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Computer-Aided Design AND APPLICATIONS

Developing an Online Game-Based Curriculum System for Martial Artists in Public Sports Using Big Data Technology

Zhen Liu[1*]

[1]School of General Education, Hunan Institute of Information,Changsha, Hunan 410151 ,China
HnWs1975@163.com

Corresponding author: Zhen Liu, HnWs1975@163.com

Abstract. In order to improve the teaching effect of the martial artists curriculum system, this paper combines the big data technology to construct the martial artists curriculum system in public sports. Moreover, this paper constructs a martial artists action-term association network by calculating the similarity between martial artists action and martial artists action and the similarity between terms and terms, and displays them visually.In addition, this paper adopts the biased random walk algorithm to predict martial artists action functions, and the final prediction results can be added to the database as prior knowledge for data analysis. Finally, this paper verifies through experiments that the method in this paper can still achieve good results on the basis of integrating multiple data sources.The experimental research shows that the martial artists curriculum system in public sports based on big data technology proposed in this paper can play an important role in martial artists curriculum teaching.

Key words: big data technology; public sports; martial artists; Online Game-Based curriculum system
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1 INTRODUCTION

Martial artists are an important part of Chinese traditional culture. Doing a good job in the teaching of martial artists in colleges and universities can not only promote traditional Chinese culture, but also promote the development of students' physical and mental health. In order to satisfy people's love, in order to stand out on the "stage", martial artists performers blindly reform and innovate their movements. The beauty of martial artists lies in the perfection of the completed movements, but more importantly, it must be combined with the connotation beauty of martial artists, so as to achieve the aesthetic effect expressed by martial artists.In order to attract the attention of the audience, more and more performers combine other boxing movements and stage effects to continuously innovate, resulting in some new martial artists movements and styles of martial artists.

In order to win a place in the sports world, martial artists have formed a strange phenomenon, that is, the gymnastics of martial artists [6]. Moreover, in order to reform and innovate martial artists, it relies on the aesthetic standards of gymnastics, such as stretching movements, graceful and graceful, beautiful shape, rhythm and rhythm.Gymnasts are required to stretch their movements, not only stretch but also behave gracefully when performing. At the same time, gymnasts put a lot of effort into their styling. In order to better show the stage art effect, some dynamic music with rhythm and rhythm is played at the same time, which not only satisfies the visual aesthetic effect of the audience, but also satisfies the audience's hearing accordingly [15]. This is why gymnastics has always had a great reputation in the gymnastics world.Therefore, martial artists draw on the aesthetic standards of rhythmic gymnastics in these aspects. For example, when martial artists perform youth boxing on the stage, they will play music related to Shaolin Temple, and the background of the stage will show the daily performance of Shaolin Temple, the daily life of young monks, and the characteristic buildings of Buddhist temples. These stage effects will attract the attention of the audience, even overshadowing the martial arts itself, which is not good for the development of martial arts itself.Not only that, we say that this is the promotion of the martial arts. But now it is rare to see athletes doing this kind of action or develop the serial flying foot into a serial three flying foot, but see the difficult movements in gymnastics (such as: back hand flip, back flip, straight back flip, back flip, etc.) appeared in the national martial arts routine competition [13].At the same time, for example, "The movement called 'single snake waist' in the martial arts is the movement of 'straight back flip' in gymnastics, which is processed by gymnasts.After the appearance of "straight body and back empty body 1080", the martial arts and drama reabsorbed this action and called it "waist change 1080" [4].However, when athletes insert these gymnastic movements into the martial arts, they do not give the real connotation to the martial arts, but just complete a series of movements of the martial arts according to the standard of gymnastics.It can be seen that the real connotation of the martial arts will not be reflected by the increase in the difficulty of the actions of the martial arts, nor will it enrich the real connotation of the martial arts. On the contrary, after adding these difficult movements, the connotation of martial arts has not been improved, but weakened. Therefore, martial arts should not pursue external high-difficulty movements, because this is actually just the performance of martial arts toward gymnastics [9].We need not to let the martial arts "take their form and lose their spirit". However, in order to truly carry forward the martial arts, reform and innovation should be carried out in accordance with the essential laws of the martial arts, rather than alienation and deterioration in the process [14].It outlines the technical requirements, user interface design, and gaming mechanics incorporated into the system. The section also discusses how immersive multimedia elements, such as virtual reality (VR) and augmented reality (AR), can be utilized to create an immersive and realistic learning environment for martial artists.

