Research on the Learning Patterns and Error Pattern Recognition of College Students' Sports Skills Based on Behavior Sequence Mining

Yingqi Fan
School of Physical Education, Guangzhou College of Commerce, Guangzhou 510000, Guangdong, China
Corresponding author: Yingqi Fan (e-mail: ggtyb321@163.com)

ABSTRACT Sports skill learning is a core component of college physical education and follows specific physiological and psychological laws. Timely recognition and correction of erroneous movements are essential for improving teaching quality, yet traditional teaching methods often show low efficiency and insufficient personalization. This study constructs a behavior-sequence-mining framework to explore learning patterns and identify error patterns in college students' sports skill acquisition. Experiments are conducted on basketball shooting and football shooting skills among 300 college students. Motion capture, video recording, and expert annotation are used to collect multidimensional learning behavior data, including joint angles, movement trajectories, practice frequency, and error frequency. After preprocessing, the PrefixSpan algorithm is applied to mine frequent phased behavior sequences, and a support vector machine model is used to classify error patterns. The results show that the proposed method effectively mines stage-specific sequence patterns and achieves 91.8% accuracy in error pattern recognition, outperforming traditional manual recognition methods. The approach can accurately locate typical error types and provide data-driven support for personalized physical education guidance.

INDEX TERMS behavior sequence mining, sports skill learning, error pattern recognition, motion capture, personalized teaching

I. INTRODUCTION

WITH the deepening of quality education, the cultivation of sports skills for college students has become the core goal of physical education teaching. Mastering scientific sports skills can not only improve the physical fitness of college students, but also cultivate their awareness and ability for lifelong exercise. The learning of sports skills is a dynamic process from cognition, connection to automation, and its formation has significant stage patterns. However, the acquisition and subsequent habituation of erroneous movements significantly impede the skill-learning process. Therefore, accurately mining the learning patterns of sports skills for college students and identifying error patterns have important theoretical and practical significance for optimizing physical education teaching modes and improving teaching effectiveness.

This article focuses on the entire process of college students' sports skill learning, with behavior sequence mining technology as the core, combined with sports skill learning theory, to explore the dynamic laws of college students' sports skill learning, identify typical error patterns at different stages of skill learning, and provide data support and technical reference for personalized teaching guidance. Currently, research on motor skill learning has achieved certain results. Scholars have analyzed the stage characteristics of motor skill formation from the perspectives of psychology and education, proposed related theories such as closed-loop control and open-loop control, and clarified the impact of factors such as practice and feedback on skill learning; In terms of technological applications, some studies have introduced deep learning and computer vision technologies to recognize motion errors, but existing research still has significant shortcomings: most studies only focus on static error recognition of a single skill, lacking dynamic mining of the entire process of skill learning behavior sequence, making it difficult to capture the regular changes in the learning process; Error pattern recognition relies heavily on a single feature and does not take into account the temporal correlation of behavior sequences, resulting in insufficient recognition accuracy and targeting; At the same time, there is a lack of research on the college student population, which ignores the differences in cognitive level, learning autonomy, and primary and secondary school students, and the applicability of research results is limited.

Based on this, this article focuses on the characteristics of college students' learning of sports skills, introduces behavior sequence mining technology, constructs a systematic research framework, and intends to solve the following core problems: firstly, how to accurately capture the dynamic sequence characteristics of college students' learning of sports skills through behavior sequence mining technology, and reveal their learning rules; The second is how to construct an efficient error pattern recognition model based on learning behavior sequences, achieving precise positioning and classification of error types; The third is how to apply the discovered learning patterns and error patterns to physical education teaching practice, providing feasible solutions for personalized teaching guidance.

