

Retraction

Retracted: Motion Capture Based on Intelligent Sensor in Snow and Ice Sports

Wireless Communications and Mobile Computing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] Q. Nian and J. Liu, "Motion Capture Based on Intelligent Sensor in Snow and Ice Sports," *Wireless Communications and Mobile Computing*, vol. 2021, Article ID 7259991, 12 pages, 2021.

Research Article

Motion Capture Based on Intelligent Sensor in Snow and Ice Sports

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With the development of motion capture technology, it has become a reality to efficiently and quickly obtain realistic human motion information. Motion capture technology has been successfully applied in many fields such as sports competitions, animation games, and film and television production. This article is aimed at studying the application of motion capture technology based on smart sensors in ice and snow sports. Put forward the idea of applying smart sensor-based motion capture technology to ice and snow sports. This article introduces in detail smart sensors, motion capture technology, and related content of ice and snow sports and conducts specific experiments on the application of smart sensor-based motion capture technology in ice and snow sports. The experimental results show that motion capture based on smart sensor technology can help athletes improve their skills and tactics. At the same time, motion capture technology based on smart sensors is also loved by most coaches and athletes, and everyone's satisfaction with this technology has reached more than 70%.

1. Introduction

In order to obtain actual character animation through the continuous development of artificial intelligence sensors, people use motion capture devices to capture the actions of performers and directly drive the actions of fictional characters through these motion data. Motion capture technology uses video equipment, motion sensors, and other equipment to track the motion of part or all of the joints of the human body or animal and measure the motion information of the joints, providing reference data for walk recognition and film and television production [1]. For sports, it is necessary to learn basic movement for various sports. These sports require continuous training to improve the proficiency and accuracy of the movement and ultimately deepen the trainer's understanding of sports. Motion capture technology can effectively measure and record the movement of the human body in three-dimensional space. In improving the production level of computer animation, the application of animation capture technology has played a big role. However, the cost of motion capture equipment is high, the cap-

ture process is complex, and the requirements for the capture site are strict, so it is particularly important to organize and reuse existing motion capture data.

Use smart sensor-based motion capture technology to collect exercise data when practicing basic training, and quantitatively analyze the data collected by computer to overcome the differences in subjective evaluation standards of different coaches, quickly perform motion analysis, and quickly provide sports coaches' detailed training data analysis results; coaches can accurately formulate more suitable training programs through the training data analysis results, thereby greatly increasing the efficiency of sports training [2]. At the same time, based on the motion capture technology of smart sensors, there are no website restrictions, the machine setup process is simple, and there are advantages such as multiple targets not affecting each other. Through various smart sensors distributed in the training venues, sports trainers no longer need to wear some traditional motion capture devices to collect and analyze various training actions of sports trainers and can also collect the data in real time. The three-dimensional image is presented.

There are more and more researches on smart sensors and motion capture technology with the advancement of science and technology. Garcia et al. designed a smart sensor to predict the established sensory fish quality index. The sensor dynamically correlates the microbial count and TVB-N with the quality index. The sensor provides the most possible value and handles fish-to-fish variability [3]. Dissanayake et al. designed a sensor in the study of safe drinking water to measure fluoride and hardness in well water through an automated mechanism [4]. In the research on some specific applications of smart sensors, Wu et al. proposed a discontinuous collection method for switched capacitor DC-DC converters. Smart sensor applications rely on ultralow power energy harvesters to operate at various environmental power levels. Collect energy within the range and charge the battery [5]. Chuang et al. have designed a thermal power generation device with a simple structure. The device is used to monitor the vehicle environment [6]. In the field of motion capture technology, researchers have also done a lot of research. Pueo and Jimenez-Olmedo said that in the field of sports performance, the purpose of motion capture is to track and record athletes' human movements, analyze their physical conditions, performance, technology, and origin, and prevent and recover injuries. Their research also systematically reviewed the latest progress of motion capture system in motion performance analysis [7]. In the research on the application field of motion capture technology, Bleser et al. said that the ability to capture human motion based on wearable sensors has a wide range of applications, such as in healthcare, sports, and happiness [8]. Baskwill et al. pointed out that gait analysis is the study of human movement. The purpose of the 3D motion capture system obtained by Humber College is to evaluate the use of 3D motion capture in the gait assessment module compared with the traditional gait assessment module [9]. The 3D motion capture system is a high-tech device used to accurately measure the movement of moving objects in three-dimensional space [10]. It is based on the principles of computer graphics. It uses several video capture devices arranged in space to record the movement of moving objects in the form of images and then uses a computer to process the data to obtain different objects in different time measurement unit space coordinates. Most of these researchers' research on smart sensors and motion capture technology is very detailed about the application of these devices and technologies in life, and their advantages have been analyzed. However, these researchers have insufficient research on the current problems of these equipment and technologies and some technical bottlenecks encountered.

The most prominent highlight in the article is the use of smart sensors and the use of inertial sensors, vision sensors, etc., in smart sensors to motion capture. The smart sensor-based motion capture technology is applied to winter sports, and the motion capture technology is used to obtain the data of various actions in the winter sports, analyze the acquired data information, and use the analysis results to guide the ice and snow sportsmen good for this exercise.

2. Motion Capture Technology and Ice and Snow Sports Based on Smart Sensors

2.1. Smart Sensor. A smart sensor is a sensor that can perform information processing functions on its own. The smart sensor is equipped with a microprocessor that collects, processes, and exchanges information [11]. It is a product that integrates the sensor and the microprocessor [12]. Compared with a commonly used sensor device, smart sensors have three advantages. The first is that software technology can be used to collect high-precision information; the second is that it has low-cost, specific programming automation functions, and the third is that it has other diverse functions that other sensors do not have. In motion capture technology, visual sensors and inertial sensors of smart sensors are often used [13]. Although smart sensors play a very important role in motion capture technology, smart sensors also have disadvantages such as high cost and large floor space. It is difficult to use this technology in some small sports games [14]. This article mainly introduces several smart sensors commonly used in motion capture technology.

