Research Article

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Research on nonlinear tracking and evaluation of sports 3D vision action

https://doi.org/10.1515/nleng-2022-0243
received March 1, 2022; accepted August 18, 2022

Abstract: In order to effectively upgrade the training quality of the athlete, the study of the three-dimensional optical steps of sports, a three-dimensional optical action amplitude tracing process based on improved reverse kinematics is discussed. The method passes through a pinhole camera, the model calibrate the camera imaging plane, the positioning mark appears in the marker point in the apart neighboring single-sequence action amplitude and then the five-point perspective imaging of the same line is captured on the same straight line by the camera on different positions and postures. The matching method's accuracy and superiority are demonstrated through experimental evaluation and compared with other similar measures. This characteristic is distinguished by the left and right image frames of the same camera. The translational movement is altered in 10–80 mm/s and the rotational movement is adjusted in 10–300 mm/s. During the confirmation, the spinning of the operational target, the longitudinal movement and the spatial location of the rotation point Measurement, the calculation variability of the stereoscopic visual moving calculation system, is given, and the method of tracking the method is high, which lay the foundation for the promotion of the training quality of the athlete. The experimental findings from simulation demonstrate that the implemented approach has great searching accuracy, establishing a solid platform for further improving the quality of athletes' training.

Keywords: sports, 3D vision, motion range tracking, nonlinear tracking

1 Introduction

With the quick growth of science and mechanics, the motion testing equipment applied in industrial, agriculture, traffic, medical, and aerospace fields requires higher detection accuracy and more flexible detection. In order to meet these requirements, in the past few years, three-dimensional (3D) sports testing technology and equipment have been widely developed. They are widely used in mechanical manufacturing, aerospace, electronics industry, medical rehabilitation, traffic supervision, sports analysis, virtual reality, and other 3D motion detection tasks [1]. As a new 3D motion measurement technology, the motion measurement is liberated from the constraint of traditional contact measurement and has developed new ideas in the field of sports measurement. A complete set of mass sports teaching systems involve 3D human motion capture, 3D human action reconstruction, and 3D human action analysis [2]. The manufacturing of 3D animated characters is challenging, and motion-pose capture technology is very complex. The 3D visual motion approach cannot effectively acquire the full set of contour data. In order to successfully increase the training quality of athletes, the 3D visual motion amplitude tracking approach is investigated in sports. The markers in the adjacent monocular sequence motion amplitude images, however, cannot be determined when the current approach is employed for motion amplitude tracking. Through a wide range of commercial product research and literature summary, although there are some high-end sports capture and analysis systems for

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professional athletes, training these systems are extremely expensive and they cannot directly promote the number of ordinary people in the number of people teach. The current teaching system is still in the experimental research stage and there are two problems: (i) The human body model is rough and the body model in the exercise reconstruction process is single, and the public teaching system is more favored in realistic. Personalized body model: (ii) Existing research main focusing capture and reconstruction the lack of effective analysis of problems in motion effects and motion. For stereo visual motion measurement systems, the 3D moving version for establishing a moving target is a key step. According to the features of progression and time of the spatial movement target motion, this work proposes an acceptable frictional body motion assumption and a spiral target 3D motion representation, and the corresponding movement is designed based on the spiral target of the spin-based target self-rotation center [3]. In the demonstration of unrevealed motion, target motion, and shape structure, the algorithm enables accurate measurement of the 3D span moving target self-rotation center and related motion parameters. During the motion parameter calculation, the characteristic point data are separately used by the minimum number of two algorithms and the LMEDs algorithm, thereby minimizing the impact of noise intercession on motion observation results, and correctly finishing the motion observation task. This work gives the measurement unreliability of the stereoscopic motion measurement technique through simulation and real test [4].

