Framework design of sports image analysis system based on three-dimensional image technology

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Abstract. Sports image analysis system based on computer vision image processing technology is a hot project in urgent need of society at present. Due to various objective and subjective factors, the application environment of intelligent module in sports image analysis system is limited, and there is still a certain gap from the social requirements. In this paper, the hardware selection of the system is focused on the applicability and cost. Based on the idea of the inherent hardware of the organizers of the grass-roots sports meeting, the system combining camera, video capture card and PC is selected, which has a high ratio of information to price. A fuzzy enhancement system of 3D digital image based on data mining is designed. Analyze the motion information in video stream to a certain extent, extract the physical characteristics and behavioral characteristics of moving objects, and use the fusion of the two to complete the dynamic target analysis in video surveillance images. The sports image analysis system designed in this paper has good universality and good application and popularization value.

Keywords: Three-dimensional image technology; Sports; Image analysis system; Frame design

1. Introduction
Motion image analysis system plays an extremely important role in sports field. It can accurately and real-time measure the motion curve of each part and the relative rotation angle of joints in the process of athletes' movements, which is helpful for coaches to correct athletes' wrong movements, so as to prevent sports injuries and improve sports performance [1]. In the current practical work, both the image analysis system imported from abroad and the software system developed in China have some shortcomings in this respect or on the other hand [2-3]. In order to mine the data in continuous visual images to the maximum extent, and to serve the actual sports work more concisely, accurately and quickly, we must design a set of image analysis system which is in line with the actual situation of our country and the requirements of sports.

People perceive the world by visually acquiring images. Images are widely used in people's lives. While images are widely used, people's requirements for image quality are constantly improving. Compared with two-dimensional images, three-dimensional images can display richer spatial...
information and give people a more intuitive feeling [4]. Data mining technology can be applied to fuzzy enhancement of 3D images, and the color features and edge features of pixels on the images are extracted to calculate fuzzy feature values, which are combined with fuzzy membership functions to complete image enhancement and solve the problem of unclear edges of 3D images [5-7]. For this purpose, this paper redesigns the frame of sports image analysis system theoretically based on 3D image technology, in order to solve the practical difficulties most effectively.

2. Present situation of motion image analysis system

In recent years, with the rapid development of science and technology and the wide application of high-speed and high-definition cameras, the function, quality, testing speed and testing accuracy of the motion image analysis system have been greatly improved. The measurement of the motion image analysis system has developed to be marked by the synchronization of three-dimensional high-speed image, three-dimensional dynamic force measurement and multi-channel electromyography measurement, which makes the kinematics and biomechanics of human body build a clear mechanical image in three-dimensional space. The research on automatic recognition of joints of human motion images on films and videotapes has achieved initial success and has been applied to practice, but this technology relying on gray recognition can only be realized by pasting obvious markers on joints of human body. In addition, the standard manikin is not completely suitable for all kinds of sports, especially for some sports with special requirements for body size [8]. Therefore, the individualized model of geometric distribution of human body mass is also an urgent problem to be solved.

Nowadays, almost all universities and training units in China are equipped with camera equipment, which can conveniently assist coaches and athletes to record and observe the sports process, but it is still difficult to calculate and analyze. A set of motion image analysis system is not only extremely expensive, but also easily eliminated by alternative products, and there are many daily maintenance problems, which are the reasons that hinder the popularization of the system in China.

3. Design of fuzzy enhancement system for 3D digital image

This paper designs a fuzzy enhancement system of 3D digital image based on data mining. The system mainly includes four modules, which are core processing module, image storage module, peripheral interface module and power supply module. The overall framework of the system is shown in Figure 1.

![Fig.1 Overall framework design of the system](image)

ARM core processing module. The ARM series chip IMX6Q processor is selected as the core processor, which has multi-level memory, flexible interface, can meet the requirements of various operating systems, and has two ARM Cortex-A9 cores [9], and the running speed is as high as 1GHz.

Peripheral interface module. Using USBHUB and serial port, it is mainly used for the transmission of fuzzy enhanced 3D digital images and processed images, as well as the connection between the core board and the host, so as to realize the data interaction between the system and the host.

Data storage module. SDRAM and FLASH memory are used, in which SDRAM memory is used as the memory space of the system and the buffer space of 3D digital images, and FLASH memory [4] is used as the storage area of operating system and application programs.

Power supply module. It is mainly responsible for providing stable voltage for the whole system to...
meet the power demand of the whole system for the normal operation of the system.

According to the analysis of the selection of main core processors and the actual needs of 3D digital image blur enhancement system, the power supply circuit and peripheral interface circuit are designed.

4. Analysis of extraction algorithm for moving objects

The detection of moving objects entering the camera field of view is based on the extremely strong change of gray level on the specific scanning line of the image. Therefore, on the image without moving objects, according to the noise on the scanning line, the noise change and sunshine change state of the picture can be measured in advance, and the change frame of moving objects can be obtained by distinguishing it from the sharp change when moving objects enter.

