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Three-dimensional dynamic simulation technology application in sports technical analysis video image sequence research

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ABSTRACT

Sports Video two-dimensional image sequence parsing has propelled to sports technical promotion to some extent, but people's demands on three-dimensional simulation constantly increase, demands on sports images' three-dimensional simulation authenticity seem to be more urgent. The paper studies on sports video image sequence three-dimensional dynamic simulation, which starts from image collecting frame to algorithm exploration then to computer simulation authenticity results analysis, with an aim to verify the paper proposed factorization algorithm's superiorities and feasibilities in three-dimensional dynamic simulation implementation. The paper firstly states sports video image sequence collecting frame design problems, introduces biplane calibration frame engineering drawing construction, it puts forward calibration frame precise analysis experiment method and experiment data. For video image sequence three-dimensional reconstructed computer simulation principle, it makes discussion, and provides three-dimensional dynamic simulation mathematical model construction steps. It analyzes sports features optical flow restoration principle and athlete human body three-dimensional motion simulation principle, focuses on introducing factorization algorithm principle features. On the basis of designing DSP dual processor array algorithm flow, targeted perspective projection linear approximation algorithm, power factor algorithm, two-dimensional image sequence algorithm and factorization algorithm simulation affects data, it makes comparison and gets the paper adopted factorization algorithm special superiority in authenticity coefficient, and verifies algorithm feasibility and superiority.

KEYWORDS

Microbial breakdown;
Crude oil;
Polluted soil;
Amended.

INTRODUCTION

Make three-dimensional dynamic simulation on motion videos' human body of athletes, it is helpful for athletes looking for skill level breakthrough orientation, current sports high-tech carries out penetration through moving body three-dimensional simulation, and shows strong motion analysis promotion effects. In order to

improve three-dimensional dynamic simulation authenticity, the paper carries on algorithm exploration and simulation analysis of sports video image sequence.

For video image sequence three-dimensional dynamic simulation research, lots of people have made efforts, from which Zhang Dong-Hai (2013) proposed a kind of experiment way through frame automatic identification precise analysis, which implemented sports technical analysis's three-dimensional reconstruction frame's computer automatic identification[1]; Cheng Jun and others (2013)designed a newly-developed human body three-dimensional modeling identification system, the system could implement multiple people sports objects real-time tracking function[2]; Li Jie and others (2013) applied optics hydrodynamics conception reasonable calculation on sports shape foundation numbers, carried out binding calculation on shape foundation number, which promoted human body sports image sequence three-dimensional dynamic simulation authenticity[3].

The paper on the basis of previous researches, focuses on factorization algorithm principle statement, with the help of advanced reconstruction frame and implementation system, it simulates and compares different algorithms' gap in three-dimensional dynamic simulation authenticity, which provides better platform for sports analysis.

SPORTS VIDEO IMAGE SEQUENCE COLLECTING FRAME DESIGNING

The purpose of sports video image sequence three-dimensional reconstruction simulation technology is to recover from two-dimensional video image to three-dimensional image through image features. Therefore, scientific collection of two-dimensional video image sequence is the basis of three-dimensional reconstruction simulation. In view of sports analysis technique, computer technology and video monitoring technology are mainly for athletes' kinematics parameters in sports process, and then by collected data and results after data processing, carries out reasonable diagnosis and evaluation on sports technology, in the hope of providing theoretical basis for athletes' technical improvements and training process. Yang Nian-Feng (2000)pointed out that technical analysis on human body sports usually utilized two-dimensional images to make three-dimensional reconstruction, and then carried out kinematics and dynamics analysis according to reconstruction data[4].

In order to provide basis for three-dimensional reconstruction simulation on sports video image sequence, it designs for image collection frame. Adopt biplane calibration frame, its engineering drawing is as Figure 1 shows, in Figure 1, mark number is locating rod, the rod can freely rotate, when frame folds, it can rotate

