

Taijiquan Auxiliary Training and Scoring Based on Motion Capture Technology and DTW Algorithm

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ABSTRACT

Learning Tai Chi requires long-term practice and guidance, which is difficult for beginners. This article proposes a Tai Chi-assisted training and scoring method based on motion capture technology and a dynamic time warping (DTW) algorithm. Firstly, by using motion capture technology, the key point data of Tai Chi movements can be accurately captured. Then, using the DTW algorithm, the learner's action sequence is compared and matched with the standard Tai Chi action sequence in order to evaluate the learner's action accuracy and fluency. Learners can promptly correct incorrect actions and improve the accuracy and fluency of their actions. This method has significant advantages in accuracy and reliability. In summary, the Tai Chi-assisted training and scoring method based on motion capture technology and DTW algorithm provides an effective auxiliary tool for Tai Chi learners, which can help them better master the techniques and essence of Tai Chi. This study is of great significance for promoting the popularization of Tai Chi and improving the learning effectiveness of Tai Chi.

KEYWORDS

auxiliary exercise, DTW algorithm, motion capture technology, Taijiquan movement

INTRODUCTION

Taijiquan is one of China's intangible cultural heritages, which is not only a kind of dialing profound Chinese martial arts but also an internal and external cultivation, rigid and flexible sports program, which has the functions of competitive confrontation, physical fitness, and cultivation of sentiment, and promotes the physical and mental health of human beings.

The Dynamic Time Warping (DTW) algorithm is a method for comparing the similarity of two time series (Chong & Polap, 2022). It is widely used in the fields of time series analysis, pattern recognition, and data mining, especially when dealing with time series with large variations in length or local alignment problems. The main idea of the DTW algorithm is to compute the similarity

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between two time series by pitting them against each other by establishing the best correspondence between different time points of the time series (Lin et al., 2022). This pairing process allows some local deformations that allow the similar parts of the sequences to be aligned without the need for perfectly equal correspondences. Therefore, the DTW algorithm is particularly well suited to deal with transformations, such as warping, scaling, and translation of time series (Li, 2022).

The teaching process of Taijiquan in China's colleges and universities is based on traditional collective and small-group teaching, supplemented by student-stratified-assisted teaching (Pashin et al., 2019). The traditional mode of learning Taijiquan movements is time-consuming. It is not easy for students to find out the mistakes and negligence in their movements during the learning period, and it is difficult to self-evaluate. Therefore, in the face of the problems highlighted in the traditional Taijiquan teaching mode, the teaching of Taijiquan is in urgent need of a training assistance model that incorporates computer network technology to help students learn. In this context, research on a Taijiquan training assistance system based on motion capture technology and a DTW algorithm was carried out.

Since the development of computers in 1946, human-computer interaction (HCI) technology has influenced the development of computer technology. HCI is the study of the development of human and computer technology. Human-computer interaction is the study of the process of information exchange between humans and computers and is studied for the aesthetics and user-friendliness of the system, which is nowadays applied in all aspects of life (Zhu et al., 2018).

The way of human-computer interaction belongs to the natural user interface; we can communicate with the computer through three-dimensional (3D) virtual reality, emotional computing, multichannel interaction, intelligent user interface, and other somatosensory technologies to realize human-computer interaction with human core convenient to operate and more interesting. Therefore, integrated intelligence has become an important feature of a Chinese Taijiquan-assisted training system (Hilfiker et al., 2018).

In this study, we will take Taijiquan as an example and combine the DTW algorithm with motion capture technology to design a Taijiquan-assisted training model, aiming to make learners' Taijiquan training more intelligent, data-driven, and visualized, and to bring more standardized and reliable suggestions for learners' daily taijiquan training.

Using the local search algorithm based on a DTW factor, three characteristic parameters related to the influence index of Taijiquan athletes, and an auxiliary training system are selected, and an auxiliary training system based on the characteristic parameters of Taijiquan movement capture and training is proposed. Through the study of daily training, gait analysis and testing, and physical consumption, the hierarchical framework and index relationship of the whole Taijiquan auxiliary training system is defined clearly. The auxiliary system is evaluated from many aspects. In order to establish an intelligent Taijiquan auxiliary training system, a multiangle exploration is carried out, and then a DTW algorithm is used to analyze the data of athletes' auxiliary training results.

The innovation lies in the DTW algorithm analysis method. On this basis, it can make full use of each athlete's Taijiquan training and physical characteristics information; through real-time motion capture and dynamic tracking, the whole data of athletes can be detected and collected. A DTW correlation factor is used to quantitatively describe the similarity degree between each comparison column and reference column and the degree of agreement with the expected goal. The minimum error is used to quantify the index, and then the influence degree weight of the auxiliary training model is determined, which can effectively analyze the factors affecting the skill level of Taijiquan.

