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Human body tree structure model application in sports techniques three-dimensional reconstitution

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ABSTRACT

Human motion recognition is one of research hotspot in recent years computer vision field, the technique promotes sports techniques development to considerable big extent. Sports researchers tend to regards video sequence images as important reference information, but sequence image is two-dimensional image after being reduced dimensions by video camera, two-dimensional image restricts necessary movement analysis to great extent, so people have urgent expectation in accurate two-dimension images three-dimensional reconstitution. The paper proposes a human model-based multiple views hierarchical image block texture expressed algorithm, in the hope of exploring the algorithm application in human movement three-dimensional reconstitution. The paper focuses on analyzing discriminant model method and generative model method. It provides human body tree structure model and image background elimination process particle filter principle that is required to use. For MH-L1 trackers principle and multi views hierarchical image block texture sparse expressed principles, it makes analysis, explores multiple views hierarchical image block texture sparse expression's algorithm steps in three-dimensional reconstitution process. On the basis of designing self-sheltering and human model inaccurate calculation caused wrong texture handling algorithm, it applies Matlab software to make three-dimensional reconstitution on four camera images, and displays reconstitution effects.

KEYWORDS

Human body tree structure model; Particle filter; Texture sparse; Multiple views layers; Three-dimensional reconstitution.

INTRODUCTION

Development of computer technology and measurement technology provide more scientific and reliable environment for sports analysis. By implementation level of computer program algorithm, it promotes some ill-conditioned matrix solution, so it provides good basis for sports video sequence images three-dimensional reconstitution. The paper studies on images' sparse texture feature, in the hope of starting from the aspect to establish three-dimensional reconstitution algorithm and providing theoretical basis for Chinese sports analysis.

For two-dimensional images background elimination and three-dimensional reconstitution researches, many people have made efforts, from which Liu Yun-Cai etc. (2013) proposed a kind of Tesco calculation-based parallel annealing particle filter method, used OpenCL frame to implement real-time label-free movement tracking task[1]; Cheng Xuan etc.(2013)put forward a kind of texture information-based three-dimensional human movements recovery method, and provided a robust, adaptive tracker model[2]; Wang Guo-Quan etc.(2013) provided a kind of sparse expression-based image block denoising method, experiment result shows that the method had great improvement effects by comparing to pure wavelet denoising method and ridge wavelet denoising method[3].

On the basis of formers researches, the paper carries on three-dimensional reconstitution research on human body walking process four cameras shot photos, in order to get better reconstitution effects, the paper adopts simulation annealing particle filter algorithm, multiple view hierarchical image block texture sparse expressive algorithm ad wrong textures handling algorithm, and implements human body three-dimensional reconstitution in Matlab software.

PROBLEM POSING AND METHODS SUMMARY

Problem posing

Video camera proceeded shooting work is projecting three-dimensional world objects into two-dimensional image planes, three-dimensional objects transform into two-dimensional images is a kind of dimension losing process, and presently people more focus on two-dimensional image three-dimensional reconstitution contents, which is also carrying on inverse operation on lost dimensions by detecting and algorithm and getting initial three-dimensional objects.

By above analysis, it is clear that recover human body three-dimensional information from image texture information is a process of solving and inverse operation. We know that video camera is shooting three-dimensional objects by projection matrix in case of fixed targets, but projection matrix generally has no inverse matrix, which is problem that needs to solve at present.

If use monocular video to carry on three-dimensional reconstitution, and then utilize frames time sequence continuity, it will appear larger ambiguity, so scholars adopt multicast video method to eliminate such ambiguity, and have full-automatic expectation on multicast video algorithm, in order to meet people demands, the paper provides a kind of full-automatic algorithm that utilizes multicast video, in the hope of providing more scientific and convenient algorithm for three-dimensional reconstitution.

In present multicast video three-dimensional reconstruction process, contents that cannot ignore are objective objects extraction and matching problems, people generally adopted prospects contour-based algorithm has following disadvantages:

1) It cannot eliminate prospects and backgrounds pixel comparison degree smaller and human body generated shadow parts in ground, which causes obtained prospects backgrounds big noise shortcomings.
2) Only reserve human body external contour information, lose internal texture information.
3) Due to human body movement generated sheltering status; it causes three-dimensional sports data inaccuracy.

Based on above disadvantages, it should consider to direct apply texture information, but direct apply texture information will suffer illumination, postures, sheltering and noises impacts, so before applying texture information, it needs to eliminate these issues, in the hope of correctly tracking object every part textures.