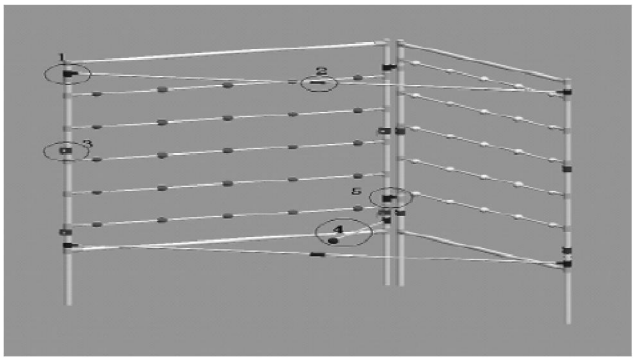

Figure 1 : Calibration frame engineering drawing schematic diagram

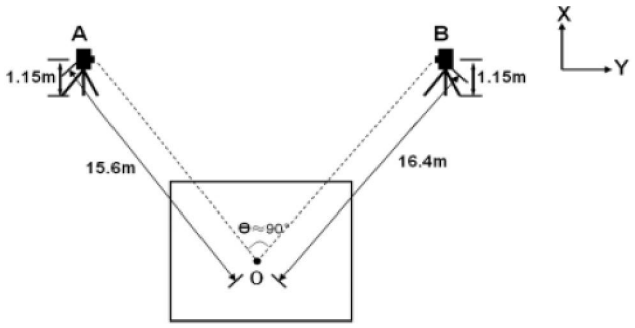

Figure 2 : Calibration frame precise analysis experiment schematic diagram

TABLE 1 : Calibration frame precise analysis experiment data

Range pole direction (coordinate axis)	Range pole actual Length (mm)	Range pole calculated length (mm)	Relative error (%)
X axis positive direction	740 mm	741.5 mm	0.20 %
Y axis positive direction	740 mm	742.3 mm	0.31 %
Z axis positive direction	740 mm	737.9 mm	0.28 %

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locating rod and let it to be parallel to crossing rod.

Apply experiment method as Figure 2 shows to make precise test on calibration frame, from which Z axis direction is vertical to paper and outwards, Figure 2 shows camera shooting areas. As TABLE 1 shows frame precise analysis experiment data.

By TABLE 1 data, it is clear that the paper designed calibration frame precise is good, all are less than 0.5%.

SPORTS VIDEO IMAGE SEQUENCE THREE-DIMENSIONAL RECONSTRUCTION COMPUTER SIMULATION PRINCIPLE SUMMARY

Niu Lian-Qiang etc. (2007)pointed out that human body three-dimensional dynamic simulation is simulating human body sports status through computer and then real reflecting people sports state[5], Kong De-Hui (2005)pointed out such human body three-dimensional dynamic simulation technology is core problem of computer visual field research, which has extremely important significances in robot visual system researching, human body sports tracking and other aspects researching[6].

Current sports analysis gets more and more wonderful, sports analysis wonderful degree has very important relations to commentator understood data, and meanwhile Chinese sports technical level are also constantly developing, which is closely connected to scientific ways application in analysis system.

We know that video image sequence generation is changing real three-dimensional space object into two-dimensional image sequence through video camera's optical projection principle, if it wants to make three-dimensional reconstruction on image sequence, then firstly it needs to extract key points on two-dimensional images, then carries out three-dimensional restoration by image features, the research provides as Figure 3 showed sports video image sequence computer simulation principle.

In Figure 3, symbol A-J definitions are as TABLE 2 show.

To establish sports videos' athlete three-dimensional dynamic simulation mathematical model, it needs to do following three steps:

STEP1. Set two-dimensional human body sports image different parts shelter parameter, the parameter uses χ_{ij}, from which subscript represents mutual sheltering human body part number.

STEP2. Collect human body motion process two-dimensional image data set A, and rank human body different parts and gain human body parts data set B, as formula (1) show:

$$A\{a_1, a_2, \cdots, a_n\} \rightarrow B\{b_1, b_2, \cdots, b_n\} \quad (1)$$

STEP3. In the i two-dimensional human body sports image, the j part key point can use T_{ij} to describe, apply formula (2), it can establish human body exercise instant three-dimensional shape foundation, and use it to make three-dimensional simulation on human body sports status.

$$\varphi_i = \left(a_i \times b_i \times \sqrt{i + k^2 - 1}\right) / \left|2 \times \chi_i \times T_i\right| \quad (2)$$