As a traditional culture, Wushu does not oppose reform and innovation, and should pay attention to the following principles while reforming and innovating: First, you can learn and learn from the success of dance and gymnastics, but you must avoid copying. Second, in the reform and innovation of Tong Wushu as a traditional culture, we do not oppose reform and innovation. We should pay attention to the following principles while reforming and innovating: First, we can learn and learn from the success of dance and gymnastics, but To put an end to copying [12]. Pay attention to the connotation of martial arts, and should not focus on externalization, that is, focus on formalized things. Finally, while reforming and innovating Wushu, a particularly important principle must be followed: it must conform to the essential attributes and laws of movement of Wushu. Martial arts is a traditional sport, and learning martial arts is beneficial to our physical and mental health [5]. First, develop a firm will and promote a noble character. After a long period of training in martial arts, people can be trained to be hard-working, proactive, open-minded, studious, and willing to learn. Secondly, entertain the public and enrich life. Martial arts are highly ornamental, and people can learn self-defense by watching them. Again, martial arts is a communicative activity, and through

competitive communication, friendship can be promoted. Finally, martial arts can improve physical quality and have the effect of strengthening the body, which is the most significant feature of martial arts people [7].

Wushu education has carried out a series of studies around how Wushu enters into education. The value of Wushu education is the basis for Wushu to enter the field of education. The value of Wushu is based on the function of Wushu. The function of Wushu is closely related to the essence of Wushu. It is precisely because Wushu Curriculum construction ignores the guiding role of education, and the basic research paradigm of education is ignored. Wushu education research deviates from the educational research paradigm and forms a research model that focuses on the function, value, and essence of Wushu [3].

The essence, function and value of Wushu in the development of modern Wushu have always been the focus of Wushu research. Wushu education continued this research theme and formed an analysis and research model centered on Wushu ontology and essence, while the focus of education research was ignored. . The basic research on effects, methods, paths, etc. that the field of education pays attention to is despised, and martial arts education without practice can only be a castle in the air. It is precisely because the research on martial arts education deviates from the research paradigm of education that the contradictions between tradition and competition, strike and dance on the development of martial arts continue into martial arts education [10]. From the perspective of education, whether it is traditional or competitive, boxing and dancing, health and moral education, as long as it is beneficial to students, it should serve students. If everything is student-centered, these contradictions are not so important. It is precisely because educating people is not the main purpose of Wushu curriculum construction that the above-mentioned contradictions appear in Wushu education. Therefore, Wushu education must establish the primary and secondary relationship between education and Wushu from the concept, and develop Wushu on the premise of meeting the needs of education and following the basic laws of education [11]. Taking education as the path of Wushu development promotes the horizontal development of Wushu courses. Wushu as education should focus on how to better exert its effect in educating people and how to better achieve the goal of educating people, which is also the focus of educational research. That is to say, the development of martial arts education should be to explore the effects, paths and methods of martial arts education from the top, rather than just horizontal curriculum construction. The development of martial arts curriculum is not equivalent to the development of martial arts education [16]. Just because the development of Wushu is above educational needs, the realization of Wushu education value and educational function is neglected, and Wushu skills are regarded as the main content of Wushu courses, so that Wushu education fails to exert its full function. From the perspective of value philosophy, value is the meaning or usefulness of the object to the subject, and value is the sum of the relationship category and attribute category, and it is the satisfaction relationship between the object's functional attributes and the subject's needs [8]. The value of education is mainly manifested in educating people, and people become the absolute core of education. The education system contains many subject courses, and the structured curriculum system composed of these courses serves the educational goal - people. From the perspective of martial arts education, while seeing the value of education for the development of martial arts, it is more important to ensure that the development of martial arts education meets the needs and laws of education. It is hoped that the practice of developing martial arts through education will treat students as passive tools , which not only violates the original intention of education, but also lacks the most basic humanistic care. Just as ethics says that purpose is an important criterion for judging the good and evil of behavior, there will be no good behavior without good purpose [2]. It is unethical to regard students as tools and ignore the practical needs of students and the development path of martial arts. The starting point of martial arts education is the growth of students rather than the development of martial arts [1].

This paper combines the big data technology to construct the public sports martial arts curriculum system, improve the quality of the martial arts teaching, and promote the further popularization of the martial arts teaching.