2.1.1. Vision Sensor. In the entire vision system of the machine, the vision sensor is its most important and most direct source of information. Vision system equipment is relatively cheap and can be easily installed in ice and snow sports activities. At the same time, they can detect and identify objects without the need for auxiliary equipment such as transponders [15]. Second, the vision system can capture a large amount of visual information in a wide range of areas, usually beyond the longitudinal and peripheral range of other sensors such as radar. And with the continuous innovation of computer vision processing algorithms, this rich visual data can be used to identify more subtle changes and differences between objects, thereby achieving more complex applications [16, 17]. At the same time, the vision system does not need to embed the device, physically print, or attach it to the target detection object from the outside. Figure 1 shows the working principle of the vision sensor.

For the vision sensor, it contains two parameters: internal parameters and external parameters. The parameters in the internal parameters are as follows: vision sensor resolution, focal length, distortion coefficient, frame rate, and pixel depth. The parameters in the external parameters are as follows: vision sensor position, rotation direction, and translation direction [18].

(1) Focal length of vision sensor

The concept of focal length in the vision sensor refers to the concentration and divergence of light in the optical system and also refers to the distance from the optical center of the lens to the focal point of the light when relatively parallel light rays enter the lens for a certain reference object. In addition, the focal length between the center point of the camera lens and the film of the camera lens machine also exists. At the same time, the distance between the center point of the camera lens and some imaging planes such as

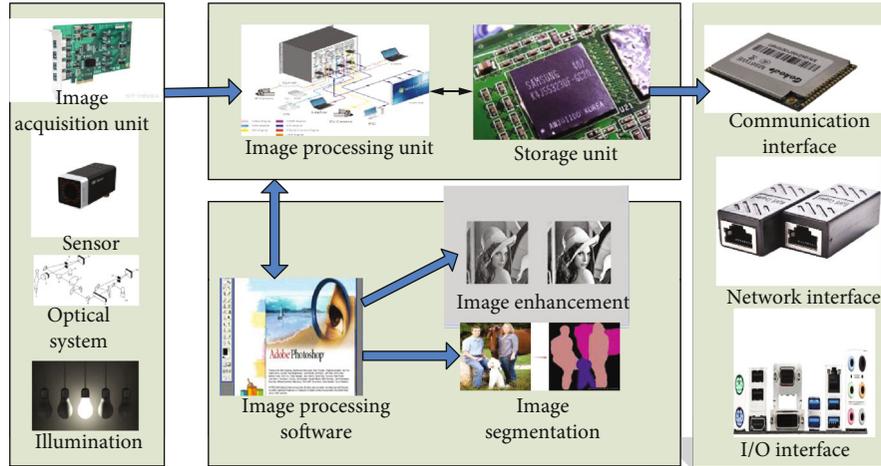


FIGURE 1: The working principle of the vision sensor.

CCD also has focus. In terms of light collection ability, the shorter the focal length, the stronger the light collection ability. In the classification of optical lenses, it can be divided into fixed-focus lenses and variable-focus lenses. In simple terms, a fixed-focus lens means that there is only a fixed, nonedge focal length and can only have a visual scene [19]. Although the fixed focus lens does not have the zoom function, the image processing of the fixed focus lens will be faster than the zoom lens during the shooting process. Compared with zoom lenses, fixed-focus lenses have the advantages of faster focusing speed and more stable image quality. In the vision system, the relative position of the vision sensor and the ice and snow sports field is fixed, and there is no need to change the photographic field of view frequently. At the same time, the requirements for image quality are high, so the fixed focus lens is used in the motion capture technology [20].

Generally speaking, the focal length and the visual field of view are inversely proportional, that is, when the imaging area is the same, the shorter the focal length of the lens used for shooting, the larger the angle of view, and the longer the focal length of the imaging lens, the shorter the angle of view [21, 22]. Regarding the concept of angle of view, in the lens, the angle of view refers to the range that can be seen during the imaging process. For example, when the focal length of the lens becomes shorter, the range that the lens can present is larger, but the quality of the corresponding image will also decrease to a certain extent [23]. When the focal length of the lens becomes longer, the presented scene becomes smaller, and the imaging of distant objects becomes clearer, but the corresponding imaging width becomes narrower. The relationship between lens focal length and angle of view is shown in Figure 2.

The conversion formula for the relationship between lens focal length and angle of view is as follows:

$$\theta = 2 * \arctan \left(\frac{D}{2F} \right). \quad (1)$$

Among them, θ angle of view is the lens angle of view; arc tan is the inverse function of tan; D is the diagonal

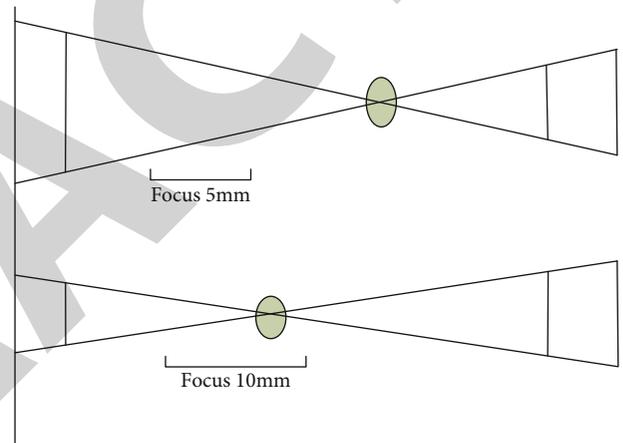


FIGURE 2: The relationship between lens focal length and angle of view.

length/longitudinal height/horizontal width of the imaging plane; F is the focal length.

This article uses a 200-page specification and takes the diagonal length to calculate the angle of view corresponding to the lens focal length, as shown in Figure 3.

(2) Image geometric distortion

Image geometric distortion. The geometric position of image pixels generated in the image processing process is deformed by reference systems such as extrusion, stretching, offset, and distortion, and the geometric position, size, shape, and direction of the image change [24]. These include pincushion distortion and barrel distortion, as shown in Figure 4.