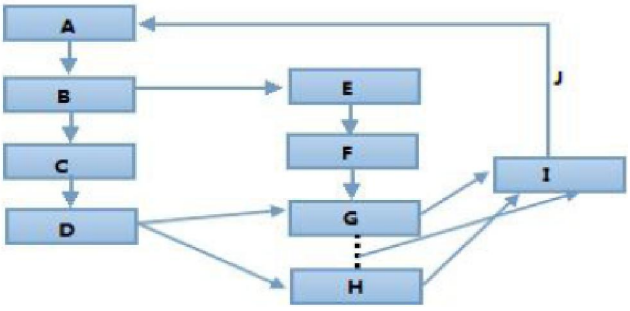

Figure 3 : Sports video image sequence computer simulation principle

TABLE 2 : Figure 3 symbol definition table

Symbol	Definition	Symbol	Definition
A	Normalized sports information collecting	F	Special sports technical analysis
B	Primary data processing	G	Intelligentized decision-making
C	Image preprocessing	H	Computer shape foundation
D	Sports image library	I	Three-dimensional sports simulation
E	Excellent athlete motion techniques information database	J	Feedback

THREE-DIMENSIONAL SIMULATION TECHNICAL PRINCIPLE ANALYSIS

Li Jie and others (2013) pointed out that in human body sports process, three-dimensional simulation is core problem of computer visual technology research, if utilize traditional algorithm to make human body sports three-dimensional dynamic simulation, then it cannot avoid different key points occurring repetition and losing these drawbacks due to human body different parts exist serious sheltering in space, which leads to human body sports three-dimensional dynamic simulation authenticity diminishing[3]. The paper proposed a kind of improved factorization algorithm, in the hope of providing more scientific theoretical basis for sports video image sequence three-dimensional simulation on the basis of eliminating traditional algorithm drawbacks.

In order to state improved factorization human body sports image three-dimensional dynamic simulation algorithm, start from sports image features' optical flow sports restoration and three-dimensional sports simulation principle, it makes analysis.

Sports features optical flow restoration principle analysis

In computer visual field, sports image features' optical flow movement restoration has played crucial roles. If people use eyes to observe human body movement, then people will see an orderly image sequence, and these images sequences should flow through human eyes, it is called optical flow in computer visual system. In two-dimensional image three-dimensional reconstruction process through its features, it can apply optical flow movement restoration method.

Optical flow movement restoration method applying steps principles are as following show: if in set human body sports process, it has a point (y,z) at moment u_1 luminance, which can use $J(y,z,u_1)$ to express, the point at moment u_2 luminance can use $J(y,z,u_2)$ to express, and in case two moments' intervals are extremely smaller, then it can use formula (3) to express two luminance, formula (3) expressed definition is the pixel point luminance will not change.

$$\mathbf{J(y,z,u_1)=J(y,z,u_2)} \tag{3}$$

If expand $I(y',z',u_2)$ position in pixel point (y,z) as formula (4), it can get as formula (5) showed relations, when u_1 and u_2 intervals are extremely small, it can have formula (6) showed relations:

$$\mathbf{I(y',z',u_2)=I(y+\Delta y,z+\Delta z,u_1+\Delta u)=J(y,z,u_1)}+\frac{\partial \mathbf{J}}{\partial \mathbf{y}}\Delta \mathbf{y}++\frac{\partial \mathbf{J}}{\partial \mathbf{z}}\Delta \mathbf{z}++\frac{\partial \mathbf{J}}{\partial \mathbf{u}}\Delta \mathbf{u}+\mathbf{h.o.} \tag{4}$$

$$\frac{\partial \mathbf{J}}{\partial \mathbf{y}}\Delta \mathbf{y}++\frac{\partial \mathbf{J}}{\partial \mathbf{z}}\Delta \mathbf{z}++\frac{\partial \mathbf{J}}{\partial \mathbf{u}}\Delta \mathbf{u}=\mathbf{0} \tag{5}$$

$$\frac{\partial \mathbf{J}}{\partial \mathbf{y}}\frac{\mathbf{dy}}{\partial \mathbf{u}}+\frac{\partial \mathbf{J}}{\partial \mathbf{z}}\frac{\mathbf{dz}}{\partial \mathbf{u}}+\frac{\partial \mathbf{J}}{\partial \mathbf{u}}=\mathbf{0} \tag{6}$$

In formula (6), variable $W=\left(\frac{dy}{du},\frac{dz}{du}\right)$ shows movement speed when human body lies in pixel point (y,z); $\nabla J=\left(\frac{\partial J}{\partial y},\frac{\partial J}{\partial z}\right)$ shows gradation gradient when human body lies in pixel point (y,z); $\frac{\partial J}{\partial u}$ represents image gradation and image collecting time interval ratio. Apply above algorithm; it can implement optical flow movement restoration process.