Steinberg and Leal proposed a 3D optical action amplitude tracking process based on the introduction of visual attention mechanism. The method first attracts the visual attention mechanism to the 3D optical action amplitude searching process, and extracts various 3D optical response amplitudes in sports, and uses this feature to complete a 3D optical action amplitude searching in sports [5]. Furthermore, huge structural displacements have been efficiently monitored in recent years employing machine vision and digital close-range measurement. The suggested visual displacement sensor can measure many locations at the same time and has overcome the limitations of traditional displacement sensors. Non-contact measurement, high precision, lack of electromagnetic interference, high degree of informationization, rapid on-site installation, and simple operation are all advantages of multi-point 3D spatial coordinates [6,7]. One of the key research areas in computer vision is binocular stereo vision technology [8,9], a type of multi-eye vision measuring technology. In order to obtain a set of stereo image pairs containing scene depth information, it puts two vision sensors in various locations and simultaneously observes the same scene from multiple angles [10]. The proposed methodology is simpler but there is a problem with poor tracking stability. Wagner *et al.* studied the 3D optical action amplitude searching process based on sports with unparalleled global visual feedback. This method utilizes the Jacques matrix, straight from the figure, measures the position error between the optical action and the movement amplitude, and calculates the desired action obtained by eliminating the error and this is based on the 3D optical reaction amplitude of the completion of the sports track. This method is powerful, other than that when the current process is implemented for motion response amplitude tracking, the marker point in the corresponding single-grade action amplitude image cannot be measured, and there is a problem with a 3D optical action amplitude searching error [11].

This study has concentrated mostly on computer vision techniques used to carry out various activities in order to deliver increased information, such as extensive complicated analysis in numerous SPORTS and to improve the performance of athletes. This research will aid in dealing with sophisticated athlete training because there is a large research scope in sports for deploying computer vision methods in numerous sports. Through simulation and real-world testing, the research demonstrates the measurement inaccuracy of the stereoscopic motion measuring approach. The matching method's accuracy and its versality are demonstrated through test verification and comparison with other matching algorithms. In this work, according to the characteristics of motion measurement and perspective imaging system, the characteristic matching algorithm based on five-point cross-contrasting univariate principle and the corresponding feature marker structure design is proposed. This matching method utilizes a 5-point perspective imaging on different locations and points towards the five-point perspective imaging of the same straight ratio. This feature is established in the left, right, and straight in the same camera. The correctness and superiority of the matching method is proved by test verification and comparison with other matching algorithms [12]. In this study, our approach will proceed with the 3D optical reaction amplitude in which the positioning mark appears in the marker point apart from neighboring single-sequence action amplitude and then the five-point perspective imaging on the same straight line by the camera on different positions and postures is done. In our strategy, we are enhancing images by employing Wavelet transform technique to characterize features in the images. The stereoscopic visual movement calculation of the system and its calculation variability are given, and the way of tracking the method is high, forming the basis for the athlete's training quality to improve.

2 Methodology

Although the proposed methodology employed is simpler but it suffers from severe tracking stability. The researchers investigated a 3D optical action amplification seeking strategy based on sports with unsurpassed global visual feedback. This approach, which is based on the 3D optical reaction amplitude of the completion of the sports track, uses the Jacques matrix to measure the position error between the optical action and the movement amplitude, then calculates the required action by eliminating the error. The indicator point in the corresponding single-grade action signal image cannot be measured, so there is a problem with a 3D optical action amplitude searching error when the current process is used for movement response amplitude monitoring and hence suffers from severe tracking stability. Thus, in this work, according to the characteristics of motion measurement and perspective imaging system, the characteristic matching algorithm based on five-point cross-contrasting univariate principle and the corresponding feature marker structure design is employed. In 3D optical reaction amplitude, the positioning mark appears in the marker point in the apart neighboring single-sequence action amplitude and then the five-point perspective imaging of the same line on the same straight line is done using the camera on different positions and postures. Hence, we can conclude that our strategy is based on lighting independent improved wavelet scale multiplication and fuzzy edge enhancement approaches, we offer a new algorithm for visual noise suppression, target edge recognition, and edge extraction with increased detection accuracy and adaptability.