2.1.2. Inertial Sensor. The main function of the inertial sensor is to detect and measure acceleration, oblique angle. It is an important part of solving navigation, direction, and motion carrier control [25]. In ice and snow sports, inertial sensors used in motion capture technology are mainly used to measure the acceleration and rotation of ice and snow sports. Inertial motion capture systems based on inertial

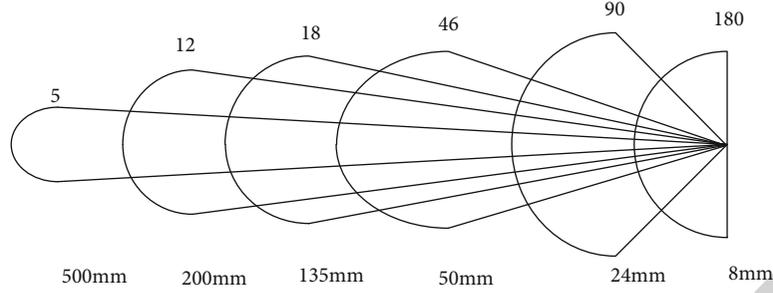


FIGURE 3: Conversion relationships between lens focal length and angle of view.

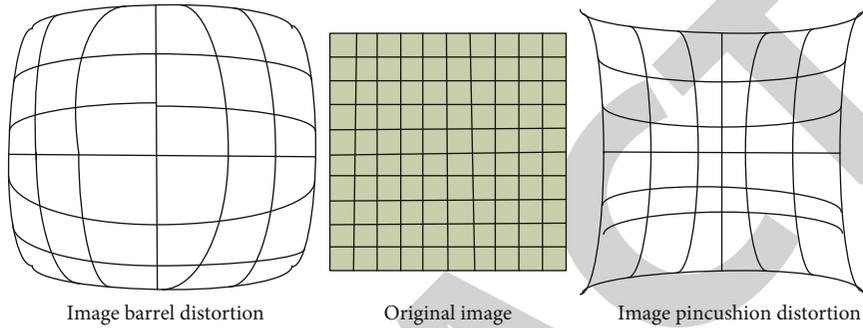


FIGURE 4: Image geometric distortions.

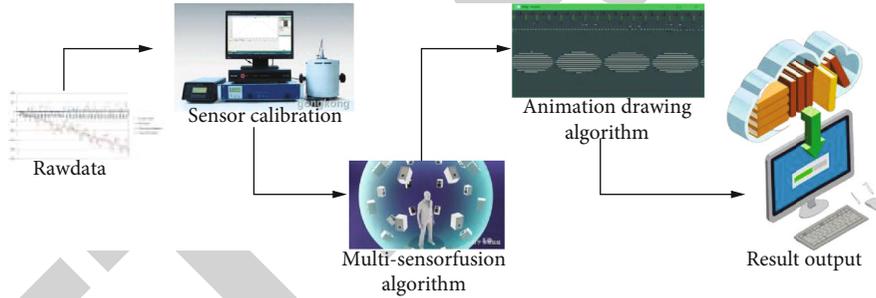


FIGURE 5: Data processing flow of the inertial motion capture system.

sensors generally abstract the human body as a model composed of multiple rigidities. Nine-axis sensor nodes are installed on the each rigidity. The general sensor node is composed of a microprocessor, a nine-axis sensor, a data transmission module, and a power management module [26]. The main job of the microprocessor is to read the data measured by each sensor and at the same time send these data to the corresponding processing module. To put it vividly, the microprocessor is the “heart” of the entire system node. The main function of the nine-axis sensor is to measure acceleration and angular velocity in a three-dimensional environment. The main function of the power management module is to provide power guarantee for each node [27]. The main function of the data collection module is simply to collect and organize the information collected by all modules and send it to the PC. Figure 5 is a data processing flow chart of the inertial motion capture system.

(1) Calculation of quaternion

The quaternion was originally proposed by the Irish mathematician Hamilton. He developed the formula of complex number $Z = A + Bi$ and obtained a quaternion, as follows:

$$W = A + Bi + Cm + Dn. \quad (2)$$

In the formula, $A, B, C,$ and D are real numbers, $i, m,$ and n are imaginary number units, and the imaginary number units satisfy the following formula.

$$i = m^2 = n^2 = imn = -1. \quad (3)$$

For convenience, quaternion can also be converted into scalar form and vector form, as shown below.

$$W = A + P. \quad (4)$$

In $P = (B, C, D) \in T^3$, quaternion addition is similar to

the addition of complex numbers. They can both add the real part of the same type of terms together, as shown in formula (5).

$$W_1 + W_2 = A_1 + P_1 + A_2 + P_2 = (A_1 + A_2) + (P_1 P_2). \quad (5)$$

According to the definition formula of the imaginary part, the quaternion multiplication formula is derived.

$$\begin{aligned} W_1 W_2 &= (A_1 + P_1)(A_2 + P_2) \\ &= (A_1 A_2 - P_1 P_2) + (A_1 P_2 + A_2 P_1 + P_1 P_2). \end{aligned} \quad (6)$$

Formulas (7)–(9), respectively, represent the definition of conjugate, absolute value, and reciprocal of quaternion.

$$W^* = A - P, \quad (7)$$

$$|W| = \sqrt{A^2 + P * P}, \quad (8)$$

$$W^{-1} = \frac{W^*}{|W|^2} = \frac{A - P}{A^2 + P * P}. \quad (9)$$

(2) Three-dimensional space rotation representation based on quaternion

Given the quaternion $W = A + P$, define $M_W : T^3 \rightarrow T^3$, as shown in Equation (10).

$$M_W(a) = W a W^*. \quad (10)$$

According to the definition of quaternion, we can get the following:

$$M_W(a) = (A^2 - \|P\|^2)a + 2P * (P * a) + 2A * (P * x). \quad (11)$$

In the formula, x represents a vector.