2 RANDOM WALK ALGORITHM AND RELATED TECHNOLOGIES

2.1 Random Walk

A random walk is also called a random walk, and its principle is similar to Brownian motion. By modeling the algorithm, the probability distribution of all possible nodes reaching the next position after each walk is calculated. After continuous iteration, a basically stable and convergent probability distribution is finally obtained. The Random Walk with Restart (RWR) algorithm is an improvement on the basis of the random walk algorithm.The formula for restarting the random walk is as follows:

$$p^{t+1} = (1-\alpha)\, p' W + \alpha p^0 \tag{1}$$

Among them, p^i represents the probability of jumping from the current node to the neighbor node v_i, α is a constant called the restart probability, and there is $\alpha \in (0,1]$. That is, the walker returns to the starting node with probability α. p^0 represents the initial vector, p^t represents the transition probability distribution at time t, and W represents the probability transition matrix.

In the process of random walk, the structure of the network is not considered. In the Node2Vec algorithm, the researchers added two new parameters: p and q. These two parameters control the sequence generated by the random walk to be more inclined to breadth-first search (BFS) or depth-first search (DFS), as shown in Figure 1.By controlling two parameters, a more suitable random walk method can be selected.

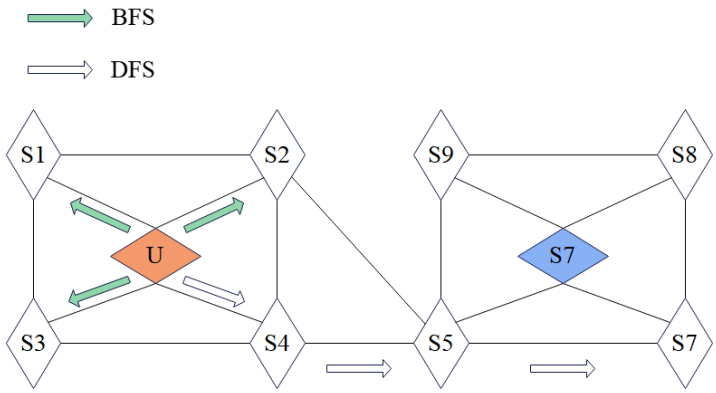

Figure 1: Illustration of BFS and DFS in random walk.

The Node2vec algorithm is an improvement based on the DeepWalk algorithm.When the current node is given, the algorithm first calculates the probability value of visiting each possible edge of the next node according to the weight values of all edges, and then adds p and q to control the direction of the walk. The specific parameter settings are shown in Figure 2.

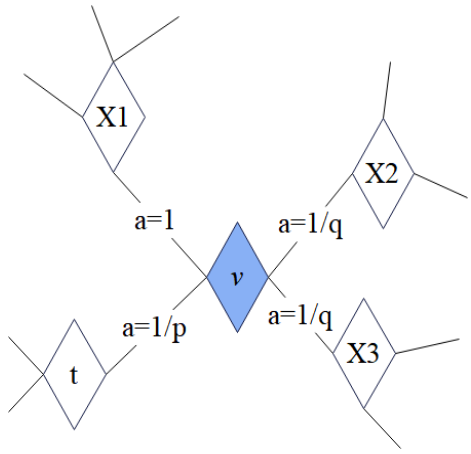

Figure 2: Description of the random walk process.

We assume that the current network jumps from node t to node v by edge (t,v), and v has three neighbor nodes X_1, X_2 and X_3. Among them, if X_1 is adjacent to t, the probability of v to X_1 does not change. If neither X_2 nor X_3 are adjacent, then the probability of v to X_2 and X_3 is the original probability divided by q, and v to t is the original probability divided by p. The formula is as follows:

$$\alpha_{pq}(t,x)=\begin{cases}\dfrac{1}{p} & if\ d_{tx}=0\\ 1\ if\ d_{tx}=1\\ \dfrac{1}{q} & if\ d_{tx}=2\end{cases} \tag{2}$$

It can be seen from the formula that p is used to control the probability of repeatedly visiting the node that has already been visited, and q is used to control whether the next walk is partial to DFS or BFS.

Second-order similarity refers to the proportion of two vertices that have the same second-order neighbor nodes.Moreover, a martial arts action and all its adjacent martial arts actions with the highest second-order similarity have the highest functional and structural similarity, and also contain the most common information. The performance in a network is that pairs of nodes with the same number of neighbors are more similar in structure, as shown in Figure 3.

As the starting node of a random walk, if a sequence is generated by an unbiased random walk, then the probability of starting from point A to other adjacent nodes is equal. For the traditional random walk method, it will not tend to point B, which may lose the information of the second-order similarity in the graph. In this paper, the second-order similarity distribution of two different vertices is calculated in the simplest way.

