of experiments, it is shown that among the numerous background segmentation methods, the effect of the original method of the Gaussian mixture model is good, the moving target in the video can be detected, but there exists some interference region. The shaded area and the reflection area are moving with the moving target, it can be mistake as prospect goals, and also can influence the effect of detection. At the same time, the reflection of the ice is strong than the common situation. Through the brightness deviation and deviation information can remove chromaticity shadows, reflections and suppress related strong reflection. We put the brightness deviation of the Gaussian mixture model and color deviation information in the original algorithm, thus the original algorithm of the Gaussian mixture model is improved.

Under the RGB space, it propose Gaussian mixture model for each pixel in the image of the three color channels R, G, B respectively, and three color channels of RGB of each pixel can be calculated, the B distribution of the Gaussian mixture model B_R B_G B_B also cab be set up. Then through these B distributions, the mean parameters of B_R B_G B_B can be calculated according to the definition and calculation formula of brightness deviation BD_i and color

deviation CD_i . Finally, based on the current B distribution of pixels and the matching situation of B_R B_G B_B, chroma deviation, deviation of brightness information, each pixel point can be classified as follows:

a. If in the color space model RGB, The value of the current pixel is not same as the B distribution (B_R B_G B_B) of the three mixture models of the one pixel together, then it is divided into as the background point.

b. If In the color space model RGB, The value of the current pixel is not same as the B distribution (B_R B_G B_B) of the three mixture models of the one pixel together, value of color deviation CDi >Th_CD, then it is divided as the target area part.

c. If in the space of the RGB color model, the current pixel color values is not match with B distribution (B_R B_G B_B) of three mixed model together, color degree value of partial differential CD < Th CD, and the brightness BD<Th_BD, It is taken as as the shadow area.

d. If in the space of the RGB color model, the current pixel color values is not match with B distribution (B_R B_G B_B) of three mixed model together, color degree value of partial differential CD < Th CD, and the brightness BD>Th_BD, It is taken as as the upside shadow area.

Among them, Th _CD represents deviation threshold and Th_BD represents brightness deviation threshold. The post-processing to remove discrete noise and the noise of the target area which is too small, and realize foreground area treatment, filling holes, and other functions are realized through mathematical morphology operators expansion, corrosion, opening operation and closing operation, etc. In order to achieve these functions and improve under the condition of complex movement image detection accuracy, and reduce the cost of the correct segmentation, increase the effectiveness of the follow-up work. Figure 4 and Figure 5 are the segmentation results of this algorithm. We define limitation value τ_{alo} , when the $BD_i < \tau_{\min}$,

$$CD_i = \sqrt{(X_i(R) - \mu_i(R)^2 + (X_i(G) - \mu_i(G)^2 + X_i(B) - \mu_i(B)^2)} \quad (6)$$

Figure 4. Source Color Image

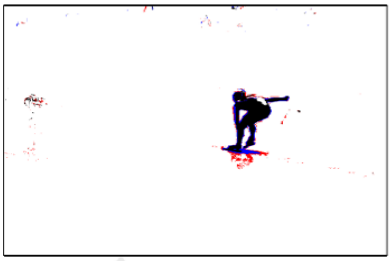


Figure 5. Results of Subtraction on the Binary Image

4. Experiment Results

In order to verify the validity of the algorithm in this study, we perform a variety of video simulation experiments, at the same time make the related comparison with Gaussian average method and method of the Gaussian mixture model. Experimental environment are the Pentium IV 3.0GHz CPU, 512MB RAM, and Visual c++ 6.0 simulation platform. The data samples for experiments mentioned above are the narration of training athletes taken by monocular camera and the frame rate is 25 frames per second, the size of each frame in the video image is 576 X720 pixels of color images. Parameters of the algorithm in the selected as the values in the Table 1.

Figure 6. Interface of Experiment System

Table 1. Choice of the Parameter

Parameter Name	Symbol of Parameters	Value of Experiment
Number of Gaussian Distribution	K	3
Learning rate	α	0.2
Brightness Boundaries Under Deviation	τ_{alo}	0.75
Colour deviation threshold	Th_CD	40
Brightness deviation threshold	Th_BD	0.8