Based on motion capture technology and a DTW algorithm, a real-time Taijiquan-assisted training system can be developed. Such a system can instantly capture the user's movements, compare them with standard movements, and provide real-time feedback, which is very helpful for beginners to help them correct their movements faster and improve their training results.

A model for assisted training and scoring of Taijiquan based on motion capture technology and a DTW algorithm can provide real-time feedback to Taijiquan learners to help them correct their

movements and improve their skills, which can accelerate the learning process and improve the training effect and, at the same time, the researchers can utilize the technology to conduct scientific research on Taijiquan movements and to deeply explore the effects on their body.

However, using this technology for training and scoring may make users too dependent on the technology, which could affect their ability to learn and perceive body movements on their own. The motion capture technology and DTW algorithms may have certain technical flaws that can lead to errors or inaccurate scoring, which can affect the effectiveness of training.

The construction of a Taijiquan auxiliary training system is studied, which is divided into three parts. In the first part, the domestic and foreign Taijiquan training factors are introduced. In the second part, the DTW algorithm-based training model of Taijiquan athletes' dynamic tracking is constructed, and the DCTF(Dynamic Tracking Assistant Training System of Taijiquan) method is used to construct the evaluation system of a Taijiquan training effect. The third part tests the evaluation index of the dynamic tracking assistant training system of Taijiquan and draws a conclusion.

STATE OF THE ART

Since the 21st century, many colleges and universities in our country had low efficiency in the training mode of Taijiquan, especially in the teaching of Taijiquan and the construction of an auxiliary training system. Lewis found that most Taijiquan training still follows the traditional Taijiquan training ideas, neglecting the training of practical skills and comprehensive abilities(Lewis, 2002). Taijiquan teaching only focuses on basic action teaching, repetitive teaching, and uneven teacher level, which makes players not interested in traditional Taijiquan training. Therefore, according to the rules of a Taijiquan game, we should pay attention to the development of auxiliary teaching or the use of a variety of hardware equipment for auxiliary training, strengthen the development and construction of professional Taijiquan knowledge courses, and enhance students' awareness and attention to Taijiquan auxiliary training. On the other hand, the ability training of Taijiquan teachers should be improved (Lipsitz et al., 2019). Based on the theory of kinematics, Taijiquan training, and other related theories and improved particle swarm optimization algorithms, Skrzęta et al first constructed the particle swarm optimization algorithm based on the traditional Taijiquan training system, explaining the theoretical basis and practical significance of subtle changes in the process of Taijiquan training by using different weight distribution methods for different Taijiquan movements(Skrzęta et al., 2021). Then, according to the multifactor relationship theory and local cooperation theory, a new multirelationship recommendation algorithm was proposed to analyze the cooperation degree of action relationship in the traditional Taijiquan training process.

The experimental results show that the heterogeneity information acquisition ability of the local weak relation recommendation algorithm is better than that of the classical recommendation algorithm. The improved algorithm has better local optimization performance and can have a positive effect on the training process of Taijiquan (Chong-gao & Połap, 2022). In order to improve the training efficiency of Taijiquan athletes and the overall coordination of Taijiquan movements,Phillips proposed a layered Taijiquan training method based on the kinematic theory. Through the research and analysis of the dynamic differences of different athletes' weight, height, body fat, and strength, a new multiaction fusion of Taijiquan based on hyper chaos mapping and an auxiliary training system was proposed. The effectiveness of the system was verified by practice(Phillips, 2019).

The results show that the algorithm can improve the individual training effect of Taijiquan players after stratification, and it is suitable for the analysis of Taijiquan training and the search for problems in the training process (Kentish, 2019). In order to find out the difference between different Taijiquan movements and the influence of movement sequence on the overall training effect, Song et al. (2018) studied 100 Taijiquan fans and simulated the "shape structure chart" in the process of drawing the shape of Taijiquan movement, realized the tactical evaluation basis in Taijiquan training, and improved the flexible transformation from traditional Taijiquan tactics to modern tactics.

Finally, the experimental results show that the difference between different movements is large, and the correlation between different movements and personnel is not significant. The position of the original Taijiquan training method is scrambled by using the chaotic sequence after deformation, and the effect of movement sequencing on the overall training effect is studied. The results show that the innovative training system of Taijiquan has a good overall coordination effect, can resist attack and defense, and be used in the actual combat of Taijiquan (Song et al., 2018). In order to solve the problems of low efficiency and tactical effectiveness in the traditional Taijiquan training process, Hu and Wu combined the Fourier function algorithm and, based on the traditional Taijiquan training fusion strategy technology, proposed the panoramic video Taijiquan movement folding search algorithm and a new hyper-chaotic cellular neural network Taijiquan training algorithm to generate the information flow in the defensive process of Taijiquan training (Hu & Wu, 2017). The results show that the algorithm can effectively reduce the error of search matching block, improve the training efficiency, effectively improve the practicability of Taijiquan tactics, and improve the effect of Taijiquan in terms of skills. Moreover, the algorithm has the advantages of key sensitivity and strong antiattack, which is suitable for Taijiquan training (Yeung et al., 2017).