The M_W transformation is a linear transformation. That is, for any vector, the scalar $\alpha \in T$ satisfies the properties of the following formula:

$$\begin{aligned} M_W(a + b) &= M_W(a) + M_W(b), \\ M_W(\alpha a) &= \alpha M_W(a). \end{aligned} \quad (12)$$

If $W = A + P$ is a unit quaternion, there is $M_W(\alpha P) = \alpha P$. This property shows that the M_W transformation has no effect on the vector. In addition, $M_W(a)$ has an important property, that is, if a and P are in the same direction, then $M_W(a)$ will not change the size and direction of a . If $W = A + P$ is a unit quaternion, then $M_W(\alpha P) = \alpha P$. If $W = A + P$ is a unit quaternion, then there must be an angle θ such that $\alpha^2 = \cos^2 \theta / 2$ and $\|P\|^2 = \sin^2 \theta / 2$. That is to say, there must be an angle $\theta \in [0, 2\pi)$ such that $\alpha = \cos \theta / 2$ and $\|P\| = \sin \theta / 2$. Let $e = 2P / \|P\|$ here, then all unit quaternions can be expressed in the form of formula (13), where $\|e\|^2 = 1$.

$$W = \cos \frac{\theta}{2} + \sin \frac{\theta}{2} e. \quad (13)$$

Part of the data is substituted into formula (13). Substituting formula (13) into formula (11) can obtain the following:

$$\begin{aligned} M_W(a) &= \left(\cos^2 \frac{\theta}{2} - \sin^2 \frac{\theta}{2} \right) a + 2 \left(\sin \frac{\theta}{2} e * a \right) \sin \frac{\theta}{2} e \\ &\quad + 2 \cos \frac{\theta}{2} \left(\sin \frac{\theta}{2} e * a \right) \\ &= \cos \theta a + (1 - \cos \theta)(e * a)e + \sin \theta (e * a). \end{aligned} \quad (14)$$

Formula (14) is the Rodriguez rotation formula, which decomposes the formula into formula (15).

$$M_W(a) = e^* a e + \cos \theta (a - e^* a e) + \sin \theta (e^* a), \quad (15)$$

where $e * a e$ is the projection of a in the e direction, $a - e^* a e$ is m , and $e * a$ is m . Figure 6 is a schematic diagram of three-dimensional space rotation.

Three-dimensional rotation (3D rotation) is a very magical phenomenon, that is, if you rotate a rigid body any number of times in three-dimensional space, as long as the center of rotation remains unchanged, no matter how many rotations you can use to rotate around a certain three-dimensional space it is represented by one rotation of the shaft.

In addition to quaternions, the rotation matrix is also a common mathematical method used to describe spatial rotation. In addition, the rotation matrix can also be derived from the concept of quaternion.

$$M_W(a) = ((A^2 - \|P\|^2)L_3 + 2PP^E + 2A[P]_a)a = H_e(\theta)a. \quad (16)$$

The value of $H_e(\theta)$ can be expressed as follows:

$$H_e(\theta) = \begin{pmatrix} 1 - B^2 - C^2 & 2CD - 2AD & 2BD + 2AC \\ 2CD + 2AD & 1 - 2B^2 - 2D^2 & 2CD - 2AB \\ 2BD - 2AC & 2DC + 2AB & 1 - 2B^2 - 2C^2 \end{pmatrix}. \quad (17)$$

L_3 in formula (17) is a $3 * 3$ unit matrix, $P = (B, C, D)$ is the vector part of the unit quaternion $W = A + Bi + Cm + Dn$, $[P]_a$ corresponds to $P * A$. The cross product matrix of is as follows:

$$[P]_a = \begin{pmatrix} 0 & -D & C \\ D & 0 & -B \\ -C & B & 0 \end{pmatrix}. \quad (18)$$

Set NW as a two-unit quaternion. First, the vector a is operated to obtain a new vector b , and then, the vector b is

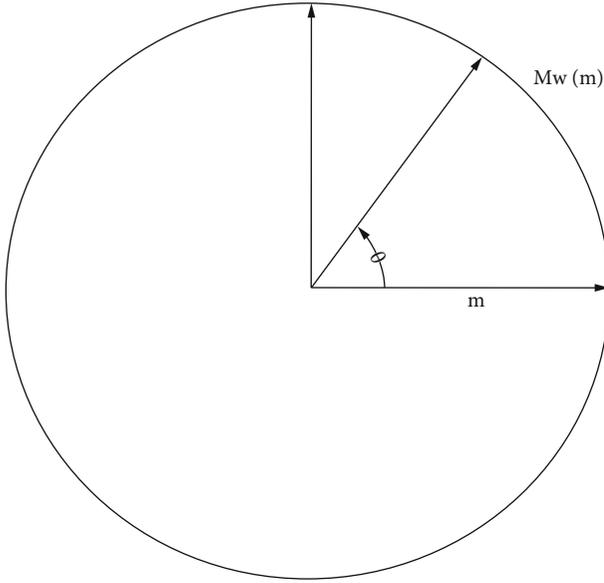


FIGURE 6: Schematic diagram of three-dimensional space rotation.

operated to obtain a new vector c . This is the same as operation a . Any rotation can find the corresponding unit quaternion, because according to the relevant calculation of formula (19), it can be concluded whether the quaternion is rotated accordingly.

$$W = A + P = \cos \frac{\theta}{2} + \sin \frac{\theta}{2} e = \cos \frac{\theta}{2} + \sin \frac{-\theta}{2} (-e). \quad (19)$$

The same rotation in Equation (19) can not only be regarded as a counterclockwise rotation of θ around axis e , but also a clockwise rotation of θ around the opposite axis $-e$.

2.1.3. Human Motion Sensor. The human motion sensor is only a human body detection sensor based on the “infrared discharge principle.” It cannot detect the speed and direction of the human movement but can only detect the human body in motion. If the human body stops moving in front of it, it cannot sense it.

2.2. Motion Capture Technology. Motion capture technology is to measure, track, and record the position of various parts of the athlete’s body through technological equipment. And convert it into computer-recognizable data coordinates [28]. Multiple data coordinates, animation production, and other fields can be applied. The following are several common motion capture techniques.