Athlete human body three-dimensional sports simulation principle analysis

On the basis of sports image optical flow restoration, then apply factorization method, it can establish human body sports process three-dimensional dynamic simulation model. If set human body sports image key points can use formula (7) to describe, then formula (7) key points composed matrix can use $\mathbf{X}_{2G\times Q}$ to express, from which G shows image sequence images amount, Q represents any frame images' key points amount.

$$\begin{bmatrix}\mathbf{v_{ik}}\\ \mathbf{w_{jk}}\end{bmatrix}\begin{matrix}\mathbf{j=1,2,\cdots,G}\\ \mathbf{k=1,2,\cdots,Q}\end{matrix} \tag{7}$$

If use $\mathbf{T}_{j\ \ 3\times Q},\mathbf{T}_{j\ \ 3\times 3}$ respectively to express three-dimensional structure model and rotation matrix established by applying factorization method, then it can get as formula (8)showed sports image shape foundation, and as formula (9) showed any image projection formula.

$$\mathbf{T_j}=\sum_{\mathbf{m=1}}^{\mathbf{L}}\mathbf{x_{ju}T_m} \tag{8}$$

$$\begin{bmatrix}\mathbf{v_{j1},v_{j2},\cdots,v_{jQ}}\\ \mathbf{w_{j1},w_{j2},\cdots,w_{jQ}}\end{bmatrix}=\bar{\mathbf{S}}_{\mathbf{j}}\left(\sum_{\mathbf{m=1}}^{\mathbf{L}}\mathbf{x_{jm}T_m}\right)+\bar{\mathbf{U}}_{\mathbf{j}}\mathbf{f}_{\mathbf{p}}^{\mathbf{U}} \tag{9}$$

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In formula (8), $\mathbf{x}_{ju}$ represents weight coefficient, $\mathbf{T}_m$ represents any frame human body sports image shape foundation, L represents shape foundation amount, in formula (9) $\overline{\mathbf{S}}_j$ represents rotation matrix the j line elements average value, $\overline{\mathbf{U}}_j$ represents time interval average value, $\mathbf{f}_p^U = [1,\cdots,1]_{1\times p}$.

In human body sports image coordinate changes handling process, it should transform original coordinate system origin into the sports image mass center so as to achieve the purpose of eliminating formula (9) $\overline{\mathbf{U}}_j$, and getting image mass center coordinate as formula (10)show:

$$\begin{cases} \overline{\mathbf{v}}_{jk} = \overline{\mathbf{v}}_{jk} - \dfrac{1}{\mathbf{Q}}\sum_{k=1}^{\mathbf{Q}} \mathbf{v}_{jk} \\ \overline{\mathbf{w}}_{jk} = \mathbf{w}_{jk} - \dfrac{1}{\mathbf{Q}}\sum_{k=1}^{\mathbf{Q}} \mathbf{w}_{jk} \end{cases} \quad (10)$$

Carry out overall processing with G frame image all key points according to formula (11), it can get relations as formula (11) :

$$\begin{bmatrix} \overline{\mathbf{v}}_{11} & \overline{\mathbf{v}}_{12} & \cdots & \overline{\mathbf{v}}_{1Q} \\ \overline{\mathbf{w}}_{11} & \overline{\mathbf{w}}_{12} & \cdots & \overline{\mathbf{w}}_{1Q} \\ \vdots & \vdots & \vdots & \vdots \\ \overline{\mathbf{v}}_{G1} & \overline{\mathbf{v}}_{G2} & \cdots & \overline{\mathbf{v}}_{GQ} \\ \overline{\mathbf{w}}_{G1} & \overline{\mathbf{w}}_{G2} & \cdots & \overline{\mathbf{w}}_{GQ} \end{bmatrix} = \begin{bmatrix} \mathbf{x}_{11}\overline{\mathbf{S}}_1 & \mathbf{x}_{12}\overline{\mathbf{S}}_1 & \cdots & \mathbf{x}_{1L}\overline{\mathbf{S}}_1 \\ \mathbf{x}_{21}\overline{\mathbf{S}}_2 & \mathbf{x}_{22}\overline{\mathbf{S}}_2 & \cdots & \mathbf{x}_{2L}\overline{\mathbf{S}}_2 \\ \vdots & \vdots & \vdots & \vdots \\ \mathbf{x}_{G1}\overline{\mathbf{S}}_G & \mathbf{x}_{G2}\overline{\mathbf{S}}_G & \cdots & \mathbf{x}_{GL}\overline{\mathbf{S}}_G \end{bmatrix} \begin{bmatrix} \mathbf{T}_1 \\ \mathbf{T}_2 \\ \vdots \\ \mathbf{T}_L \end{bmatrix} \quad (11)$$