The main contributions of this article are reflected in three aspects: firstly, innovative research perspective, deeply integrating behavior sequence mining technology with the study of college students' motor skill learning, breaking through the limitations of traditional static analysis, realizing the dynamic law mining of the entire process of skill learning, and enriching the research methods of motor skill learning; Secondly, a complete technical process of "data collection sequence preprocessing rule mining error recognition" has been established, combined with the PrefixSpanPrefixSpan algorithm and machine learning classification model, to improve the accuracy and efficiency of error pattern recognition and solve the problem of strong subjectivity and low efficiency in traditional recognition methods; Thirdly, based on the characteristics of college students, we should explore the phased patterns and typical error patterns of their sports skill learning, propose targeted teaching optimization suggestions, provide practical references for the reform of university physical education teaching, and promote the development of physical education teaching towards refinement and individualization.

The technical solution of this article is the core of the research, as follows: firstly, the research object and skill types are determined, and two common skills of basketball shooting and football shooting among college students are selected as the research carrier. College students with different sports foundations are selected as the research sample to ensure the representativeness of the sample; Secondly, design a data collection plan that combines motion capture devices with video recording to collect multidimensional data such as action sequence data, practice frequency, and error frequency during the skill learning process of college students, and construct a database of motor skill learning behavior sequences; Then, the collected raw data is preprocessed, including data cleaning, denoising, and standardization. The raw action data is converted into mineable behavior sequences, and frequent behavior sequences are mined using the PrefixSpan algorithm. The phased patterns of college students' motor skill learning are extracted, and the core behavioral characteristics of different learning stages are clarified; Next, based on the mined behavioral sequence features, an error pattern recognition model is constructed, and combined with the support vector machine (SVM) algorithm, the error action sequence is classified and recognized to clarify the characteristics and manifestations of different error patterns; Finally, the effectiveness of the research method is verified through experiments, and the recognition accuracy and efficiency of the proposed method are compared with traditional manual recognition methods. The application value of learning rules and error patterns is analyzed, and targeted teaching optimization strategies are proposed.

The analysis basis of this article mainly includes three aspects: firstly, the theory of motor skill learning, drawing on closed-loop control system theory and cognitive psychology theory, clarifying the stage characteristics of motor skill formation, and providing theoretical support for mining learning laws; The second is the principle of behavior sequence mining technology, which relies on sequence mining algorithms such as PrefixSpan to effectively mine and analyze learning behavior sequences; The third is experimental data support, collecting first-hand data on college students' motor skill learning through field experiments to ensure the scientific and reliable nature of research conclusions. The scope of this article focuses on the exploration of patterns and recognition of errors in the learning of sports skills among college students. The research results can be extended to the teaching practice of various common sports skills among college students, providing support for the improvement of the quality of physical education teaching in universities.

II. RELATED WORK

In recent years, research on learning patterns and error pattern recognition based on behavior sequence mining has gradually become an important direction in the fields of educational technology, sports science, and personalized behavior prediction. Scholars have explored the topic of "Learning patterns and error patterns of college students' motor skills based on behavior sequence mining" from different perspectives. Chang et al. [1] proposed a privacy enhanced frequent sequence mining and retrieval method for privacy protection in personalized behavior prediction, aiming to address the privacy leakage risk of behavior data during sequence mining and improve the practicality and security of prediction models. Prakash and Rajendran [2] aimed to reveal the behavioral patterns of learners in virtual reality education, and combined cognitive network analysis and differential sequence mining to decode the behavioral trajectories of learners in VR environments, in order to solve the problem of traditional methods being difficult to capture complex behavioral sequence structures.

Kelly and Carter [3] focused on the impact of new media on the prevention and treatment skills of sports injuries among college students, and proposed a skill enhancement strategy based on new media intervention, attempting to solve the problem of low information transmission efficiency in the process of sports skill learning. Sun and Espeso

[4] focus on the transformation of teaching practices and 21st century skill development for teachers in Chinese sports colleges, proposing a path to transform teaching concepts and methods to address the dilemma of traditional teaching models being unable to meet the comprehensive development needs of students. Hussein [5] designed a ground tennis physical ability and basic skill model based on emotional characteristics for female students, attempting to solve the problem of neglecting individual emotional differences in skill training. Al Nedawi, Al Nedawi, and Yass [6] proposed a training method to improve the basic skills of handball through visual tracking exercises, aiming to solve the problem of insufficient visual attention and coordination of movements in students' skill learning.