2.1 3D visual range of motion tracking in sports

The noise suppression in dynamic sequence images and the accurate positioning of target edges are key techniques in motion parameter measurements based on sequence images. Different from target edge detection under static conditions, the accurate noise removal and the positioning of the target edge is related to the camera and light source due to the movement of the target. Therefore, in this project, based on the research and analysis of the original image suppression noise and target edge detection methods, we propose a new algorithm for image noise suppression, target edge detection, and edge extraction with higher detection accuracy and higher adaptability based on lighting independent improved wavelet scale multiplication and fuzzy edge enhancement techniques. Specific steps are shown in Figure 1. In Figure 1, original image is given as an input to the wavelet transform that is a powerful tool for image processing which further processes the image by undergoing several steps of lighting independent which is a de-noising technique based on measured lighting field for removal of the noise further in wavelet scale multiplication. Two adjacent scales are multiplied as a product function to magnify the edge structures and suppresses the noise further to pass the results to the fuzzy enhancement that is employed for adaption and filtering techniques to offer a suitable framework and produce the final filtered image.

Any physical space can be characterized in its motion by a 3D velocity field, projected in the two-dimensional plane that constitutes a two-dimensional velocity field, known as an optical flow. The concept of light flow was originally proposed by Gibson, when the target moves, its resulting images undergo a series of changes, this changing information is as if light is flowing, so it is called "light flow." The motion detection algorithm depends on light flow in order to investigate the distribution of light flow, which is generally divided into two steps: first calculate the image light flow; and then obtain the target motion and structure information from the light flow [13]. The calculation of the light flow requires various additional restrictions and the motion and structure recovered

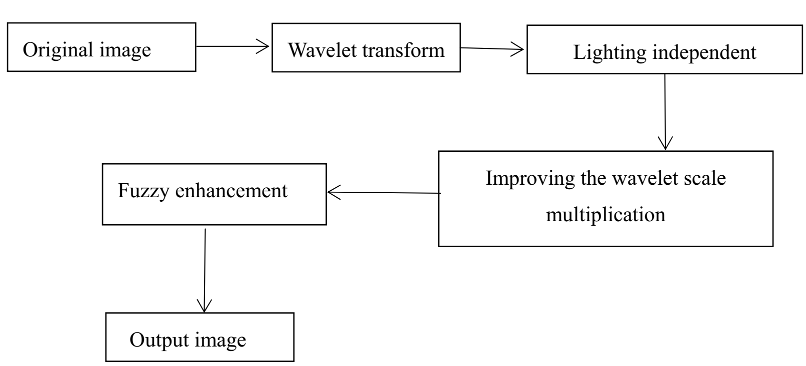

Figure 1: Schematic diagram of the edge detection flow.

by the light flow must also be based on the necessary assumptions, such as the light flow changes are smooth, the target surface is smooth, *etc*. After obtaining the relationship between the light flow and the target motion parameters and the structure parameters, the relevant equations can be solved to obtain the desired motion information. A motion estimation algorithm based on optical flow is briefly presented below. Optical flow method generally corresponds to the process of processing short-time small displacement in human vision. For the first time this paper proposes the "basic equation" between gray scale change and light flow in continuous motion estimation processing, thus opening a new field of research: the brightness function set at t moment, (x,y) position is $I(x,y,t)$, assuming its instantly constant namely $\mathrm{d}I/\mathrm{d}t = 0$, expanded (1):

$$I_x u + I_y v + I_t = 0. \tag{1}$$

Let $u = \mathrm{d}x/\mathrm{d}t$, $v = \mathrm{d}y/\mathrm{d}t$, then formula (2) is given as follows:

$$\nabla I \cdot U = -I, \tag{2}$$

where $\nabla I = (I_x, I_y)$, $U = (u, v)$.

The above formula is the "basic equation." One of the most important features and advantages of the optical flow method is that it does not need to establish a matching of the corresponding features during the motion detection process between the images. However, the inability to solve the "basic equality" from those proposed by horn and shrunk to solve two unknowns simultaneously is an unsettled problem which brings difficulties for continuous processing, for which the various algorithms feature in how to overcome the discomfort qualitatively [14,15]. Existing continuous processing algorithms can be divided into two sections, namely, constraint and unconstrained, which can be divided into grayscale and speed assumptions.