To sum up, human body sports video images three-dimensional reconstitution should develop towards backgrounds scientific elimination and textures correctly tracking orientations, in order to explore two-dimensional images three-dimensional reconstitution principles, the paper puts forward human model-based multiple view hierarchical image block texture sparse expression application methods in human body sports three-dimensional reconstitution.

Method summary

In video image three-dimensional recovery researches, scholars generally adopt two methods as following :

Method 1. Discriminant model method.

Method 2. Generative model method.

Chen Cheng etc.(2011)stated method 1 was mainly learning from image features (such as prospects contour) to human body three-dimensional postures mapping relationship from training data, the relationship could apply regression model to approximate express and also could directly apply training obtained data, and to every new image feature, it adopted TABLE checking method to solve corresponding human body three-dimensional postures, and stated the method had disadvantage as lacking of human body postures data[4].

Corazza S etc.(2010)proposed method 2 was looking for an optimal solution in human body model parameters space, the optimal solution could well explain present observed images, and utilized multiple views prospect contour to solve visible shell, and then utilized human body skeleton model to fit the visible shell, in method 2,how to define human body model and image fitting extent possibility model was key factor part in algorithm success, in prospect contour designing possibility model method, except for prospect contour, it could also use convenient information, in the hope of adding internal contour to prospect images, generally human body model parameters freedom degree was higher, it had 30 freedom degrees at least, which let space that people needed to search to be very big, therefore method 2had disadvantage of huge computation[5].

The paper adopted human body model is kinematics human body model that conforms to hierarchical searching features, in every hierarchy searching process, it utilizes MH-L1trackers to look for best objective texture. In order to promote algorithm accuracy, it puts forward a kind of steady texture updated strategy.

In order to weaken human body self-sheltering and poor texture impacts on texture template, the paper utilizes human body three-dimensional model to detect textures after sheltering, use template coefficient to detect tracking textures quality.

HUMAN BODY MODEL AND ANNEALING PARTICLE FILTER ALGORITHM

Human body sports process detects human body texture information that needs to possess certain regional attribute, scientific and reasonable regional attribute setting is helpful for promoting texture information collecting, present texture information detection region setting generally adopts human body kinematics model method, the chapter first section makes statement on human body model, in the hope of building basis for subsequent human body multiple view hierarchical texture tracking.

Of course, in order to get better human body contour, it is necessary to eliminate backgrounds, and scientific and reasonable background elimination algorithm method decides background contour effects, therefore, the chapter the second section states annealing particle filter algorithm that adopts in the paper, in the hope of providing theoretical basis for more clearly and specific three-dimensional reconstitution.

Human body model

The paper designed human body model is as Figure 1 shows, in Figure 1,human body model is a tree structure.

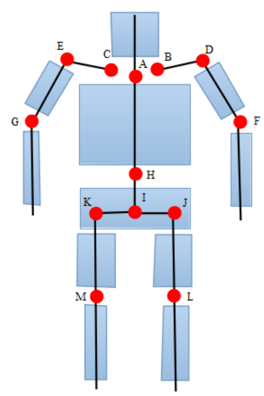

Figure 1 : Human body tree structure model schematic diagram

In Figure 1, A-M totally 13 parts nodes names and freedom degrees are as TABLE 1 show.

TABLE 1 : Figure 1 symbol name and its freedom degree number

Symbol	Name	Freedom degree	Symbol	Name	Freedom degree
A	Neck	3	H	Spine base	3
B	Right shoulder blade	2	I	Pelvis	6
C	Left shoulder blade	2	J	Right thigh root	3
D	Right shoulder	3	K	Left thigh root	3
E	Left shoulder	3	L	Right knee	2
F	Right elbow	2	M	Left knee	2
G	Left elbow	2	Note: unit of freedom degree is (piece)		

By Figure 1 and TABLE 1 contents, root node position sets in the part of pelvis, by hierarchical searching tree structure, in searching process, it needs to first define parent node,and then define sub node. In the process of applying the model in the paper, after defining trunk, pelvis and head positions, it defines arms and thigh, and finally defines small arm and shank.

Simulation annealing particle filter algorithm principle

In Bayes tracking, particle filter has been widely used, in smaller background changes scenes video sequence images, by particle filtering; it can get better tracking results.

Particle filter is a random sampling simulating Bayes posterior probability process on the basis of weight, is actually a kind of random searching method, its algorithm steps are mainly composed of prediction and updating.