If make matrix simplified writing on formula (11), it can get as formula (12) showed three-dimensional dynamic simulation model equation:

$$\overline{\mathbf{X}} = \mathbf{N}_{2G\times 3L}\mathbf{C}_{3L\times Q} \quad (12)$$

SPORTS VIDEO IMAGE SEQUENCE HUMAN BODY THREE-DIMENSIONAL SIMULATION ALGORITHM FLOW AND SIMULATION RESULT ANALYSIS

Simulation algorithm flow

The paper adopts DSP to establish human body model, it applies two DSP processors that are respectively TMS320C64X+DSP processor one and TMS320C64X+DSP processor two, selected camera collection array is controlled by ARM11 processor unified ordinate, transfers frame image data to TMS320C64X+DSP processor one by data bus. Use TMS320C64X+DSP processor one to fulfill image processing algorithm, 2D image reconstruction algorithm and 2D image complementation algorithm, and finally generate single frame human body three-dimensional modeling image, and transmit processor completed data to TMS320C64X+DSP processor two.

TMS320C64X+DSP processor two extracts 256 colors true color camera stream media synchronous data information, and applies 3D video flowing reconstruction algorithm, then it can implement single frame human body three-dimensional modeling image video flowing reconstruction calculation, so that generate continuous frame structure human body 3D modeling data flow, and finally apply video flowing media compression algorithm, it can output fluent human body three-dimensional modeling result. Apply DSP dual processor array algorithm flow as Figure 4 shows.

In Figure 4, number 1-10 expressed definition is as TABLE 3 shows.

Different algorithms simulation result comparative analysis

The paper applies TVP5146 video decoder to obtain 100 pieces of human body sports image sample, and establishes is as a data set, sets samples image capture time interval as 0.3s, selects 1000 pieces of key points from every frame image, firstly applies algorithm

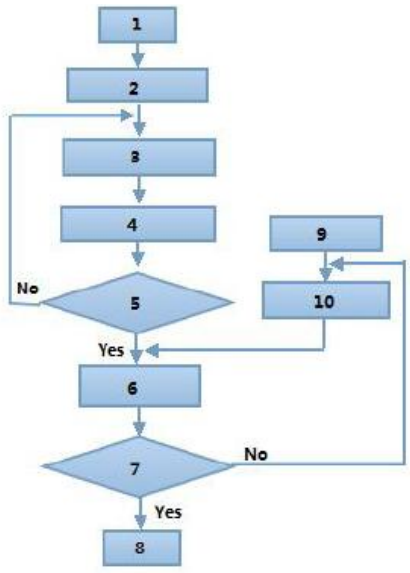

Figure 4 : DSP dual processor array algorithm flow chart

TABLE 3 : Figure 4 number definition table

No.	Definition	No.	Definition
1	Video capture	6	Three-dimensional reconstruction algorithm
2	TVP5146 video decoding	7	Whether fulfill three-dimensional algorithm?
3	Depth image processing algorithm	8	Video compression
4	Complementation image processing algorithm	9	True color camera
5	Whether two-dimensional algorithm fulfills or not?	10	Extract frame synchronous data

1perspective projection linear approximation algorithm to carry out human body sports three-dimensional dynamic simulation, then applies algorithm 2 power factor algorithm to carry out human body sports three-dimensional dynamic simulation, secondly applies algorithm 3 two-dimensional image sequence algorithm to carry out human body sports three-dimensional dynamic simulation, finally applies algorithm 4 factorization algorithm to carry out human body sports three-dimensional dynamic simulation.

Apply formula (13) showed formula to carry out authenticity coefficient computing :

$$\begin{aligned} imag\_err &= T_{ij} - W_{ij} \\ &= [quater(R)] \times [quater(Q) \times W_{ij} + T_i] - W_{ij} \\ &= \begin{bmatrix} u_{1j} - u'_{1j} \\ v_{1j} - v'_{1j} \\ \cdots \\ u_{Fj} - u'_{Fj} \\ v_{Fj} - v'_{Fj} \end{bmatrix} \end{aligned} \quad (13)$$

By authenticity coefficient computing, it can get algorithm 1, 2, 3 comparison status, as Figure 5 shows.