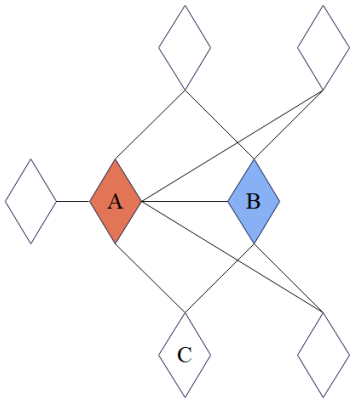

Figure 3: Illustration of second-order similarity.

The formula is as follows:

$$p\left(v_j \mid v_i\right)=\frac{u_i \bullet u_j}{\sum_{t \in adj(i)} u_i \bullet u_t} \tag{3}$$

Among them, u_i represents the adjacency information of the i-th vertex in the network. $u_i \bullet u_j$ represents the number of common neighbor nodes between the i-th vertex and the j-th vertex, and $adj\left(i\right)$ represents the neighbor node set of the i-th node.

2.2 Pagerank Algorithm

Graph is a nonlinear data structure. It consists of a series of vertex sets and edge sets, denoted as G= $G=\left(V,E\right)$. Among them, V represents the vertex set, E represents the edge set, and $V=\left\{v_1,v_2,v_3\ldots,v_n\right\};E=\left\{<v_i,v_j>\mid v_i,v_j\in V\right\}$ is the two vertices contained in each element in the edge set E, representing the two endpoints of the edge.

Graphs can be stored using adjacency matrices. For an unweighted graph, the two-dimensional array of values is used to indicate whether there is an edge between two vertices. Usually, it is represented by "1" or "0". The value of element a_{ij} in the adjacency matrix A is as follows:

$$a_{ij}=\begin{cases}1, & <v_i,v_j>\in E\\ 0, & <v_i,v_j>\notin E\end{cases} \tag{4}$$

The resulting adjacency matrix representation is as follows:

$$A=\begin{bmatrix}0 & 1 & 1 & 1\\ 1 & 0 & 0 & 1\\ 1 & 0 & 0 & 0\\ 0 & 1 & 1 & 0\end{bmatrix} \tag{5}$$

Also for a weighted graph, the value a_{ij} of each two-dimensional array is as follows:

$$a_{ij}=\begin{cases}\mathrm{w}_{ij}, & <v_i,v_j>\in E\\ \infty, & <v_i,v_j>\notin E\end{cases} \tag{6}$$

If v_i, v_j is adjacent, the value of a_{ij} is equal to the weight of the edge, otherwise the value of a_{ij} is infinite.

Starting from a certain vertex in the graph, the process of traversing the remaining vertices in the graph in a specific order is called graph traversal. We assume that a website has four pages A, B, C and D, and the interlinking relationship between them is shown in Figure 4.

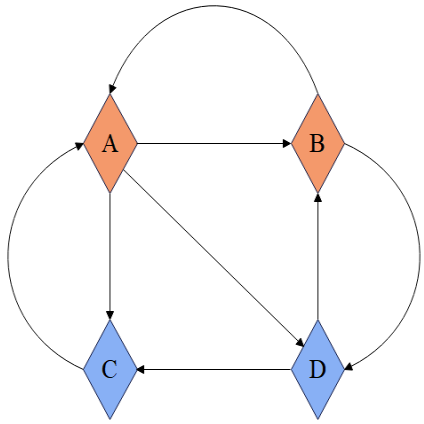

Figure 4: Web page links represented by a directed graph.

Among them, outlinks represent links to other pages. Similarly, an incoming link means that other pages can jump to the current page.Before the PageRank algorithm starts to execute, it first assigns a PageRank value to each page in the website, denoted as PR. According to the given PR value, the algorithm is continuously iterated until the probability distribution reaches a plateau, usually a threshold is given. The algorithm formula is as (7):

$$PR\left(p_i\right)=\alpha\sum_{p_j\in M_{pj}}\frac{PR\left(p_j\right)}{L\left(p_j\right)}+\frac{1-\alpha}{N} \tag{7}$$

Among them, M_{pj} is the set of all pages that have out-links to page p_i, $L(p_j)$ is the number of out-links of page p_j, and N is the total number of all pages in the website. α is the damping factor, which is used to represent the probability that the browser accesses the Internet by clicking on the link.

The martial arts term similarity indicates the semantic correlation between two given terms, and the martial arts term similarity calculation in this paper is based on the improved calculation method of Cheng Liang et al.