If use $\mathbf{x}_t$ to represent the t frame human body three-dimensional posture vector,use $\mathbf{z}_{1:t}$ to represent observed image sequence from the 1 frame to the t frame, then it can use as formula(1)showed Markov assumption to get as formula (2) showed prediction $\mathbf{x}_t$ probability distribution functions computational formula:

$$\begin{cases} \mathbf{z}_{1:t} = \{z_1, z_2, \cdots, z_t\} \\ p(\mathbf{x}_t|\mathbf{x}_{t-1}, \mathbf{z}_{1:t-1}) = p(\mathbf{x}_t|\mathbf{x}_{t-1}) \end{cases} \quad (1)$$

$$p(\mathbf{x}_t|\mathbf{z}_{1:t-1}) = \int p(\mathbf{x}_t|\mathbf{x}_{t-1}) p(\mathbf{x}_{t-1}|\mathbf{z}_{1:t-1}) d\mathbf{x}_{t-1} \quad (2)$$

In formula(2) probability on the premise of the $t-1$ frame human body posture vector, the probability of the t frame human body posture vector occurrence shows human posture vector state transferring function from the $t-1$ frame to the t frame. If assume that as formula(2) showed probability distribution function has been obtained in the $t-1$ frame,then till the t frame, image z_t will be observed,now it can get formula(2)predicted posterior probability before immediately renewing according to formula (3).

$$p(\mathbf{x}_t|\mathbf{z}_{1:t}) = \frac{p(\mathbf{z}_t|\mathbf{x}_t) p(\mathbf{x}_t|\mathbf{z}_{1:t-1})}{p(\mathbf{z}_t|\mathbf{z}_{1:t-1})} \quad (3)$$

In formula(3) human posture three-dimensional vector $\mathbf{x}_t$ and image z_t fitness degree possibility function can use $p(\mathbf{x}_t|\mathbf{z}_{1:t})$ to express, then use prediction and updated posterior probability, it carries on constantly iterating,finally gets expected filtering efficiency.

Simulated annealing particle filter algorithm establishes on the basis of order weight sampling algorithm, its algorithm steps are as following show:

STEP 1. Get measurement value as formula(4)shows,in formula(4) z_k represents latest measurement value, $\hat{z}^i_{k/k-1}$ presents predicted measurement value.

$$z_k \sim fitness = \exp\left[-\frac{1}{2R_k}\left(z_k - \hat{z}^i_{k/k-1}\right)\right] \quad (4)$$

STEP 2. At the moment $k=0$,collect N pieces of particles samples from importance function, from which extracted particles and importance density function take transferring prior as formula (5)shows, the process is initialization process.

$$\left\{x^i_{0:k}, \frac{1}{N}\right\}_{i=1}^{N}; X^i_k \sim q\left(X^i_k \middle| X^i_{k-1}, Z_k\right) = p\left(X^i_k \middle| X^i_{k-1}\right) \quad (5)$$

STEP 3. According to formula(6),calculate importance weight, and then according to optimal value,utilize formula (7)to update every particle speed and position, in the hope of let particle to draw near realistic state, in formula(7) $|rand \quad n|$ and $|Rand \quad n|$ represent Gaussian distribution random number that is larger than 0,the random number can implement by $abs[N(0,1)]$in Matlab,finally concentrate on utilizing latest observation value on particle, apply formula(8)to make normalization processing.

$$w_k^i = w_{k-1}^i p\left(Z_k \middle| X_{k-1}^i\right) = w_{k-1}^i \exp\left[-\frac{1}{2R_k}\left(z_k - \hat{z}_{k/k-1}^i\right)^2\right] \quad \textbf{(6)}$$

$$X_k^i = X_{k-1}^i + v_{k-1}^i; v_{k-1}^i = \left|rand \quad n\right|\left(p_{pbest} - X_{k-1}^i\right) + \left|Rand \quad n\right|\left(p_{pbest} - X_{k-1}^i\right) \quad \textbf{(7)}$$

$$w_k^i = \frac{1}{\sum_{i=1}^{N} w_k^i} \cdot w_k^i \quad \textbf{(8)}$$

STEP 4. If it meets formula(9),then it samples again, and maps weighted sample $\left\{x_{0:k}^i, w_k^i\right\}_{i=1}^N$ into equal weight sample $\left\{x_{0:k}^i, N^{-1}\right\}_{i=1}^N$,after carrying on the fourth step, realistic state nearby particle weight will obviously increase.

$$N_{eff} = \frac{1}{\sum_{i=1}^{N}\left(w_k^i\right)^2} < N_{threshold} \quad \textbf{(9)}$$

STEP 5. Output as formula(10) showed state estimation and variance estimations P_k

$$\begin{bmatrix} \hat{X}_k \\ P_k \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{N} w_k^i X_k^i \\ \sum_{i=1}^{N} w_k^i \left(X_k^i - \hat{X}_k\right)\left(X_k^i - X_k\right)^T \end{bmatrix} \quad \textbf{(10)}$$

STEP 6. If it meets set requirements then ends algorithm, otherwise starts from STEP2. and goes ahead with new round circulation.