The single visual motion measurement system is measured using a single camera and related attachment placed on the measurement site for the calculation of 3D motion parameters of the measured motion target. This method uses a single sequence image to establish equations containing target motion parameters and structural parameters, as in consideration of a two-dimensional image, therefore, sometimes the motion measurement method corresponds to 2D-to-2D feature. After the feature of the stand-alone sequence image is established, it is possible to interaction of an equation $P' = R \cdot p + T$ for solving associated motion parameter and structural parameters. In the case where the corresponding feature point is more than 8, we can solve the relative solution T' of the rotating matrix R and the flat matrix. Since a camera's two-dimensional image cannot accurately capture the details of 3D space, that is the certain type of uncertainty measure present in various objects. Hence stereoscopic motion is employed where the translational motion of figure boundaries defined by changes in binocular disparity over time in real life 3D scene. There is a need to attach a certain amount of constraint conditions. The application of the single-machine measurement system mainly includes two aspects:

1) The auxiliary tool as a 3D motion measurement utilizes sensor fusion techniques, combined with other motion sensors to complete the measurement of motion target related to motion parameters.
2) The 3D motion measurement is performed separately by the prior knowledge, and the known motion targets the known feature of the structure and the motion target of the test target, and the known motion reframe such as robot navigation, spacecraft docking, human body finger motion analysis [16].

2.1.1 Optimization scanning of 3D optical response amplitude in sports

Suppose $G(x,y,\sigma)$ represents the action spatial scale variable Gaussian function, (x, y) stands for action spatial coordinates, σ shows the scale coordinate, and detects the 3D optical action extinction point

$$D(x, y, \sigma) = \frac{\sqrt{G(x, y, \sigma) - (x, y) \times I(x, y)}}{L(x, y, \sigma)}, \tag{3}$$

where, $I(x, y)$ stands for the starting image coordinate, and $L\ (x, y,\sigma)$ represents the image volume generation.

It is assumed that the Euclidean distance between $U_{a,b}$ represents an action amplitude feature point A and $U_{\min}$ represents the most adjacent distance from the action feature point and U represents the action amplitude times adjacent distance and R represents an action amplitude feature interval distance threshold. It is used to position the 3D optical response amplitude point.

$$\mu \le (R) = [a, b]\frac{R \otimes U_i}{U_{a,b} \otimes R} \times U_{\min} \otimes \varpi(W). \tag{4}$$

During the 3D optical response amplitude optimization tracking in any sports, the integrated 3D spatial point is brought into the camera imaging plane, positioning a 3D optical action amplitude marker point, giving the current time markup point status prediction equation, and removing error candidate points [17]. The generic methodology is discussed below: supposing that the total cameras is MTA, X_j shows the 3D space point of the optical action, and the 3D space X_j is launched to the camera photographic plane, forming a 2-dimensional space area U_j^i, then

$$\lambda_j^i = \frac{U_j^i \otimes X_j}{m} \otimes p^i \otimes W^S, \tag{5}$$

where P^i is the zoom factor, and W^S shows the projection matrix.

It is assumed that the starting maximum threshold measure of $T_{\max}$ represents the response, amplitude marker point $T_{\min}$ represents the minimum threshold value of the response amplitude marker area, and n shows the limit threshold of the total tag points and the various action amplitude marker points are used for binarization using Eq. (6).

$$T_0 = \frac{(T_{\max} - T_{\min}) \otimes T}{n_o} \otimes \beta(y). \tag{6}$$

During the 3D optical action amplitude optimization searching process of sports, the period of response action amplitude effect is given by the acquisition error candidate point prediction area, and the three-order self-regression model tracking of the action amplitude track is obtained. A 3D optical action is given in the probability of external search area, in this regard, based on the 3-dimensional virtual response amplitude tracking in sports [18]. The specific procedure is discussed below. Suppose from V_{i-1} speed to the speed of the action takes the $T - 1$ time, to acquire $u_g(t)$ velocity, Eq. (7) can be used to give a period of response action amplitude effect:

$$g(t) = \frac{V_{t-1} \otimes (t-1)}{u_g(t) \oplus \varepsilon(\partial)} \times w^{(p)}, \tag{7}$$

where $\varepsilon(\partial)$ represents the self-regression coefficient, and $w^{(p)}$ represents a distortion compensation amount.