The Occurrence Degree (OD) is defined to measure the degree of association between term t and document l:

$$OD(t,l)=\begin{cases}1 & if\ t\ appears\ in\ l\\ 0 & if\ t\ is\ not\ present\ in\ l\end{cases} \tag{8}$$

If the term t appears in l, then $OD(t,l)$ is recorded as 1. If the term t does not appear in l, $OD(t,l)$ is recorded as 0.The term t does not appear directly in l, but may be associated with l through its descendants.Therefore, OD can be further adjusted according to the "is_a" relationship of the ontology. The adjusted $OD(AOD)$ is defined as follows:

$$AOD(t,l)=\begin{cases}1 & ifOD(t,l)=1\\ \dfrac{\left|\bigcup_{i=1}^{n}S(t_i)\right|}{S(t)} & ifOD(t,l)=0,\ t_i\in desc(t),\ OD(t,l)=1\end{cases} \tag{9}$$

Among them, n represents the number of descendant nodes of t that appear in l, and t_i represents the i-th descendant node that appears in l. $\left|\bigcup_{i=1}^{n}S(t_i)\right|$g represents the number of different terms contained in $S(t_1)$, $S(t_2)$, and $\ldots S(t_n)$, $|S(t)|$ represents the number of terms contained in $S(t)$, and $desc(t)$ represents the set of all descendant terms of t.If the term t appears in l, then $AOD(t,l)=1$, otherwise, the value of $AOD(t,l)$ is defined by the descendant term of t.

Now, the degree of association of a term in a term has been obtained, so the relationship between terms can be related by means of correlation, and the co-occurrence degree (COD) between terms can be defined as follows:

$$COD(t_1,t_2)=\sum_{i=1}^{n}\left(OD(t_1,l_i)\cdot OD(t_2,l_i)\right) \tag{10}$$

Among them, t_1 and t_2 represent two different terms, n represents the number of terms included, and l_i represents the serial number.

Based on formula (10), the algorithm continues to adjust OD between t_1 and t_2, and adjusts COD to the adjusted co-occurrence degree (ACOD):

$$ACOD(t_1,t_2)=\sum_{i=1}^{n}\left(AOD(t_1,l_i)\cdot AOD(t_2,l_i)\right) \tag{11}$$

The meaning of the parameters in the formula does not change. According to $ACOD$, the formula for adjusted R score (ARS) is as follows:

$$ARS(t_1,t_2)=\log_{10}\left(\frac{ACOD(t_1,t_2)}{ACOD(t_1,t_1)\cdot ACOD(t_2,t_2)}\right) \tag{12}$$

$ARS(t_1,t_2)$ stands for ARS between t_1 and t_2. After normalization, the final R score $ARSS$ is obtained as follows:

$$ARSS(t_1,t_2)=1+\frac{99*\left(ARS(t_1,t_2)-ARS_{\min}\right)}{ARS_{\max}-ARS_{\min}} \tag{13}$$

Among them, $ARS_{\max}$ and $ARS_{\min}$ represent the maximum and minimum ARS -scores, respectively. According to the similarity calculation formula between the martial arts terms, the similarity matrix R_n of the martial arts terms is obtained as:

$$R_n=\begin{bmatrix} ARSS(t_1,t_2) & \cdots & ARSS(t_1,t_m) \\ \vdots & \ddots & \vdots \\ ARSS(t_m,t_1) & \cdots & ARSS(t_m,t_m) \end{bmatrix} \tag{14}$$

Among them, m represents the number of martial arts terms.

The co-occurrence degree of different martial arts terms is obtained by calculating the ARS value, and the ARS value will be used as an important weight for the random walk to predict the action function of the martial arts.

2.3 Similarity of Martial Arts Actions

The action association relationship of martial arts comes from Human Protein Reference Database (HPRD) and starBaseV2.0 database, the similarity is calculated by Jaccard coefficient, and the similarity is stored in the database. Likewise, the similarity matrix R_{gg} between the actions of the martial arts is:

$$R_{gg} = \begin{bmatrix} J(g_1, g_2) & \cdots & J(g_1, g_n) \\ \vdots & \ddots & \vdots \\ J(g_n, g_1) & \cdots & J(g_n, g_n) \end{bmatrix} \tag{15}$$

Among them, $J(g_i, g_j)$ is the similarity of the actions of the martial arts, and n is the number of the actions of the martial arts.

In the OAHG platform database, in addition to integrating various ontology data, the similarity between the martial arts term and the martial arts term and the martial arts action and the martial arts action is calculated according to the above method, and a multi-layer heterogeneous association network is constructed, as shown in Figure 5.