MULTIPLE VIEW HIERARCHICAL IMAGE BLOCK TEXTURE SPARSE EXPRESSION AND HUMAN BODY SPORTS THREE-DIMENSIONAL RECONSTITUTION

MH-L1trackers principle analysis

MH-L1trackers refers to image block texture-based sparse expression, if use $y \in R^m$ to represent obtained LR image,use $x \in R^n$ to represent ideal HR image,use $D \in R^{m \times n}$ to represent sampling matrix, use H to represent fuzzy operator, $n \in R^m$ represents Gaussian white noise, then image obtained model can as formula(11)shows:

$$y = DHx + n \quad \textbf{(11)}$$

Similarly initialize image block pixel grey value, convert it into one dimension vector y ,and the vector represents texture template T linear combination,it can get relationship as formula (12)shows,in formula (12) a represents texture template coefficient.

$$y \approx Ta = \begin{bmatrix} t_1 & t_2 & \cdots & t_n \end{bmatrix}\begin{bmatrix} a_1 & a_2 & \cdots & a_n \end{bmatrix}^T \quad \textbf{(12)}$$

In order to try to reduce self-sheltering and noises impacts as much as possible, it needs to ensure texture template coefficient as non-negative, so in MH-L1trackers,it adds common template, and use $B = \left[T, T, -I\right]$ to represent whole template set, and objective texture y sparse expression changes into optimization form as formula (13) shows,in formula $\|\bullet\|_1, \|\bullet\|_2$ respectively express ℓ_1, ℓ_2 normal form, c represents texture template coefficient and common template coefficient:

$$\begin{aligned} &\min \quad \|Bc - z\|_2^2 + \lambda \|c\|_1 \\ &\text{s.t} \quad c \geq 0 \end{aligned} \tag{13}$$

Multiple view hierarchical image block texture sparse expression

As Figure 2 shows,texture template and common template sparse expression-based objective texture schematic diagram, in Figure y_1 represents human body right upper arm objective texture, y_2 represent human body right small arm objective texture, T_1 represents human body right upper arm texture template, T_2 represents human body right small arm texture template, c_1, c_2 respectively represent template coefficient.

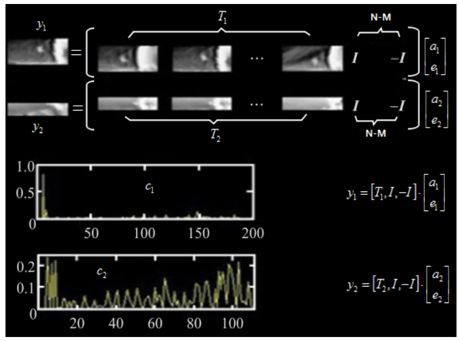

Figure 2 : Texture template and common template sparse expression-based objective texture schematic diagram

If present view v possibility function uses objective texture and its coefficient expressed differences to express, then it can get forms as formula(14)shows:

$$p\left(z_t^v \middle| x_t\right) = \exp\left\{-\alpha \|Ta - y\|\right\} \tag{14}$$

Wrong texture handling algorithm

Wrong texture generation is mainly caused y human body self-sheltering and human body model calculation inaccuracy, from which texture handling algorithm after human body self-sheltering is using previous frame human body three-dimensional model and combining with camera parameters then can get camera matrix, when matrix determinant is above zero, one point X value camera plane depth under world coordinate system meets formula (15):

$$\begin{cases} \mathbf{P} = [\mathbf{M} | \mathbf{p}_4] \\ \mathbf{X} = (X, Y, Z, 1) \\ depth(\mathbf{X}; \mathbf{P}) \propto s \\ \mathbf{x} = s(x, y, 1)^T = \mathbf{PX} \end{cases} \tag{15}$$

In formula(15), $\mathbf{P}$ represents camera matrix, $\mathbf{M}$ is a matrix of three multiplying by three, $\mathbf{p}_4$ is a three-dimensional column vector, $\mathbf{X}$ represents one point under world coordinate system, $depth(\mathbf{X};\mathbf{P})$ represents depth function. Algorithm maintains a depth buffer in running process, it can distinguish whether Figure 1 model shelters or not by z buffer, as Figure 3 shows z buffer algorithm-based human body self-sheltering detection effects.