Motion capture technology has been researched at home and abroad for decades, and it has a wide range of applications, mainly in the fields of detection, control, and analysis. It was initially proposed by Johansson, a foreign psychologist, in his moving light display (MLD) experiment in the late 1970s. He placed tensorized markers on the joints of the experimenter's body, and the data transmitted by the computer from the sensors showed the trajectory of the joints, recording the complete process of movement. In the late 1980s, as the research on motion capture technology was deepened by famous universities and scientific research institutes in various countries, the technology received wider attention all over the world. In 2007, a United States company named Organic Motion Inc. introduced a stage motion capture system, which was the first motion capture system in the world that did not need to be attached to the human body with a tracker, completely removing the human body from the tedious task of tracking. This system is the first motion capture system in the world that does not require a tracker to be attached to the human body, completely freeing the human body from cumbersome motion-tracking equipment.

Domestic research on motion capture technology started later than foreign countries. The research on digital gloves conducted by the Institute of Automation of the Chinese Academy of Sciences (IAAS) mainly introduces a new type of data glove, CAS-Glove. It creates a kind of finger motion model according to the characteristics of CAS-Glove and the physiological constraints of fingers.

By analyzing the current situation of motion capture systems, more and more researchers have begun to pay attention to the research on motion-capture-based-assisted training systems. Kim et al have generally made efforts to reduce the cost, improve the real-time performance, capture accuracy, reduce the obstruction to the performers, etc. The research hotspots are mainly based on two aspects. On the one hand, they are based on traditional computer vision research, which can be divided into mechanical, electromagnetic, acoustic, and optical according to their different principles. On the other hand, they are based on the motion capture technology of depth images (Kim et al., 2017).

In conclusion, most of the current Taijiquan training modes do not involve the DTW algorithm, the construction of auxiliary training, and a scoring system based on the dynamic capture and training data of Taijiquan movements. On the other hand, China has done a lot of basic research on the training mode of Taijiquan, but there are relatively few research results in the auxiliary teaching of a Taijiquan training process, the specific quantitative training dynamic evaluation system, and the promotion of a Taijiquan training effect. But there is no research on the intelligence of the training assistance system of Chinese Taijiquan athletes and the construction of related models.

TAIJIQUAN AUXILIARY TRAINING AND SCORING SYSTEM BASED ON MOTION CAPTURE TECHNOLOGY AND DTW ALGORITHMS

Application of a DTW Algorithm in the Model

The current mainstream DTW algorithm is an intelligent algorithm with “optimal two-way interaction characteristics” based on the idea of dynamic programming, which adjusts the overall structure of the Taijiquan training process in both directions and automatically groups the structures to select the best way (Lv et al., 2017). Through the random processing of single “node” structures (meaning a single Taijiquan action capture set with weak correlation or similarity) characterized by multiple “information source” structures (nodes), the mutual coupling analysis of bidirectional Taijiquan training morphology structures and the vector processing analysis of multiple coupling combinations, it is possible to achieve the optimal method with the “optimal interaction characteristics combinations of vector processing analysis, which can achieve the overall optimization of the overall morphology of the carpal bones and the analysis of the carpal bone morphology” (Xu et al., 2017).

Looking at the entire Taijiquan training population, it is more likely that multiple structural groups with high structural similarity of movements will be identified and then selected for two or more tests and analyses, whereas movements with low correlation between carpal bone morphology and structure are less likely to be selected for two or more analyses (Chong-Gao & Polap, 2022). After this multiple comparative analysis, the new generation with overlapping characteristics of carpal bone morphology growth demands not only the inherited information from the previous round of intelligent selection of carpal bone morphology and structure but also to optimize it better than the previous generation. In this way, after several interactive cycles of bidirectional carpal information, a specific training process that meets the minimum normal training requirements is finally generated, that is, the analyzed value of the normal boundaries of the morphology of a certain Taijiquan movement is close to the value of the normal requirements of the actual Taijiquan movements, so as to realize the unique Taijiquan movements under the conditions of the “optimized DTW algorithm” in the training process.

In this way, the unique Taijiquan movements under the “optimized DTW algorithm” condition can be captured and recorded in the overall morphology analysis during the training process (Salgado et al. 2016). Moreover, the model can realize self-learning and recording functions, and the more data processes accumulated from exercise training, the stronger the system’s self-learning ability and self-evaluation ability (Hachaj & Ogiela, 2020). Above is the DTW algorithm used in the research of Taijiquan motion capture and Taijiquan-assisted training and scoring model.