The mechanical motion capture relies on the mechanical device associated with the athlete, and the athlete’s body drives the mechanical motion. The equipment is equipped with corresponding measuring and recording equipment to track athletes’ movement trajectory. The advantage of mechanical motion capture is low-cost and high-precision, and multiple athletes can move and capture multiple characters at the same time. Due to the mechanical constraints of the athletes, the actions of the athletes are complicated and

quickly become inconvenient, so the real-time capture method also has obvious limitations.

Electromagnetic motion capture uses electromagnetic signals to solve tracking and recording problems. When the dancer performs in the motion capture field, the dancer’s sensor will send an electromagnetic signal containing position information to the electromagnetic processing unit. The electromagnetic processing unit needs to calculate the specific direction of each sensor within time, and the bad feature of electromagnetic motion capture is that there are strict environmental requirements. There must be no metal objects that interfere with electromagnetics in the motion capture space. Otherwise, it will hinder the electromagnetic field of the motion capture field and affect the accuracy of the final data.

Active optical motion capture refers to sticking a marking point that can emit light signals on the captured object. After that, the camera recognizes and tracks the light spot. These capture marks basically consist of LEDs. We need to connect a lot of data lines to the LED. If there are too many threads entangled with the dancer, the flexibility of the movement will decrease.

In the passive optical motion capture image, the camera emits a light source, and most of the marking points of the moving object are bright reflective balls. The camera senses the reflected signal and processes it to generate motion data. The advantages of passive motion capture are mature technology and correct motion capture, and athletes can move freely. The passive type is flexible and can be used quickly, but the outdoor sunlight hinders reflection and is difficult to capture, so it is only suitable for indoor use. Figure 7 shows several ways of motion capture technology.

In the application of these motion capture techniques, mechanical motion capture technology is widely used in action film shooting and sports competition detection; electromagnetic motion capture is widely used in some small stage performances; optical motion capture technology is widely used in animation production and film production.

China’s research and development time for motion capture technology is later than that of other countries. Compared with other countries, the research results of motion capture technology are still relatively backward. In the animation production market in China, the price of an ordinary animation production system is not rare, and the operability, difficulty, long production time, and high cost of using the system are too great. High-priced, high-cost motion capture technology limits its application in the Chinese market. However, with the rapid development of the computer graphics and image industry, Chinese researchers have begun to devote a lot of effort to the research of motion capture technology. Professor WuJiankan and his team at the Institute of Automation, Chinese Academy of Sciences, and Professor Jin Wenguang from Zhejiang University, they lead their respective research teams to engage in motion capture technology related research, standing at the forefront of domestic research. Professor Jin Wenguang is currently mainly engaged in research on wireless wearable human-computer interaction technology and equipment, wireless sensor networks, wireless communication and embedded

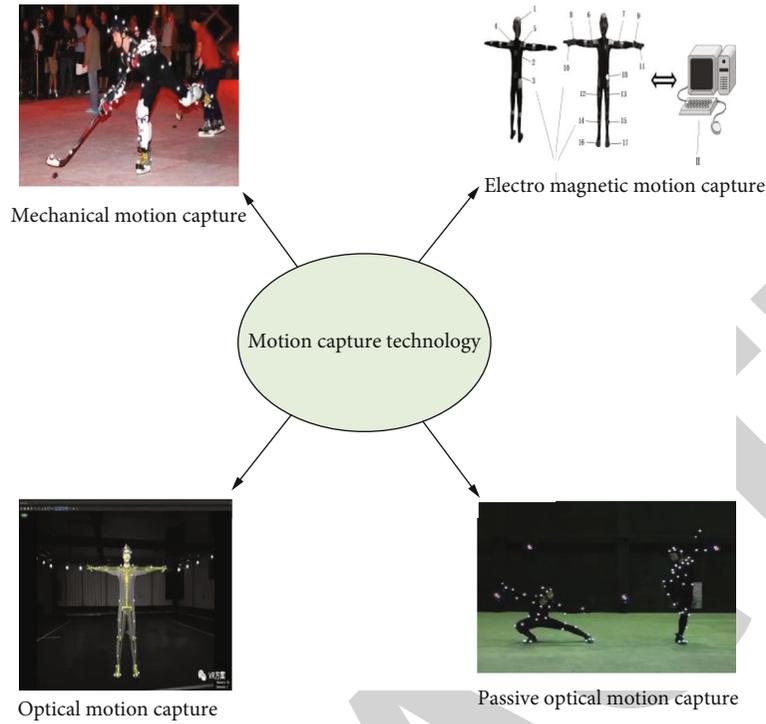


FIGURE 7: Several ways of motion capture technology.

TABLE 1: Sequence of calculation templates in motion capture technology.

Sports behavior	Number of sequences	Exercise cycle
Walking	5	150 frames
Running	6	89 frames
Jumping	9	400 frames
Kicking	2	296 frames
Boxing	6	221 frames
Cutting	4	286 frames
Stretching	7	421 frames
Rotating arms	5	159 frames

systems, and signal acquisition and processing and has also published a large number of articles on wireless sensor networks and other technologies. Dalian Dongrui Film Co., Ltd. cooperated with some other companies to participate in the research and development of motion capture system technology and manufactured motion capture system products in Mainland China and also has independent intellectual property rights. In the application of motion capture technology, 60% of the existing 3D animations are completed by using motion capture technology, and good results have been achieved from the perspective of the presentation effect. In addition to a large number of applications in animation production, motion capture technology has a large number of applications in intelligent human-computer interaction, sports training, robot remote control, and virtual systems.