(a) The number 12 frame

(b) The number 15 frame

(c) The number 17 frame

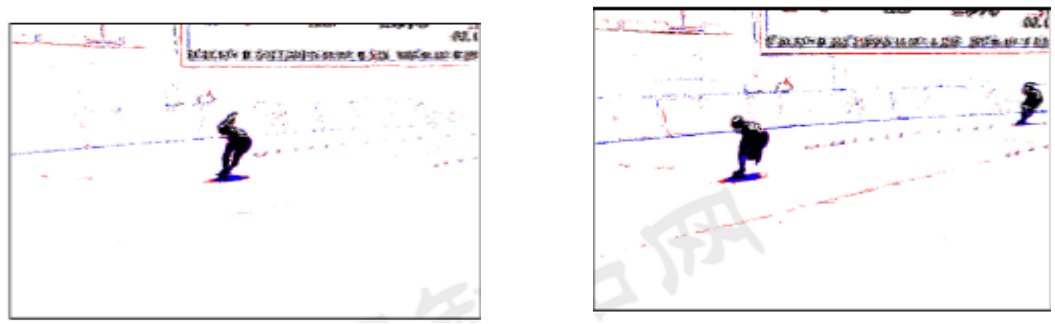
(d) The number 19 frame

Figure 7. Source Color Image

(a) The number 12 frame (b) The number 15 frame

(c) The number 17 frame (d) The number 19 frame

Figure 8. Result of Subtraction on Binary Image with the Method of Mixture of Gaussians Model



(a) The number 12 frame (b) The number 15 frame

(c) The number 17 frame (d) The number 19 frame

Figure 9. Result of Subtraction on Binary Image with the Method of the Improved Gaussian Mixture Model

In order to validate the results, the improved add brightness deviation and chroma deviation of the Gaussian mixture model of background segmentation algorithm are adopted. Through comparison of the experimental results and the experimental data, it can be found that the experimental results of the algorithm is superior to other methods, and this algorithm is suitable for the images segmentation of human body movement in the ice environment with complex background.

5. Conclusion

In the study, it mainly analyzes the road speed skating training under background segmentation of human movements, on the basis of the classic of the Gaussian mixture model, it improves the model through adding brightness deviation and color deviation.

The new improved algorithm can be applied to the special scene, and can get good background segmentation effect. From the experimental results of the algorithm compared with other common background segmentation algorithm, the segmentation effect of the algorithm proposed in the paper is the best, it not only can realize the dynamic segmentation of athletes prospect information, and also can effectively restrain the shadows, strong light, and mist important it can identify the surface reflection. So it is found that in this complex ice scenarios, our algorithm has good effect and has the better performance.

References

[1] Christopher Wren, Ali Azarbayejani, P finder: Real-Time Tracking of theHuman body. *IEEE Transactions on Pattern Analysis and MachineIntelligence.*1997;19(7): 780~795.
[2] O Javed, K Shafique, M Shah. *A hierarchical. approach to robustbackground subtraction using color and gradient information.* Wkshp. onMotion and Video Computing IEEE. 2002: 22~27.
[3] YZ Hsu, HH Nagel, G Rebers. New Likelihood Test Methods forChange Detection in Image Sequence. *Computer Vision, Graphics, andImage Processing.* 1984; (26).
[4] PL Rosin, T Ellis. *Image Difference Threshold Strategies and ShadowDetection.* Processing of the British Machine Vision Conference. 1995.
[5] D Gutchess. *A background model initialization algorithm for video surveillance*. Proc. of the 8th IEEE Int'l Conf. on Computer Vision Vancouver. 2001: 733~740.
[6] PW Power, JA Schoonees. *Understanding background mixture models for foreground segmentation*. Proc. of IVCNZ. 2002: 267~271.
[7] D Hall, J Nascimento, P Ribeiro, E Andrade. *Comparison of target detection algorithms using adaptive background models.* International workshop on Performance.
[8] G Bailo, M Bariani, P Ijas, M Raggio. *Background Estimation with Gaussian Distribution for Image Segmentation, a fast approach.* IEEE International Workshop on Measurement Systems for Homeland Security, Contraband Detection and Personal Safety Orlando, FL, USA, 2005:29~30.
[9] R Cucchiara, C Grana, M Piccardi, A Prati. Detecting moving objects, ghosts and shadows in video streams. *IEEE Trans on Pattern Anal and Machine Intell.* 2003; 25(10): 1337~1342.
[10] Zhiliang Wang, Jian Gao, Chuanxia Jian, Yu Cen, Xin Chen. OLED Defect Inspection System Development through Independent Component Analysis. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(8): 2309-2319.
[11] Ming-Huwi Horng. Multilevel Minimum Cross Entropy Image Thresholding using Artificial Bee Colony Algorithm. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2013; 11(9): 5229-5236.
[12] Aghlmandi D, Faez K. Automatic Segmentation of Glottal Space from Video Images Based on Mathematical Morphology and the hough Transform. *International Journal of Electrical and Computer Engineering (IJECE)*. 2012; 2(2): 223-230.
[13] Jun Lai, Mei Xie. Automatic Segmentation for Pulmonary Vessels in Plain Thoracic CT Scans. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(4): 743-751.