Suppose, $\lambda(i)$ generates Gaussian noise from the standard variance of 1, then the three-order self-regression model of the movement amplitude tracking is obtained using Eq. (8).

$$x_1 = \frac{\lambda(i) \otimes \{A, B, C, D\}_{I=1}^{P} \otimes N\{O, \sum\}}{\mathrm{DN} \otimes x_p}, \tag{8}$$

where $\{A, B, C, D\}_{I=1}^{P}$ is the action amplitude from various time slots. $N\{0, \sum\}$ represents the circulation matrix of the action amplitude. DN represents the distortion parameters of the camera, and X represents location constraints between action amplitude feature points.

It is assumed that the selection registration area selected from the generation of M_{px} and M_{py}, (v_x, y_y) shows the velocity of the marker action amplitude measured on the old slot and the possibility of 3D virtual action amplitude is external to the search area.

$$E(M_{px}, M_{py}) = \frac{(v_x y_y)}{(M_{px}, M_{py})} \otimes \phi(p) \times \psi_{(u_x, y_y)}, \tag{9}$$

where $\psi(p)$ represents the action amplitude partial search for excellent iteration, and $\psi_{(u_x, y_y)}$ represents the exact position of the action amplitude.

2.1.2 Utilities of 3D motion in the field of sport

3D motion analysis systems, which utilize markers to track motion, are expensive and time-consuming. As a result of the nature of biomechanics research, most studies have had a very small number of trials, making it difficult to apply modern analysis techniques such as machine learning techniques. In most biomechanics investigations with big datasets, researchers employ educated predictions for data reduction before beginning data gathering, and they are confined to investigating only a few variables at specific occurrences (*e.g.*, shoulder flexion angle at ball release). Researchers have begun to utilize more complex analytic methods, such as principal component analysis, support vector machines, and regressions on larger datasets, as computers and computational technologies have evolved.

3 Experimental analyses

An experiment is required to demonstrate the effectiveness of the proposed 3D virtual response amplitude searching technique in sports based on improved reverse kinematics. An experimental simulation platform for 3D virtual movement amplitude scanning in sports was built

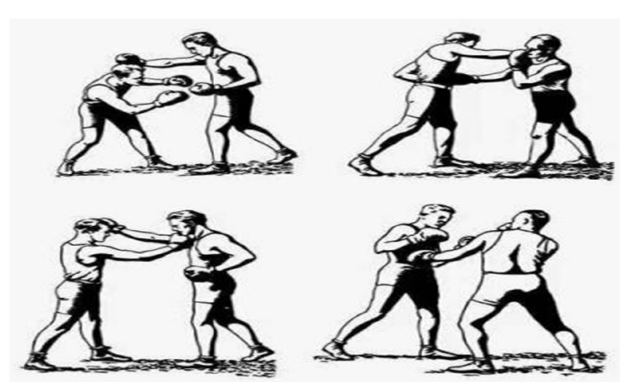

Figure 2: Comparison of tracking results of two different methods.

Table 1: The *F* values obtained by the different edge detection techniques

Evaluation factor	Technique 1	Technique 2	Technique 3	Technique 4	Technique 5
F	0.7171	0.8521	0.8561	0.9615	0.9845

under MATLAB environment. Experimental data came from boxing match video records in 2012. Using the reverse kinematics and the non-calibration global visual feedback method, the tracking results of two different methods are compared, Figure 2 and Table 1.