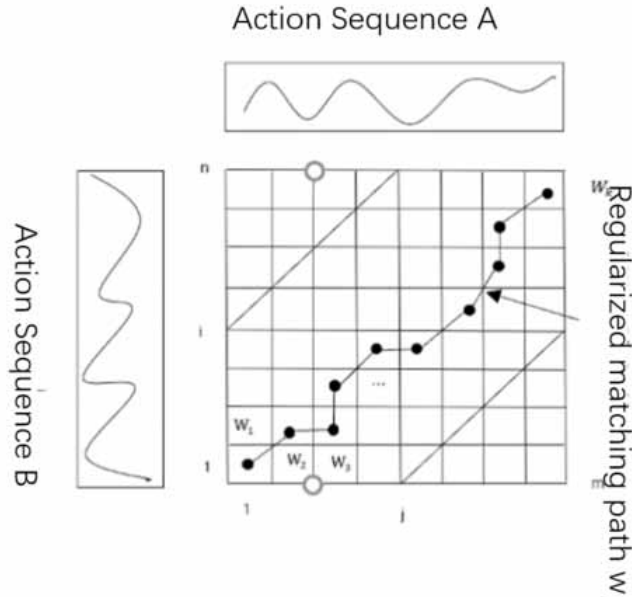
Implementation Steps of a DTW Algorithm in This Model

Suppose there are two sequences of actions: $A = (A_1, A_2, \dots, A_i, \dots, A_m)$, $B = (B_1, B_2, \dots, B_j, \dots, B_n)$. A is the test sequence, B is the template sequence, m, n denote a total of m and frames of the action sequences A and B , respectively. A_i denotes the feature vector of the “ i ” frame, and B_j denotes the feature vector of the “ j ” frame. When $m = n$, the cumulative distance between two action sequences can be calculated directly. When $m \neq n$, it is necessary to stretch or shorten the two action sequences, so in the construct of the matrix of $m * n$, the elements of the matrix (i, j) represent the distance from point A_i on the curve to the curve B_j , $d(A_i, B_j)$, this distance uses the Euclidean distance to measure the similarity. The smaller the Euclidean distance, the greater the similarity. The formula is as follows:

$$d = (A_i, B_j) = \sqrt{\sum_{w=1}^N (A_{iw} - B_{jw})^2} \quad 1 \leq w \leq N. \quad (1)$$

The formula represents the Euclidean distance between the corresponding points of two action sequences, where A_{iw} and B_{jw} are the eigenvalues of the i th and j th frames of action sequences A and B , respectively. N is the dimension of the action sequence, as shown in Figure 1.

Figure 1. DTW regularization path



The line passing through each point aligned between sequences A and B is called a regularized path, which is the optimal path from point (1,1) to point (m,n). W denotes the planning path, and the k th element of W is defined as $W_k = (i,j)k$, which has the following:

$$W = \{w_1, w_2, \dots, w_k, \dots, w_{m+n-1}\} \quad \max(m,n) \leq k \leq m+n-1. \quad (2)$$

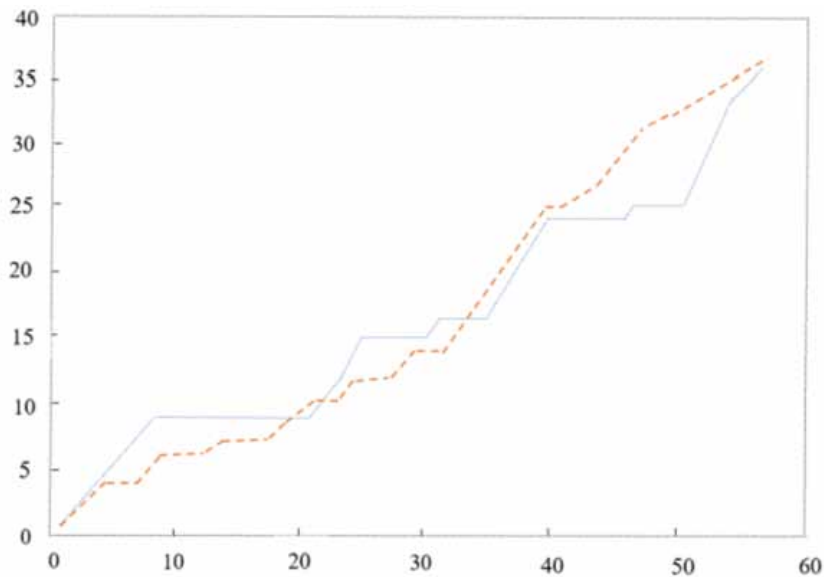
The dynamic regularization path needs W to satisfy three constraint cases, including boundary constraints, continuity constraints, and monotonicity constraints. Combining the three constraints can be introduced. The point $y(i,j)$ has only three elements connected to it, which are $(i+1,j)$, $(i,j+1)$, $(i+1,j+1)$. Define $y(i,j)$ as the sum of the Euclidean distance of A_i and B_j and the distance of the nearest element that can reach this point, which is called the cumulative distance. In the constraints, starting from the point of (1,1), the search arrives at the point of (m,n) point ends. The cumulative distance is inversely proportional to the similarity. The larger the cumulative distance, the less similarity between the two action sequences.