2.3. Ice and Snow Sports. The movement of ice and snow refers to the movement of people relying on ice and snow

in a cold environment. Ice and snow sports occupy an important position in the history of world sports, becoming an important part of northern residents' mass sports, competitive sports, and winter culture. Ice sports and snow sports are usually divided into two categories: ice sports and skiing. The main characteristics of the development of ice and snow sports are as follows: strong rationality, high investment, high sports risk, etc. According to the survey, the main motivation for people to participate in this sport is to strengthen their sport. Move your body, vent your feelings, improve your athletic ability, pursue excitement, and cultivate your feelings. The development of winter recreational sports and a large number of ice and snow sports in the three northeastern provinces has expanded people's leisure methods, improved people's quality of life in their spare time, and established a communication platform. At present, the skiing foundation among the general public is still relatively weak. Although the potential ski population is huge, it is still in its cradle. There are many areas worthy of improvement in terms of related policies, system construction, and ski market operations. At present, the main reasons for ski enthusiasts to participate in skiing are economic factors, government funding subsidies, social investment in ski resorts, sports and cultural environments, and the degree of development of the ski industry. Some scholars have analyzed the people participating in ice and snow sports in different regions and found that outdoor ice and snow sports are mainly young people and people above the middle class, and there are more men than women. In the ice and snow sports conducted by the school, the students mainly engage in outdoor sports in winter. It can be seen that the development of a large number of ice and snow

TABLE 2: Scoring rules.

Serial number	Project	Details	Percentage of scores
1	Take off	The height of the jump from the ground during the game	10%
2	Acceleration	Acceleration throughout the game	10%
3	Body posture	Whether the body is always in balance during the game	35%
4	Technical action	Whether the various technical actions during the competition are up to the standard	45%

sports is inseparable from the guidance of correct sports values by the two major operators of schools and society. In addition to the use of various means and effective methods to create ice and snow culture, the atmosphere of sports and social sports activities in primary and secondary schools is further enhanced. The competent authority pays more attention to updating management concepts and supplementing and integrating beneficial resources in order to make investment in the ice and snow sports industry. Diversification, it is necessary to guide the society to pay attention to the development of the ice and snow sports industry chain. The ice and snow sports industry chain covers various fields such as ice and snow sports training, scientific research in the field of ice and snow, ice and snow design, ice and snow equipment manufacturing, modern ice and snow services, and ice and snow cultural tourism. The construction of the entire domestic ice and snow sports industry chain has been initially completed.

Ice and snow culture appeared in a very early period in the history of human civilization and developed like other cultural forms. Its uniqueness is reflected in the development of ice and snow sports and ice and snow tourism. Ice and snow culture has gradually become a concept of modern culture. Ice and snow culture is a unique cultural form. It is created by people in a specific ice and snow ecological environment, reflecting the spiritual outlook, values, organizational forms, systems, and other regional ethnic group cultures formed under the influence of historical accumulation and natural environmental factors. Therefore, the construction of ice and snow culture can promote the integration and supplement of traditional, modern, and postmodern cultural concepts. From the perspective of cultural characteristics and attributes, ice and snow culture is a kind of regional culture, with internal characteristics such as objective nature, openness and compatibility, cultural and psychological duality, and ethnic rationality. The ice and snow culture of the Winter Olympics is a very representative ice and snow culture. As a constituent element of the Olympic culture, it has brought unlimited charm to human civilization. Some studies believe that the construction of ice and snow sports culture should be based on the core value system of the Olympic Movement and the value concept of "sports that give cultural vitality" as the main theoretical basis. Some scholars have also conducted research on large-scale ice and snow culture with local characteristics. Both the Ice and Snow Festival and the Spring Golden Week show various characteristics of the ice and snow culture, highlighting the diversity of ice and snow sports.

3. Application Experiment of Motion Capture Technology Based on Smart Sensors in Ice and Snow Sports

3.1. Setting of Related Content of Motion Capture Technology Based on Smart Sensors. This experiment calculates the corresponding templates for 8 common sports behaviors, including walking, running, jumping, kicking, boxing, cutting, stretching, and rotating arms. Several motion sequence columns are selected for each motion behavior, and then, a single-period motion segment is obtained by manual interception. In the course of the experiment, by recording the sports data of the athletes and then according to the computer sequence template, the computer can identify the sports actions of the athletes more quickly, as shown in Table 1.

At the same time, in the preliminary mechanical scoring of the various actions captured during skiing by the motion capture technology, the specific scoring division is shown in Table 2.

In addition, we also selected the three most important actions for curling: throwing, guiding, and wiping ice. Unlike skiing, every action in curling takes up 100%.

3.2. Motion Gesture Recognition Based on Sensor Information Integration. In the course of the experiment, some typical classifiers are used to recognize the action gesture capture. Table 3 shows some typical classification and recognition upside-down methods and test results.

Among them, GMM is a method of parameter estimation, which is the generalization of ordinary moment estimation method. Each GMM is composed of K Gaussian distributions, and each Gaussian is called a "component." These components are linearly added together to form the probability density function of the GMM.

3.3. Specific Experiments of Motion Capture Technology Based on Smart Sensors in Ice and Snow Sports. In the course of this experiment, a total of 12 ice and snow sports enthusiasts will be tested. There are two types of experiments: skiing and curling, with 6 people in each of the two sports. Motion capture technology based on smart sensors will be used in these two experimental projects. During the experiment, other groups of experimenters were also selected to conduct experiments at the same time, and the experimental results were integrated with the data, and finally, the average of the experiments was obtained. During the experiment, the data before and after the experiment were counted. Tables 4

TABLE 3: Typical classification recognition method of upside down.

Classifier	Number of collectors	Number of action categories	Recognition rate	
			On the turn	Flip down
L1 distance	30	15	24.3%	56.2%
K-NN	5	6	49.6%	71.2%
J48	5	8	35.85%	65.25%
MLP	6	5	80.2%	78.9%
GMM	60	28	45.6%	61.2%

TABLE 4: Data statistics table of ski athletes before and after the experiment.

	Take off	Body posture	Technical action
Before the experiment	6%	28%	36%
After the experiment	8%	31%	41%

TABLE 5: Statistics of the degree of coordination of each part before and after the curling experiment.

	Throwing	Guiding	Wiping ice
Before the experiment	78%	72%	79%
After the experiment	89%	88%	90%

TABLE 6: Training scores of skiers.

	Plow brake	Plow turn	Giant slalom	Small turn	Half plough swing
1st	6	5	8	3	8
2nd	4	2	6	6	9

and 5 show the score data statistics before and after the experiment and the cooperation degree statistics of each part before and after the curling experiment, respectively.