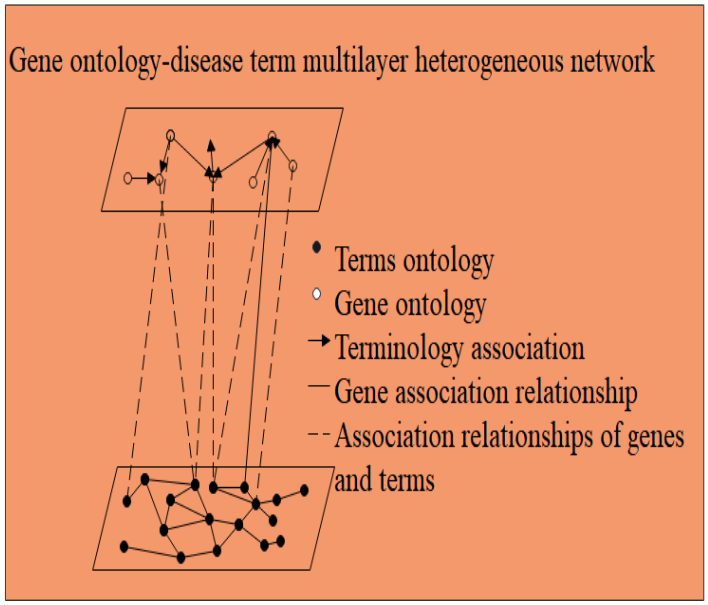

Figure 5: The multi-layer structure network of martial arts action ontology-martial arts terms.

The network at the upper layer is a directed acyclic graph, the hollow nodes represent terms, and the directed lines represent the inclusion relationship of terms. The lower network is the action association network of the martial arts, and the solid nodes represent the action ontology of the martial arts. The line connecting the two martial arts action bodies represents the association relationship between the martial arts actions, and the dashed line represents the relationship between the term and the martial arts action. Furthermore, a martial arts action can contain multiple terms, and a term can be included in multiple martial arts actions at the same time. Finally, a multi-layer heterogeneous network of martial arts action ontology-martial arts terms is constructed.

Based on the above network, the Random walk with restart gene disease association (RWRGDA) was developed. For RWRGDA, all the martial arts terms related to the input martial arts action are defined as seed nodes, while other terms not directly related to the input martial arts action are defined as non-seed nodes. These non-seed nodes are considered candidate terms related to the action of the martial arts. The RWRGDA algorithm simulates the process of a walker randomly walking from the

current position to the adjacent nodes.The flow chart of RWRGDA algorithm is shown in Figure 6.The first step of the algorithm is to calculate the similarity between the actions of the martial arts and the terms of the martial arts and store them in the database. The second step is to construct a martial arts action-martial arts term similarity network centered on the input martial arts action. Considering the influence of the network scale on the algorithm complexity, the second-order similarity of the generated network nodes is calculated, and the values with low second-order similarity between seed nodes and non-seed nodes in the network are eliminated. Then, it is iterated by restarting the random walk algorithm in the network. The third step gets the sequence of all random walks and counts the number of occurrences of all martial arts actions. Then, it removes all the seed martial arts actions from the sequence, sorts according to the probability value of the candidate martial arts action functions, and the sorted result is the final prediction result.

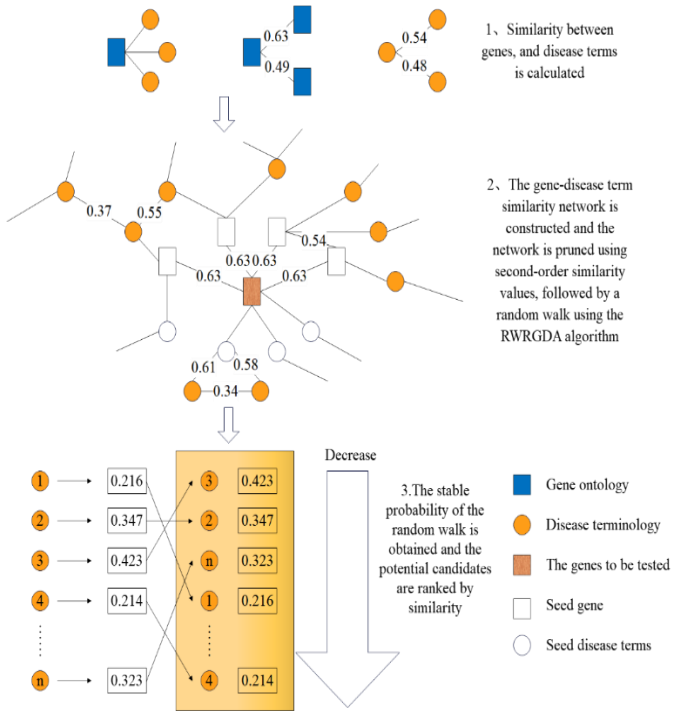

Figure 6: Flowchart of RWRGDA algorithm.