$$\gamma(i,j) = d(A_i, B_j) + \min\{\gamma(i-1, j-1), \gamma(i, j-1), \gamma(i-1, j)\}. \quad (3)$$

The dynamic time regularization path of the traditional DTW algorithm is an upward folding line, which is a folding line close to the diagonal at the most ideal time. However, as the amount of data increases, the regularization path cannot approach the diagonal, resulting in an increase in both computation and complexity, leading to a lower recognition rate. In addition, the DTW algorithm in the dynamic regularization process may appear on a sequence of points, and another sequence of multiple points mapping will have an impact on the calculation, so the DTW is improved. The improved formula is as follows:

$$\gamma(i,j) = d(A_i, B_j) + \min\{\alpha\gamma(i-1, j-1), \beta\gamma(i, j-1), \delta\gamma(i-1, j)\}. \quad (4)$$

Figure 2. The straight path before and after the improvement

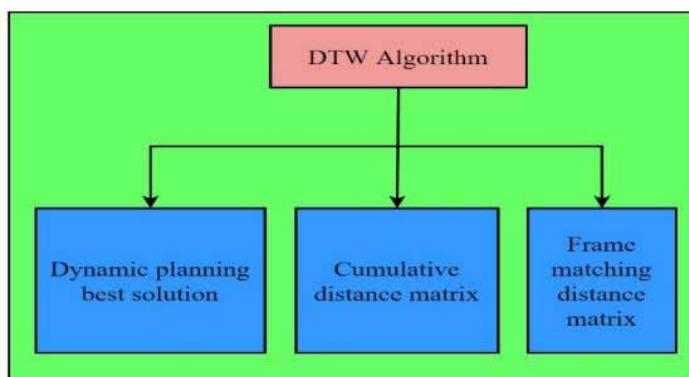


α , β , δ are optimization coefficients that reduce unnecessary mappings and shorten the path search time.

Different from the traditional DTW algorithm, this method realizes the scoring and intelligent analysis of Taijiquan movements by comparing them with the standard values, performing arithmetic processing and analysis. This method provides a more accurate and intelligent aid for Taijiquan training, which is expected to improve the training effect and movement skills of youths, see Figure 3.

First of all, the Taijiquan movement in the first round of training is locked and screened, and the movement capture is carried out. The wrist shape, the vector representation combination of the Taijiquan movement, and the data set of the Taijiquan movement capture of different groups with high similarity are selected (Hachaj et al., 2018). Different types of carpal bones are constructed. The analysis needs of different training processes and the database based on the existing Taijiquan movement, wrist shape data intelligent processing model, use a multilayer node structure. It is

Figure 3. Systematic characteristics of a DTW algorithm (dynamic time warping)



assumed that the number of primary input values of the target, an implicit input value of demand feature, output layer data of demand judgment, and its nodes required in the model are A, B, C, D, and E, respectively, as shown in Figure 4. The required coding length L is:

$$L = A \times B + A \times C + B \times C + A \times D + B \times E,$$

A is the head of the exerciser, BE is the elbow of the exerciser, and CD is the knee area of the exerciser.

Next, the demand function of the analysis scheme of the movement form in the training process of Taijiquan needs to be determined. In order to realize the two-way analysis and transmission of the related Taijiquan movement and the corresponding wrist shape information data input signal W_i , the similar wrist shape of the initial target population and the minimum analysis scheme demand value X_i in the movement process of Taijiquan movement are assigned to the DTW algorithm. Therefore, the square sum of the error between the output value of the demand coefficient and the expected value of demand in the analysis of wrist shape and Taijiquan movement is Y_j . If the excitation function is a symbolic function, the fitness function and excitation function are (5), (6), (7), and (8), respectively.

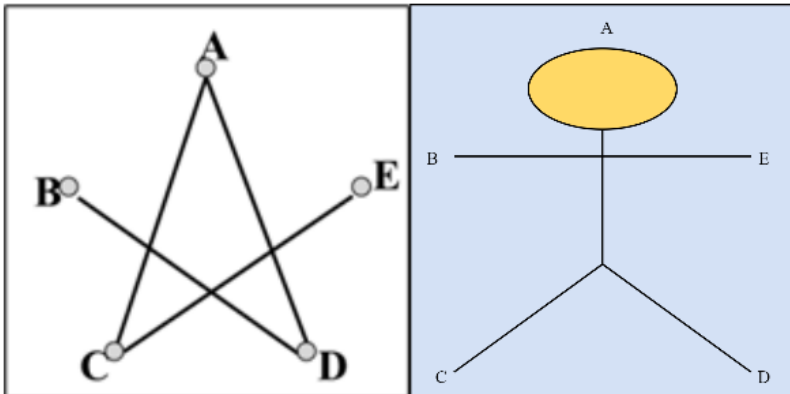
$$z = \sum_{i=1}^m w_i x_i - \theta \quad (5)$$

$$y = f(X_i) = \begin{cases} 1, & \sum_{i=1}^m w_i x_i > \theta, \\ 0, & \sum_{i=1}^m w_i x_i \leq \theta, \end{cases} \quad (6)$$

$$Y_j = \frac{e^{-s_j} x_{nj}}{1 + e^{-s_j}} + \frac{x_{nj}^2}{1 + e^{-s_j}} \quad (7)$$

$$\text{sgn}(x) = \begin{cases} 1, & x > 0, \\ 0, & x \leq 0. \end{cases} \quad (8)$$