From Table 1 and Figure 2, the impact of motion amplitude searching depends on upgraded reverse kinematics which is better than the non-calibration global optical feedback process. This is mostly due to the 3D optical action amplitude searching in different sports using the improved reverse kinematics approach. First calibrating the camera photographic plane in accordance with the special hole camera architecture, locating mark area appearing in the range of action of an adjacent monocular pattern, and removing the incorrect candidates, this work ensures the effect of motion searching depending on improved reverse kinematics [19].

Using the reverse kinematics and the non-calibration method of global visual feedback, the stability of two different methods can be seen in Figure 3.

As is illustrated in Figure 3, the stability of 3D optical action amplitude tracking in sports is better than that of sports depends on the non-calibration global optical feedback process, this is mostly due to the usage of this process for tracking 3D optical response amplitude in the picture. To obtain a time series architecture of the range of action, given the probability of the 3D optical action amplitude outside the optimal region, depends on completing the 3D optical motion amplitude searching on sports. The response of the improved reverse kinematics method for 3D optical motion amplitude searching in sports is enhanced. Experimental results from simulation justifies that the implemented process has high searching accuracy that lays a strong foundation for further enhancing the training of athlete's quality wise. To significantly promote the training quality of the player, amplitude tracing process based on improved reverse kinematics is used. The technique passes through a pinhole camera, the model synchronizes the camera imaging plane, and the alignment mark appears in the marker point in the apart adjoining single-sequence action magnitude, and then the camera on different positions and postures performs five-point perspective imaging of the same line on the same straight line. The left-right and distinct image frames of the same camera define this property.

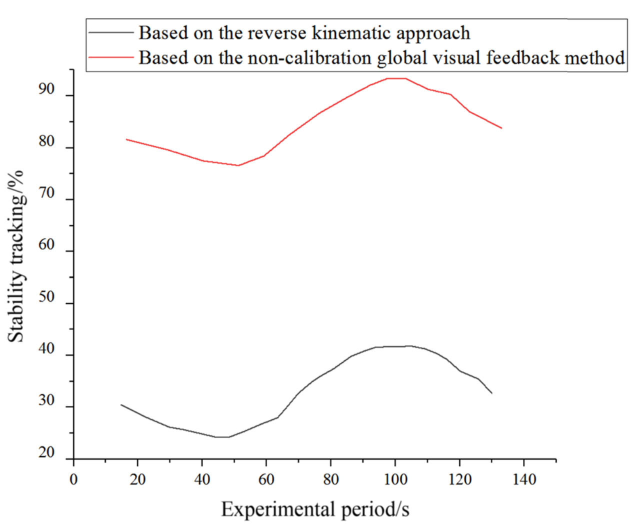

Figure 3: Stability comparison of different methods.

4 Conclusion

This work studied the composition of stereo motion measurement system, image processing, 3D rigid motion object modeling, and rotation center measurement, and has passed the experimental test. According to the characteristics of motion measurement and perspective imaging system, the feature matching algorithm based on the five-point intersection ratio invariance principle and the corresponding feature marking bar structure design are presented. In this research, the characteristic matching method based on the five-point cross-contrasting unitary concept and the accompanying feature marker structure design are presented in accordance with the characteristics of motion measurement and perspective imaging systems. The translation motion value changes within 10–80 mm/s and the rotation motion value varies between 10 and 300/s, measuring the motion parameters such as rotation motion, translation motion, and spatial positioning from the rotation center. The matching method uses the camera at different positions and poses on the same line with space and establishes corresponding feature matching between different image frames of the left and right camera. The future scope of this research is that it will be very helpful in future studies. It can also provide a time series design of the range of action, given the likelihood of the 3D optical action amplitude outside the ideal area, and the responsiveness of the improved reverse kinematics approach for 3D optical motion amplitude seeking in sports is enhanced. The correctness and superiority of the matching method are proved by experimental verification and comparison with other matching methods.

Funding information: The authors state no funding involved.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: The authors state no conflict of interest.

Data availability statement: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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