In Figure 5, horizontal coordinate represents overlapping amount, vertical coordinate represents corresponding overlapping pixel numerical value's three-dimensional simulation authenticity coefficient. From figure, it is clear that algorithm 1, 2, 3 authenticity coefficient values have similar change trend, all are diminishing with overlapping pixel amount increases, and corresponding value is relative similar. As TABLE 4 shows that algorithm 1, 2, 3 obtained human body sports three-dimensional dynamic simulation data.

The paper researched algorithm is factorization that is also algorithm 4, apply algorithm 4, the obtained human body sports three-dimensional simulation result is as Figure 6 shows.

By Figure 6, it is clear that in algorithm 4, authenticity coefficient value appears fluctuant status in overlapping pixel amount, authenticity coefficient value com-

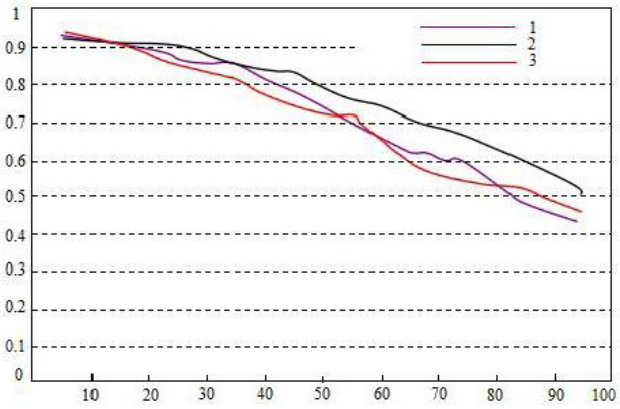

Figure 5 : Algorithm 1, 2, 3 simulation result authenticity coefficient status

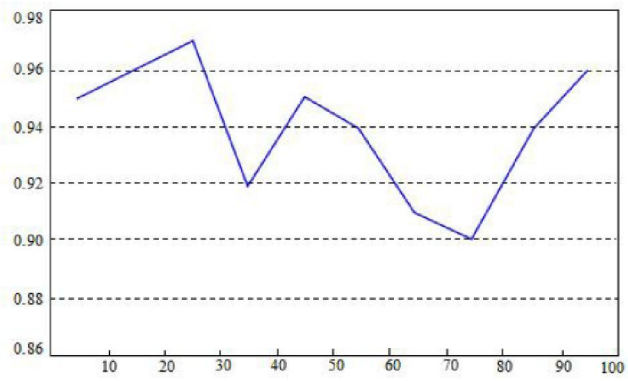

Figure 6 : Algorithm 4 simulation result authenticity coefficient status

TABLE 4 : Algorithm 1, 2, 3 obtained simulation result data table

Algorithm type	Image sample amount	Selected key points amount	Authenticity coefficient average value
Algorithm 1	120	950	0.73
Algorithm 2	135	920	0.75
Algorithm 3	132	952	0.78

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pares to algorithm 10203, it has obvious improvements, its average authenticity coefficient value arrives at 0.92, algorithm 4 applied image amount is 140, selected key points amount is 925, therefore the paper applied factorization algorithm has larger superiority.

CONCLUSION

1) The paper firstly states sports video image sequence capture frame designing problem, introduces biplane calibration frame engineering drawing construction, provides calibration frame precise analysis experiment method and experiment data that builds basis for camera scientific capturing video data.
2) Then writer makes discussion on video image sequence three-dimensional reconstruction computer simulation principle, it puts forward three-dimensional dynamic simulation mathematical model establishment steps, which provides guidance for three-dimensional simulation techniques algorithm designing.
3) Secondly, analyze sports features optical flowing restoration principle and athlete human body three-dimensional sports simulation principle, focus on factorization algorithm principle features introducing, which provides theoretical basis for sports video image sequence three-dimensional dynamic simulation.
4) Finally, design based on DSP dual processor array algorithm flow, targeted perspective projection linear approximation algorithm, power factor algorithm, two-dimensional image sequence algorithm and factorization algorithm simulation effects data, it makes comparison, gets that the paper adopted factorization algorithm special superiority in authenticity coefficient aspect, verifies the algorithm feasibility.

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