Figure 4. Carcass structure required code length L



The specific DTW processing method of analyzing the carpal shape of the target is shown in Figure 5. Among them, from x_1 to x_n are random group targets. w_{nj} is the corresponding mode.

Combined with the requirements of the current college students' wrist shape required for normal physical growth (He & Wang, 2018), the Taijiquan movement capture technology and demand prediction model mentioned show the difference in carpal shape between the examinee after the Taijiquan movement and dynamic movement and combine the difference of carpal shape with the time length of the Taijiquan movement and dynamic movement to carry out weight analysis and processing in different degrees. Assuming that the key points of the carpal structure corresponding to Taijiquan are A, B, C, D, and E, respectively, the stability network of the carpal structure formed by Taijiquan is a pentagonal structure, as shown in Figure 4. In this way, the relevant analysis error will be greatly reduced, which shows that the actual adaptability of the model is very high, that is, the better the analysis and record of the action form of an individual's youth Taijiquan practitioners, the better the growth prediction of the action structure form in the future training process (Lin et al., 2022).

A is the head of the exerciser, BE is the elbow of the exerciser, and CD is the knee area of the exerciser.

Finally, in order to find out the influence of the Taijiquan movement capture and dynamic movement on the shape and structure of carpus, in this system model, the average value of carpus shape corresponding to different groups of training objectives and different movements is compared to judge (Lin et al., 2021). The first is the secondary discrimination: the DTW algorithm is generally used to select the detected and analyzed carpal shape targets (according to the difference degree comparison of the interval values of different types of carpal shape) through the vector group random sorting method of normal carpal shape demand degree, that is to say, input in advance in the computer, and then calculate and analyze the big data information of carpal shape history corresponding to the different Taijiquan. The demand degree of a certain trainer's carpal shape analysis data (i.e., specific carpal shape prediction scheme x) is obtained. Then, the automatic grouping and group vector generation are realized through the wrist shape database with similar requirements. Every product that meets the minimum normal demand value of carpal shape is discriminated twice and many times by the optimized DTW algorithm, and the discrimination probability is intelligently processed by the sorting results. The corresponding distribution principle is the high repetition discrimination probability corresponding to the normal value of the carpal shape. The analysis values of other carpal shapes correspond to the corresponding low discrimination probability; (i.e., secondary or multiple

Figure 5. Information output diagram

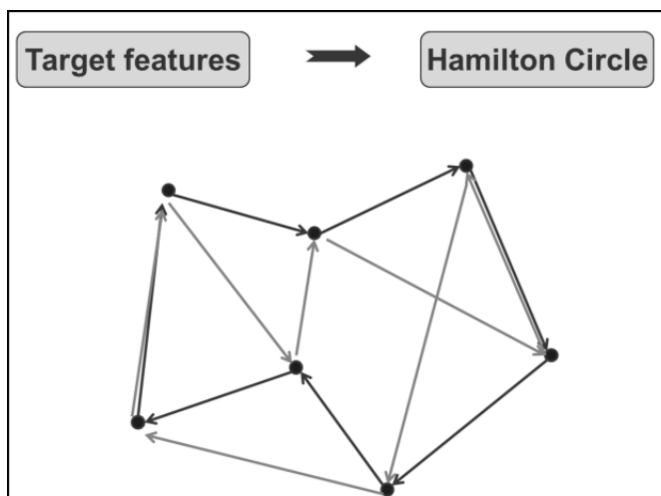
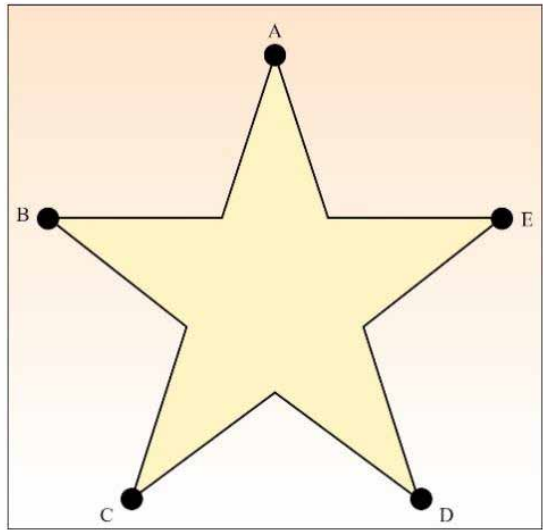
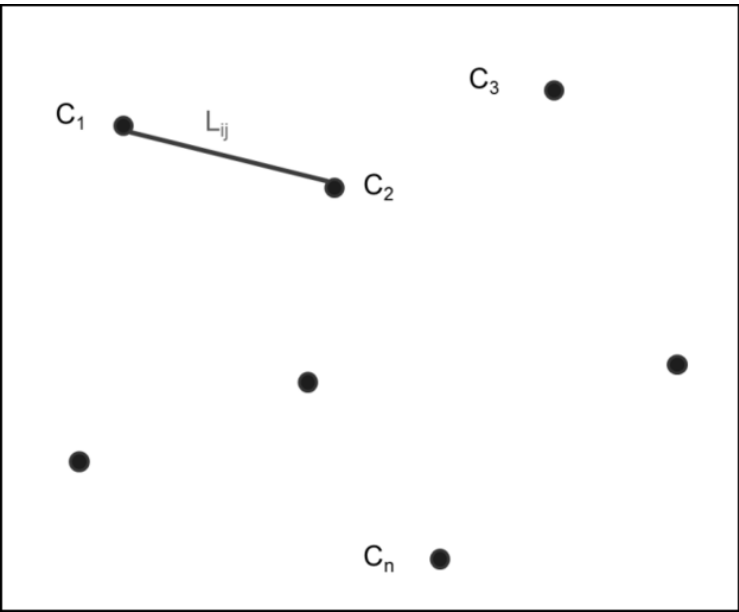