When it is detected that a moving object enters the visual field, it is necessary to extract the region of the moving object in the image. One of the usual methods of warranty is the background image difference method. In this method, the background image is stored in advance, and then the difference operation is performed with the observed image, and only the moving object itself is extracted. Error accumulation and light change in background update are the main factors that affect the accuracy of background difference method, so many researchers have devoted themselves to studying the performance of various background models to minimize the influence of dynamic changes of scenes on accurate segmentation [10].

The essence of background difference method is to subtract each frame of video image from the determined background image, and compare the deviation to get the motion area. It can be described by the formula:

\[
D(x, y) = \begin{cases} 
0 & \text{if } \text{abs}(f_i(x, y) - f_b(x, y)) < \text{Th} \\
1 & \text{else}
\end{cases}
\]

(1)

\(f_i(x, y)\) is the input image frame, and \(f_b(x, y)\) is the background image frame.

If the input image frame does not contain athletes, it is the same as the background image frame, and \(D(x, y)\) is 0 at this time; On the contrary, if the input image frame contains athletes, it is different from the background image frame. At this time, according to the threshold value, \(D(x, y)\) may not be 0.

5. Framework design of sports image analysis system

5.1 System flowchart

In this paper, when the system is implemented, considering that the system functions should run on the embedded platform in front of the camera, it has practical significance. Because the hardware platform has not been determined, the implementation is carried out by using C language programming on the PC, without using the image processing functions provided by the third party, so that it can be transplanted to the embedded platform for preparation in the future. In this paper, ACDSee is used to save the image sequence captured by video locally. with the help of the interface program provided by Microsoft Visual C++ 6.0, the system can complete the simulation system test, which can more intuitively display the functions completed by each functional module. however, the core functions of the system mentioned in this paper are all completed by c language. Figure 2 below shows the flow chart of system execution.
The system starts to execute, starts to read video sequence data according to the specified path, executes the analysis flow once in sequence, and then loops the next analysis flow until the external interruption or no video data input ends. The following is a step description of the system flow algorithm:

1. Establishing an initial background model B by initialization; A video frame I; Binary region map TU; Termination condition T = False;
2. Execution process

\[
\text{WHILE } ( ( I \neq \text{NULL} ) \text{ and } ( T \neq \text{True} ) )
\]

\{
I \text{ differential, B thresholding to get TU;}
Update B;
De-noising TU;
Perform binary morphological operation on TU;
Mark TU Unicom, establish data structure and record relevant information parameters;
IF (connected number > 10) break;
Extracting image feature data;
Image analyzer decision;
Output conclusion;
Update I, T;
\}

(3) End
System exits!

5.2 Fast tracking of human joint points

Because BDM(Block Distortion Measure) often has more than one minimum point, the globally optimal motion vector will be excluded if inappropriate choices are made in the previous steps. One way to overcome this defect is to keep multiple candidates for the next step. Although doing so can improve the performance of FSS, the amount of calculation increases greatly, and the amount of...
calculation increases rapidly [11]. The adaptive multi-candidate hierarchical search algorithm adaptively adjusts the number of candidates used as the search center in the next step. The algorithm is based on comparing the BDM of the best matching position with the BMD of other searching positions at the current stage, which is defined as follows:

\[ G_k = \frac{BDM_k - BDM_{\text{min}}}{BDM_k} \]  

Here, \( BDM_{\text{min}} \) and \( BDM_k \) are the minimum BDM value at the current stage and the BDM value at the \( k \) th position respectively. If \( G_k \) is close to 1 for all \( k \), it means that the direction of finding the global optimal motion vector towards the current position is probably uncertain. Then the next search area should be limited to the neighborhood of the current minimum position.

The specific algorithm is as follows:

The first step is to initialize the search center \((m, n)\) at (0,0) and take the search step \( p \) as half of the maximum motion displacement \( w \), i.e. \( p = w/2 \).

Step 2, use \((m_h, n_h)\) as the search center, where \( h \) is the number of candidates selected in the previous step, and the search step is halved.

Step 3: For all \( h \), calculate the BMD value at the motion vector \((m_h \pm p, n_h \pm p)\), and find out the smallest BMD value.

Step 4, which is the same as Step 2 and Step 4, uses all the obtained candidates as the search center in the next step.

Step 5, if the search step size is equal to 1, the position corresponding to \( BDM_{\text{min}} \) is the searched motion vector; Otherwise, go to step 2.

5.3 Image segmentation

The so-called image segmentation, in a broad sense, is based on the similarity criteria of some features or feature sets of an image, including gray, color, texture, etc., to group and cluster image pixels, and divide the image plane into several non-overlapping areas with certain consistency. However, there are abrupt changes in the characteristics of pixels between different regions, that is, they are inconsistent.

It is assumed that the gray value of the target part in the image is lower than that of the background part. Segmentation steps are as follows:

Firstly, the original image is segmented by Ostu to get the segmentation threshold \( T_1 \). According to \( T_1 \), the original image is divided into two parts, \( M \) and \( B \), and the gray value of \( M \) part is low.