3 RESEARCH ON THE CONSTRUCTION OF MARTIAL ARTISTS CURRICULUM SYSTEM IN PUBLIC SPORTS BASED ON BIG DATA TECHNOLOGY

The martial arts curriculum system module in public sports constructed in this paper based on big data technology is shown in Figure 7. In this paper, the teaching process of the martial arts course is identified, and the intelligent recognition results shown in Figure 8 are obtained. On the basis of the above research, this paper studies the martial arts curriculum system in public sports based on big data technology, explores the effect of the martial arts curriculum system in public sports, and obtains the results shown in Table 1 and Figure 9.

Core course module 1	
Core course module 2 (bilingual)	
Elective course module A1	Elective course module B1
Elective course module A2	Elective course module B2
Elective course module A3	Elective course module B3
Core course module 3	
Core course module 4 (bilingual)	
Elective course moduleA4	Elective course moduleB4
Elective course moduleA5	Elective course moduleB5
Elective course moduleA6	Elective course moduleB6
Professional curriculum design	

Figure 7: Modular professional curriculum system.

(a) (b) (c)

Figure 8: The result of intelligent recognition in the teaching process of martial arts: (a) Original martial arts teaching image, (b) Martial arts image with background removal, (c) Intelligent recognition of teaching graphics in martial arts.

Number	*Teaching effect*	*Number*	*Teaching effect*
1	*89.48*	*18*	*87.49*
2	*88.18*	*19*	*87.90*

3	*88.19*	*20*	*89.86*
4	*87.20*	*21*	*90.33*
5	*87.08*	*22*	*87.36*
6	*86.39*	*23*	*91.09*
7	*89.43*	*24*	*91.37*
8	*90.82*	*25*	*89.64*
9	*90.74*	*26*	*91.97*
10	*87.34*	*27*	*86.05*
11	*87.35*	*28*	*90.91*
12	*91.15*	*29*	*90.47*
13	*90.94*	*30*	*86.08*
14	*88.48*	*31*	*89.33*
15	*88.57*	*32*	*88.76*
16	*87.79*	*33*	*87.85*
17	*90.66*		

Table 1: Effect verification of the martial arts curriculum system in public sports based on big data technology.

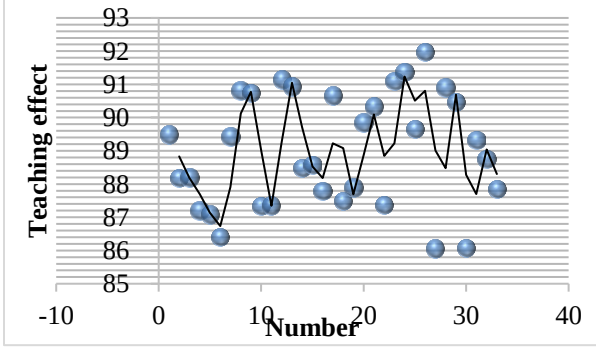

Figure 9: Validation of the effect of the curriculum system.

From the above research, we can see that the martial arts curriculum system in public sports based on big data technology proposed in this paper can play an important role in the teaching of the martial arts curriculum.

4 CONCLUSION

Integrating curriculum ideological and political education into the teaching of martial arts in colleges and universities can cultivate students' sense of competition and team spirit, and can stimulate students' patriotism. When carrying out the training activities of martial arts, students are required to have a higher will quality, which can combine the teaching of the martial arts with the ideological and political education, strengthen the will quality of the students, and cultivate the students to form a good sense of rules.It can be seen that the establishment of an intelligent public sports martial arts curriculum system is an inevitable trend in the development of martial arts teaching in colleges and universities. It can not only improve the physical quality of students, but also improve the moral sentiment of students. Therefore, it is necessary to strive to explore ways to combine the two to provide students with a better learning and growth environment. This paper combines the big data technology to construct the curriculum system of the public sports martial arts curriculum. The experimental research shows that the martial arts curriculum system in public sports based on big data technology proposed in this paper can play an important role in the teaching of the martial arts curriculum.