At the same time, before the experiment officially starts, the athlete will also receive feedback on some data and pictures captured by the motion capture technology during the athlete's training. The athletes make some technical and tactical adjustments after receiving the feedback results. Of course, the athletes' coach will also change the training program based on some data fed back from the motion capture technology. Table 6 shows the scores of some actions recorded by the skiers before the experiment by the motion capture technology in multiple training sessions.

4. Application Experiment Analysis of Motion Capture Technology Based on Smart Sensors in Ice and Snow Sports

4.1. Application Analysis of Motion Capture Technology in Ice and Snow Sports. In the experimental part of this article, some statistics on the two ices and snow sports of skiing and curling are carried out. All the data in this experiment are the average data calculated after several experiments. According to the statistical results, the sports comparison

chart before and after the experiment can be obtained in Figure 8, as shown below.

According to Figure 8, in the two sports of skiing and curling, the gap between the two groups of experimenters before and after the experiment is still very obvious. In skiing, the scoring rate of this group of experimenters in action performance has increased by 5% than before. In curling, the coordination of the ice guiding process has been improved most obviously, reaching a 16% improvement.

At the same time, this analysis combines the error rates of the previous two groups of experimenters in their respective sports fields and the error rates that occurred during the motion process based on motion capture technology to conduct a comparative analysis (data comes from the control group test). The comparison results are shown in Figure 9.

According to Figure 9, we can know that the error rate of each group of athletes in their respective sports before the start of the experiment is still common, and the error rate of curling is higher. Through the data feedback of motion capture technology, the error rate of each group of personnel in the experiment has been significantly improved. It can be seen from the figure that the error rate of each link in skiing has dropped by at least two percentages. In curling, the error rate of guiding and wiping ice dropped by 5%.

4.2. Analysis of Application Changes of Motion Capture Technology in Ice and Snow Sports. In the experiment of motion capture technology in ice and snow sports, this experiment also conducted a survey on the application changes of motion capture technology in various sports. Through the collation of the survey data, it was concluded that the motion capture technology was used in various sports. Figure 10 shows a chart of application changes in sports and competitions.

According to Figure 10, we can conclude that the application range of motion capture technology based on smart sensors is getting wider and wider, and people use it more and more frequently. For example, in the application of motion capture technology in virtual reality systems, in order to realize the interaction between humans and virtual environments and systems, it is necessary to determine the position and direction of the participant's head, hands, body, etc., and accurately track and measure the participant's movements. These actions are detected in real time so that the data can be fed back to the display and control system. These tasks are indispensable for virtual reality systems, which is exactly the research content of motion capture technology. In traditional track and field events, motion capture technology has been used nearly 50% in recent years. It shows that the motion capture technology based on smart sensors is more in line with people's requirements.

4.3. Application Satisfaction Analysis of Motion Capture Technology in Ice and Snow Sports. This experiment conducted a relatively simple satisfaction survey on the application of motion capture technology in ice and snow sports. In this survey, various ice and snow sports coaches and athletes were surveyed. The survey results are shown in Figure 11.

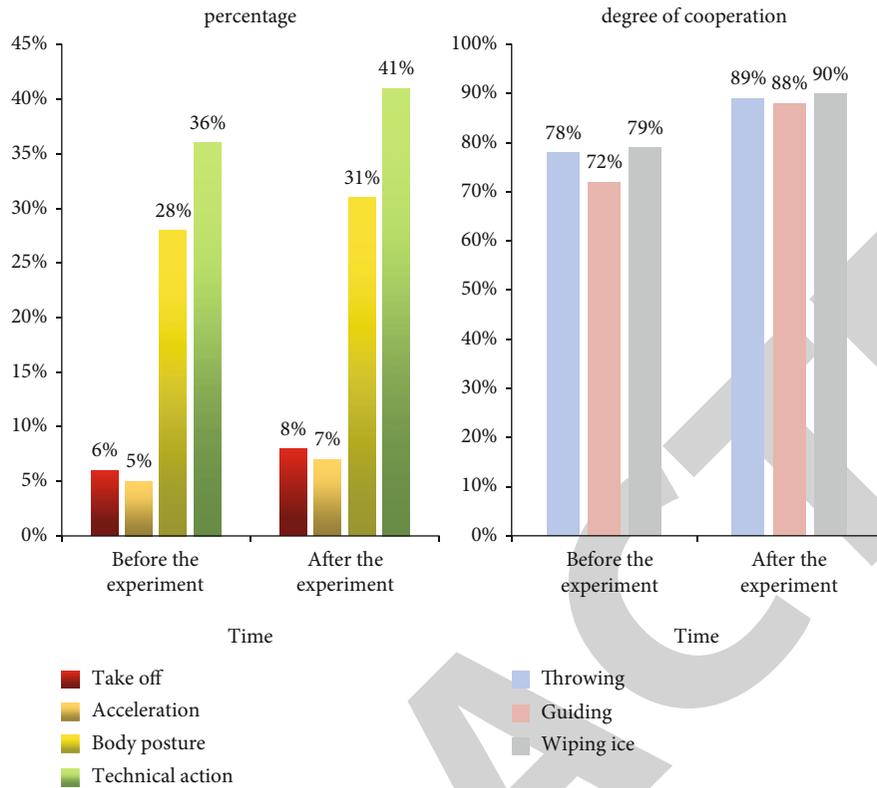


FIGURE 8: Comparison of exercise data before and after the experiment.