Figure 6. The pentagonal structure formed by the key positions of the carpal morphological structure



discrimination) probability (Ribeiro et al., 2016). In this way, by analyzing the carpal bones of groups with long-term Taijiquan movement or dynamic movement, the growth data state of carpal bones can be found out and compared with the known normal carpal bone structure, and then the degree of influence (that is, the difference of movement in the training process of the Taijiquan is represented by the difference of carpal bones) can be found out. C1, C2, C3 to Cn are the key monitoring points of carpal structure, and the specific detection is shown in Figure 7.

Figure 7. The detection process of key monitoring points of carpal structure



The black circles represent key points for monitoring the structure of the carpal bones and the lines represent movement trajectories.

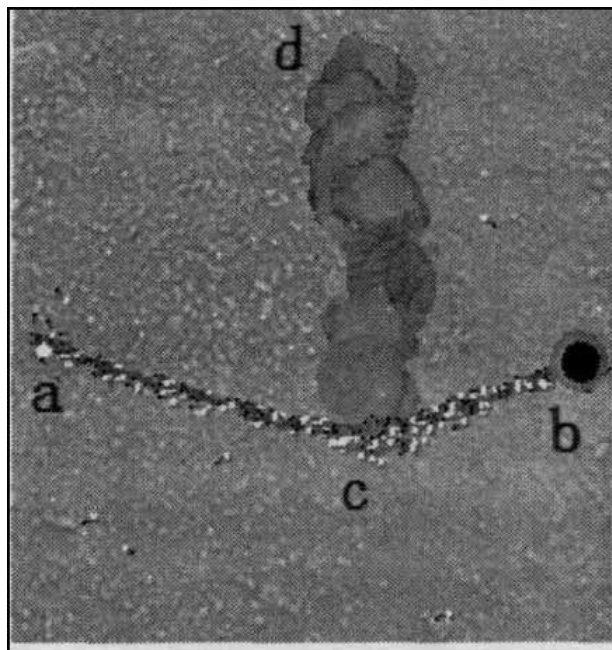
EXPERIMENTAL PROCESS AND RESULTS ANALYSIS

Auxiliary Training and Scoring Model of Taijiquan Based on Motion Capture and a DTW Algorithm

Four points, A, B, C, and D, are the key points to detect the local morphology of the carpal. They are also the core factors to realize the auxiliary training and scoring process of the Taijiquan.

In order to find the relationship between the auxiliary correction and training effect of the Taijiquan movement so that the Taijiquan movement can better bring a positive impact on the physical growth of teenagers, a unique model of the Taijiquan movement capture, prediction, and analysis is established from the aspect of a DTW algorithm model construction (Hastomo, 2020). Under the Taijiquan-assisted training model, the different ways of wrist shape (for example, the normal carpal shape of different ages, different genders, different regions, and different blood types) corresponding to different Taijiquan movements and how to analyze whether the carpal shape of the examinee conforms to the carpal shape corresponding to the standard Taijiquan movements are mainly based on the automatic comparison and analysis system of normal carpal shape on the level of big data and the intelligent combination mode of automatic two-way information interaction (Jiménez, 2019). After the detection and accurate processing of the key carpal data (if the corresponding weight is different, the greater the correlation, the greater the corresponding weight), the carpal shape of the specific Taijiquan training population can be analyzed, and the future growth shape can be predicted (Papalampidi et al., 2021). This kind of intelligent, comprehensive evaluation method based on big data analysis has the following characteristics: it does not need to mark and screen the group characteristics of potential Taijiquan exercises in advance but based on the intelligent evaluation process completed by the automatic analysis system based on a DTW algorithm (Yang et al., 2021).