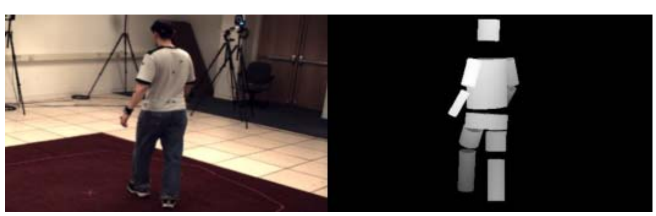

Figure 3 : Human body self-sheltering detection based on z buffer

Targeted at human body three-dimensional sports model inaccurate calculation generated texture mistakes handling algorithm steps are as Figure 4 shows.

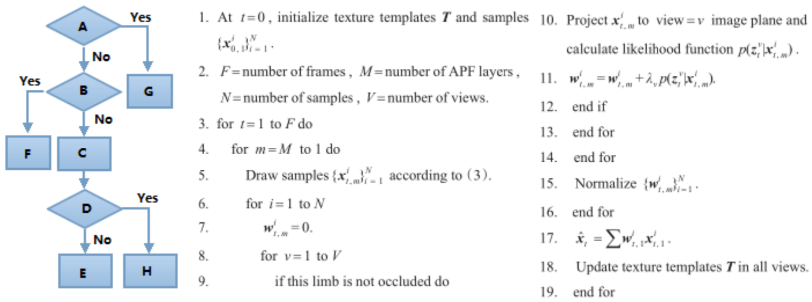

Figure 4 : Inaccurate calculation-based texture mistake handling algorithm steps

Figure 4 flow chart's A-H definition is as TABLE 2 shows.

TABLE 2 : Figure 4 flow symbol definition

Symbol	Definition	Symbol	Definition
A	Be sheltered in view	E	Add into texture template, and adjust weight coefficient
B	Previous frame view is sheltered	F	Initialize texture template
C	Update texture template weight coefficient	G	Set view weight as 0
D	Calculate wrong textures	H	Add the view weight

Three-dimensional reconstitution result display

For walking process implemented video sequence image's three-dimensional reconstitution, apply simulated annealing particle filter algorithm to carry on background elimination handling, apply multiple view hierarchical image block texture sparse expression to do texture detection, apply self-sheltering handling algorithm and calculating inaccurate processing algorithm to carry on texture template updated strategy one part, in Matlab software, handle with four cameras shot photos, it gets three-dimensional reconstitution efficiency graph as Figure 5 shows.

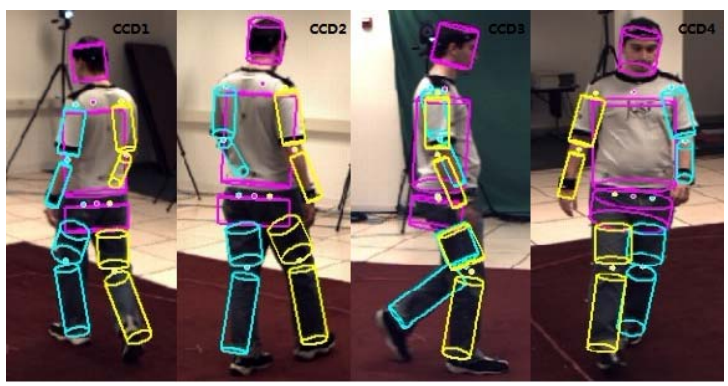

Figure 5 : Image block texture sparse expression-based human body walking three-dimensional reconstitution efficiency graph

CONCLUSION

It summarizes present video sequence two-dimensional image three-dimensional reconstitution research contents, puts forward three-dimensional reconstitution is two-dimensional camera shot inverse process problem, summarizes present video image three-dimensional recovery research methods, focuses on analyzing discriminant model method and generative model method, which builds basis for the paper discussed human body model-based multiple view hierarchical image block texture coefficient expression's application in human body sports reconstitution. It provides human body tree structure model and image background elimination process particle filter principle that needs to use, and provides theoretical algorithm for simplifying texture detection and background elimination. Targeted at MH-L1 trackers principles and multiple view hierarchical image block texture sparse expressed principles, it makes analysis, explores multiple view hierarchical image block texture sparse expression algorithm steps in three-dimensional reconstitution process. On the basis of designing self-sheltering and human body model inaccurate calculation brought wrong textures' handling algorithm, applies Matlab software to carry on three-dimensional reconstitution on four cameras' photos, and shows reconstitution effects.

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