Calculate the standard deviation \( \sigma_1 \) of the \( M \) part at this time. In this way, the part below the threshold in the original image histogram can be regarded as the gray statistical histogram of the target area.

Then, we evaluate \( T_1 \) to determine whether \( T_1 \) can accurately segment the real target. The \( M \) obtained from the above segmentation is segmented by Ostu to obtain the segmentation threshold \( T_2 \), and the original image is divided into two parts according to \( T_2 \) to obtain \( M_1 \) and \( M_2 \), in which the gray value of \( M_1 \) part is low. Use the following evaluation criteria to judge whether the threshold \( T_1 \) can well separate the target from the background:

\[ T_1 - T_2 \leq \sigma_1 \]  

If \( T_1 \) and \( T_2 \) can satisfy the formula (3), it is considered that the threshold \( T_1 \) can well separate the
target from the background, $M$ is the target part, and the algorithm stops; On the contrary, $M$ needs to be further segmented. Segment $M$ according to the previous steps and judge whether the segmented threshold can segment objects.

With the reduction of the region to be segmented, the proportion of target information is getting larger and larger, and the threshold value is getting closer and closer to the optimal threshold value, and finally the correct segmentation result is obtained.

5.4 Visual processing module
Module function: The binary image data input by the motion detection module is processed by denoising, binary morphology, connected labeling and other technologies, so as to obtain a binary region map that can more accurately express the moving target, which can meet the requirements of the feature extraction module.

Image processing, image recognition and image understanding are the three major research contents of computer vision. This paper makes full use of the three technologies to cooperate with each other to complete the system functions. The regional image of the moving target is obtained by image processing technology, and the physical and behavioral characteristics of the moving target are extracted. The image recognition and understanding technology is used to determine what kind of object the moving target is and what action it is performing. The sequence flow of 3D image processing technology is shown in Figure 3.

![Sequence flow chart of 3D image processing technology](image)

**Fig.3** Sequence flow chart of 3D image processing technology

In the visual analysis of moving objects, the influence of environment and the detection and extraction of foreground objects will cause noise, because in the process of segmentation and binarization, some small image areas will be produced, which is called noise. Therefore, even if a good motion detection technology can effectively fuse those noises, this step must be taken to avoid serious consequences.

Precondition: the foreground information image transmitted by the motion information detection
module. The starting condition of this module is not strict. As long as the binary image expressing the moving object is received, the module can start working.

Implementation details: The workload of this module can be said to be the largest in the system, including the integration of small area noise removal, morphological operation and connectivity labeling. In this paper, the size of the area is checked by connection recursion (the area threshold is set to 12), and the small area noise is removed; Morphological operation is to solve the problems such as burrs and holes in the moving target area. Translation operation is carried out through the operation template to solve the problem of unsatisfactory shape, and an ideal binary region map of the moving target is obtained. Whether the moving target leaves or enters the monitoring screen is determined by factors such as barycenter coordinates and moving direction of the moving target data structure established by the last inspection. Maintaining and updating the data structure of the moving target is the focus of the work.

5.5 Detailed design and implementation of timing module
When the starting gun goes off and the USB port of PC receives the timing instruction from the sensor, the system starts the timing module formally. Use WM_TIMER message mapping to time.

First, call the function SetTimer () to set the timing interval, for example, SetTimer(0,200,NULL) sets the time interval of 200ms. Then add the timed response function OnTimer () in the application program, and add the response processing statement in this function to complete the operation of reaching the timed time. This timing method is very simple and can realize certain timing function, but its timing function is just like the delay function of Sleep () function, with very low precision, the minimum timing precision is only 30 ms, the CPU occupation is low, and the priority of timer message in multitasking operating system is very low, so it can't get timely response, and often can't meet the application in real-time control environment. It can only be used to realize the situation that the timing accuracy is not high, such as the dynamic display of bitmaps.

Analyze the captured video images frame by frame. Some basic classes of DirectShow are mainly used here. After preprocessing the resolved single frame picture, the sprint information of athletes can be obtained by using background difference time-line judgment. Sprint information includes runner's runway number and sprint time. Finally, the sprint time is superimposed with the preset time, and the final comparative results of athletes are obtained.

6. Conclusion
In this paper, a sports motion image analysis system based on 3D image technology is designed by integrating motion detection technology, visual processing technology and image pattern recognition technology. In order to improve the intelligence of the video surveillance system, and considering the limitation and feasibility of the implementation platform, the core module of the system is realized by C language, so that it can be transplanted to the embedded platform at the lowest cost in the future. This system is based on data mining technology, which can enhance the blur of three-dimensional digital images. The processing time of the system is greatly reduced, and the fuzzy enhancement of three-dimensional digital images has achieved good results. The sports image analysis system based on 3D image technology designed in this paper has the advantages of high precision, high reliability, convenient system maintenance, wide application range, low price, good universality and good application and popularization value.

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