Figure 8. Points a, b, c, and d are the core factors in the implementation of the Taijiquan training and scoring process



The purpose of movement evaluation and analysis is to compare with the standard movement, to evaluate the movement sequence to be compared (i.e., to judge how well the movement is done). The traditional method is the way of manual observation, relying on experienced coaches, referees to point out the differences in the movements and evaluating and scoring the movements. The result of scoring is affected by subjective factors, so DTW algorithms are needed to assist manual scoring, and the use of human skeletal data for scoring has certain advantages.

The DTW algorithm is used to calculate the DTW distance between the test movement sequence and the standard movement sequence as a similarity evaluation parameter. The right wrist and the left wrist are chosen as joint angle features. A movement in the Taijiquan was used as the evaluation object, and 50 students were selected as samples for the test movement sequence. Most of the DTW distances of the left wrist angle were distributed between 200 degrees and 800 degrees. A few were distributed between 800 degrees and 1,200 degrees.

For the experimental analysis, the evaluation method was constructed with the following formula:

$$S_a = S_c - (d_1 - d_2) * f_c, \quad (9)$$

where S_a denotes the score of an angular feature, and S_c denotes the score of the angular assignment, which is 12.5. d_1 denotes the value of the DTW distance, and d_2 denotes the minimum value within the valid interval of the DTW distance. f_c is the loss parameter, whose value size is related to the magnitude of the movement change, and the loss parameter is small in the joints with a large magnitude and large in the joints with a small magnitude. The final score is the sum of the joint angle scores of the left and right wrists.

After the experiment to get the base value of DTW distance and joint point loss parameters for different joint angles, and finally substituting into the formula to get the score of movement evaluation, the results of movement evaluation are shown in Table 2

At present, among the groups who have been engaged in the Taijiquan and power sports for a long time in China, the shape and structure of the wrist bones of most people will be more or less influenced by the movements and postures of the Taijiquan (Liao et al., 2023), which is imperceptible. In the detection of the carpal shape, the system has set up a standard data evaluation model of carpal shape and structure corresponding to the Taijiquan. Therefore, the research takes the carpal shape corresponding to the standard Taijiquan action randomly selected from multiple groups of carpal shapes (two in each group) of multiple targets to be tested in the same age, gender, and region as the benchmark test object (Kamel et al., 2019). Therefore, the results of this experiment showed that this Taijiquan-assisted training and scoring model based on motion capture technology and a DTW algorithm can accurately compare and analyze the current state of the specific target's carpal shape

Table 1. DTW distance and loss parameter value table

Perspectives	DTW distance $d_{2(second)}$	The loss parameter f_c (%)
Left wrist	200	0.436
Right wrist	230	0.413

Table 2. Movement evaluation results

Joint angle name	DTW distance $d_{1(second)}$	Evaluation mark (score)	Professional marking (score)
Left wrist	785	9.9	10.6
Right wrist	587	11.0	11.3

and structure according to the normal carpal shape corresponding to the standard Taijiquan actions of the same age, gender, and region, then it can know whether the shape of the wrist bone of a target is affected after the Taijiquan and power exercise, so as to realize the auxiliary evaluation of the Taijiquan in the training process (Bascones, 2019).

CONCLUSION

Traditional Taijiquan training methods can no longer meet the current training requirements. On this basis, a Taijiquan training scoring model based on motion capture technology and a DTW algorithm was studied. Firstly, the research status quo and existing problems of Taijiquan training assistance in China were reviewed, and then the Taijiquan training assistance and scoring model based on motion capture technology and a DTW algorithm was proposed.

Finally, through experiments, it was found that the similarity between the Taijiquan impact analysis scenarios identified by the training assistance and scoring model and the known impact analysis scenarios was within a stable standard reference range. The accuracy of the errors indicated that the predictive analysis system could analyze the effects of Taijiquan exercise or dynamic exercise on the morphological structure of the wrist bone and could be applied to the intelligent analysis system of the morphological structure of the wrist bone in adolescents. The experimental results showed that the model could be used to determine whether there was movement consistency in the overall category of Taijiquan with similar characteristics.

In the movement evaluation, the DTW algorithm was used to match different length curves, and a set of formulas was defined with the difference of joint angle curves as the experimental parameters to realize the evaluation and scoring of movements. The results showed that the capture model based on the DTW algorithm does not differ much from the professional scoring when scoring the learner's movements, which proves the feasibility of the model. However, this model only considered the training effect and did not consider other factors, so the model still has room for improvement.

AUTHOR NOTE

The figures used to support the findings of this study are included in the article.

The authors declare that they have no conflict of interests.

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