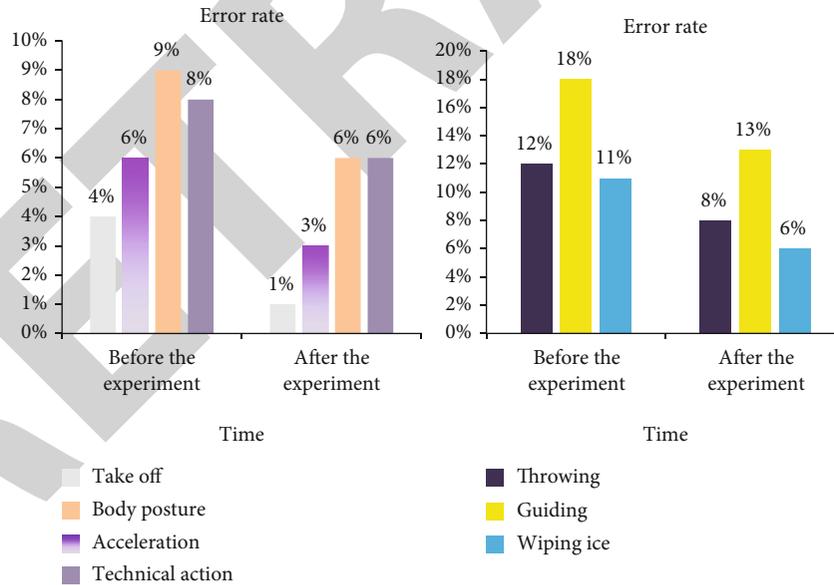


FIGURE 9: Comparison of error rates before and after the experiment.

It can be seen from Figure 11 that the motion capture technology based on smart sensors has been recognized by most coaches and athletes, and the comprehensive score is above 7 points (1-10 points, the greater the score, the higher the satisfaction). It can be seen from the figure that athletes are more satisfied with motion capture technology than coaches, and their overall satisfaction has reached more than 75%.

5. Conclusions

Based on the experiment and result analysis of the article, this article draws the following conclusion: the motion capture technology based on the smart sensor of the meter has fewer restrictions on the applicable conditions, and the application field has become more and more extensive. The detection and recognition of sports actions is a high-level

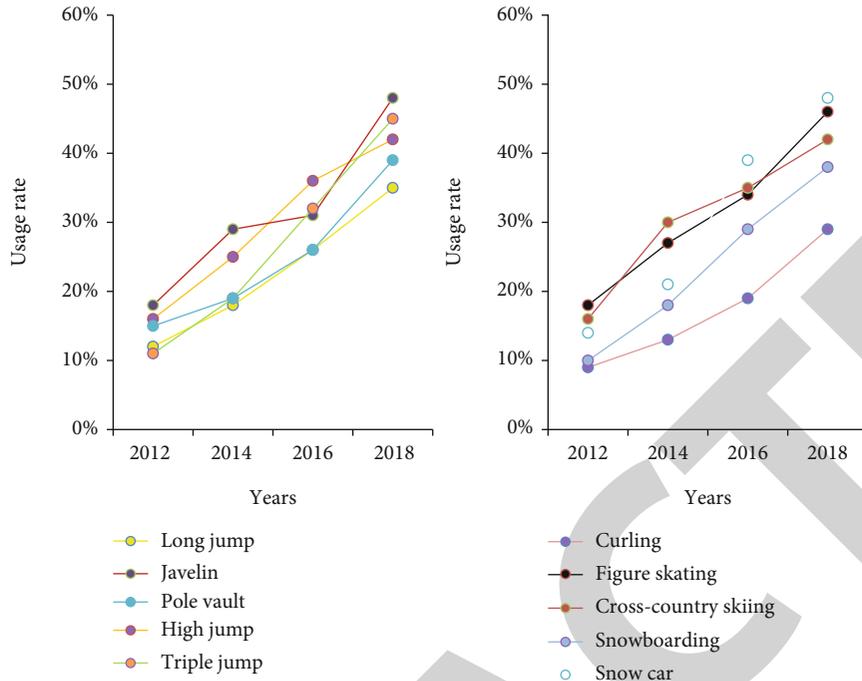


FIGURE 10: Changes in the application of motion capture technology.

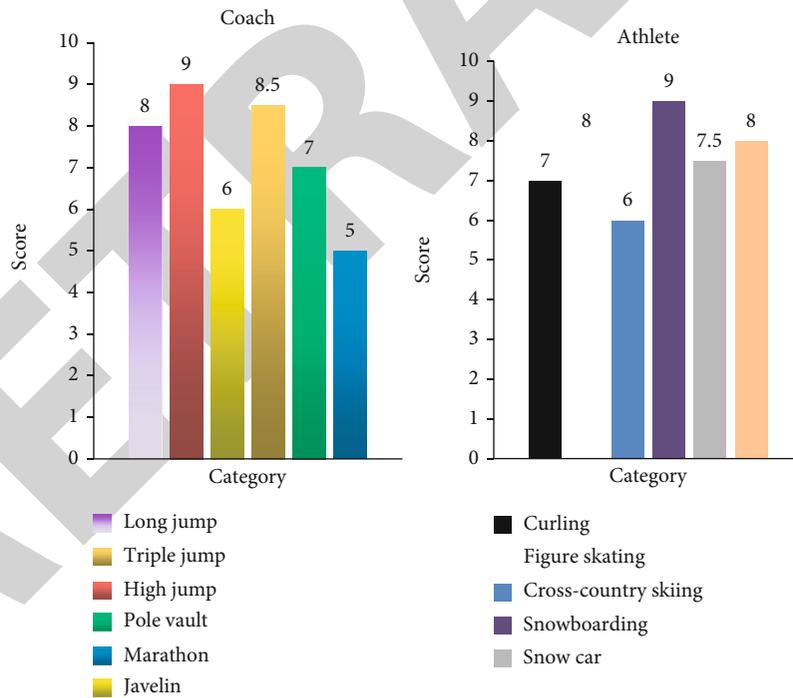


FIGURE 11: Satisfaction survey situation.

analysis in the field of computer vision. The purpose is to allow computer sensors to autonomously analyze the behavior of the target individual in the image through the acquired image information. Many motion analysis applications for specific scenarios have developed maturely, such as the analysis of athletes' technical movements in sports competitions. This paper conducts experiments on the application of smart

sensor-based motion capture technology in ice and snow sports. The experimental results also show that the use rate of smart sensor-based motion capture technology in sports has been close to 50% in recent times, and it is based on smart sensors. The motion capture technology has also been affirmed by most coaches and athletes, with a comprehensive score of 7 points.

Data Availability

No data were used to support this study.

Conflicts of Interest

There are no potential competing interests in our paper. And all authors have seen the manuscript and approved to submit to your journal.

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