Zhen Liu, https://orcid.org/0009-0002-3137-2846

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REFERENCES

[1] Colyer, S. L.; Evans, M.; Cosker, D. P.; Salo, A. I.: A Review of the Evolution of Vision-Based Motion Analysis and the Integration of Advanced Computer Vision Methods Towards Developing a Markerless System, Sports Medicine-Open, 4(1), 2018, 1-15. https://doi.org/10.1186/s40798-018-0139-y

[2] Díaz, R. G.; Laamarti, F.; El Saddik, A.: DTCoach: Your Digital Twin Coach on the Edge During COVID-19 and Beyond, IEEE Instrumentation & Measurement Magazine, 24(6), 2021, 22-28. https://doi.org/10.1109/MIM.2021.9513635

[3] Ershadi-Nasab, S.; Noury, E.; Kasaei, S.; Sanaei, E.: Multiple Human 3d Pose Estimation from Multiview Images, Multimedia Tools and Applications, 77(12), 2018, 15573-15601. https://doi.org/10.1007/s11042-017-5133-8

[4] Gu, R.; Wang, G.; Jiang, Z.; Hwang, J. N.: Multi-Person Hierarchical 3d Pose Estimation in Natural Videos, IEEE Transactions on Circuits and Systems for Video Technology, 30(11), 2019, 4245-4257. https://doi.org/10.1109/TCSVT.2019.2953678

[5] Hua, G.; Li, L.; Liu, S.: Multipath Affinage Stacked—Hourglass Networks for Human Pose Estimation, Frontiers of Computer Science, 14(4), 2020, 1-12. https://doi.org/10.1007/s11704-019-8266-2

[6] Li, M.; Zhou, Z.; Liu, X.: Multi-Person Pose Estimation Using Bounding Box Constraint and LSTM, IEEE Transactions on Multimedia, 21(10), 2019, 2653-2663. https://doi.org/10.1109/TMM.2019.2903455

[7] Liu, S.; Li, Y.; Hua, G.: Human Pose Estimation in Video Via Structured Space Learning and

Halfway Temporal Evaluation, IEEE Transactions on Circuits and Systems for Video Technology, 29(7), 2018, 2029-2038. https://doi.org/10.1109/TCSVT.2018.2858828

[8] McNally, W.; Wong, A.; McPhee, J.: Action Recognition Using Deep Convolutional Neural Networks and Compressed Spatio-Temporal Pose Encodings, Journal of Computational Vision and Imaging Systems, 4(1), 2018, 3-3.

[9] Nasr, M.; Ayman, H.; Ebrahim, N.; Osama, R.; Mosaad, N.; Mounir, A.: Realtime Multi-Person 2D Pose Estimation, International Journal of Advanced Networking and Applications, 11(6), 2020, 4501-4508. https://doi.org/10.35444/IJANA.2020.11069

[10] Nie, X.; Feng, J.; Xing, J.; Xiao, S.; Yan, S.:. Hierarchical Contextual Refinement Networks for Human Pose Estimation, IEEE Transactions on Image Processing, 28(2), 2018, 924-936. https://doi.org/10.1109/TIP.2018.2872628

[11] Nie, Y.; Lee, J.; Yoon, S.; Park, D. S.: A Multi-Stage Convolution Machine with Scaling and Dilation for Human Pose Estimation, KSII Transactions on Internet and Information Systems, 13(6), 2019, 3182-3198. https://doi.org/10.3837/tiis.2019.06.023

[12] Petrov, I.; Shakhuro, V.; Konushin, A.: Deep Probabilistic Human Pose Estimation, IET Computer Vision, 12(5), 2018, 578-585. https://doi.org/10.1049/iet-cvi.2017.0382

[13] Szűcs, G.; Tamás, B.: Body Part Extraction and Pose Estimation Method in Rowing Videos, Journal of Computing and Information Technology, 26(1), 2018, 29-43. https://doi.org/10.20532/cit.2018.1003802

[14] Thành, N. T.; Công, P. T.: An Evaluation of Pose Estimation in Video of Traditional Martial Arts Presentation, Journal of Research and Development on Information and Communication Technology, 2019(2), 2019, 114-126. https://doi.org/10.32913/mic-ict-research.v2019.n2.864

[15] Xu, J.; Tasaka, K.; Yamaguchi, M.: Fast and Accurate Whole-Body Pose Estimation in the Wild and Its Applications, ITE Transactions on Media Technology and Applications, 9(1), 2021, 63-70. https://doi.org/10.3169/mta.9.63

[16] Zarkeshev, A.; Csiszár, C.:Rescue Method Based on V2X Communication and Human Pose Estimation, Periodica Polytechnica Civil Engineering, 63(4), 2019, 1139-1146. https://doi.org/10.3311/PPci.13861