Hassan, Hussein, and Tahir [7] explored the contribution of psychological motivation to the acquisition of basic volleyball skills knowledge and proposed motivational strategies to address the problem of cognitive behavioral disconnect in skill learning. Alrazaq and Baseem [8] proposed the application of the Bransford model in the cultivation of critical thinking skills based on cognitive development level, attempting to solve the problem of mismatch between students' cognitive level and skill learning objectives. Lahinda and Riyanto [9] proposed an interactive learning model for cognitive enhancement through the empowerment of physical education based on interactive media technology, aiming to solve the problem of insufficient technology integration in traditional physical education teaching. Ahsan [10] explored the application of modern technology in the process of physical education teaching and learning, and proposed a practical framework for technology integration to address the problems of single technological means and insufficient data collection in physical education teaching.

Overall, the above-mentioned scholars have conducted preliminary research on behavior sequence mining and pattern recognition in college students' motor skills learning from the perspectives of privacy protection, VR behavior decoding, new media intervention, teaching transformation, emotional modeling, visual training, psychological motivation, cognitive development, interactive media, and modern technology integration. They have proposed their own models, methods, or strategies. However, there are still some shortcomings in current research: most studies focus on the impact of a single dimension (such as emotion, cognition, or technology) on skill learning, lacking systematic mining and analysis of the complete behavioral sequence during the learning process; There is still a lack of dynamic and quantifiable recognition mechanisms based on behavioral sequence data for identifying error patterns; In addition, there are significant differences in methods between different studies, and there is a lack of a unified sequence analysis framework, making it difficult to achieve cross situational comparison of learning patterns and induction of error patterns. Therefore, how to combine frequent sequence mining and differentiated sequence analysis to systematically identify typical behavioral paths and common error patterns in college students' motor skill learning while ensuring privacy remains a key issue that urgently needs to be addressed in current research.

III. METHOD

A. DATA COLLECTION AND PREPROCESSING OF DYNAMIC SKILL LEARNING BEHAVIOR

Data collection is the foundation of research (as shown in Figure 1), aimed at obtaining complete behavioral sequence data of college students during their learning of motor skills, ensuring the authenticity, completeness, and representativeness of the data. Firstly, determine the research subjects and skill types, select 300 college students from a certain university as the research sample, covering different sports foundations (zero foundation, average foundation, good foundation), including 180 male students and 120 female students, aged between 18-22 years old; Selecting basketball shooting and soccer shooting, two common sports skills among college students, as research carriers, these two skills have clear action processes and typical types of errors, which facilitate data collection and analysis. This study was approved by the Ethics Committee of Guangzhou College of Commerce, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

Secondly, design a data collection plan that adopts a multi-channel collection method of "motion capture devices+video recording+manual recording": Precise kinematic data, including 14-segment joint angles and center-of-mass trajectories, were collected using an OptiTrack Prime 13 optical motion capture system (8-camera setup) with a sampling frequency of 60Hz. The system was calibrated to a residual mean error of <0.50mm. Simultaneously, motion videos were recorded using two Sony Alpha 7 IV cameras (1080p, 60fps) positioned at 90-degree sagittal and frontal planes. Manual recording and calibration were performed by three physical education experts with over 10 years of coaching experience, with an inter-rater reliability (Cohen's Kappa) maintained above 0.85 [11].

Data preprocessing aims to eliminate noise and redundancy in raw data, convert it into standardized data that can be used for sequence mining, and is divided into three steps: first, data cleaning, removing abnormal data caused by motion capture device failures, video blurring, and manual recording errors, and filling in missing values (using linear interpolation); The second is data standardization, which converts continuous data such as joint angles and motion trajectories into a unified scale, and uses the Min Max standardization method to map the data to the [0,1] interval, eliminating the influence of dimensionality; The third is sequence construction, which arranges the preprocessed action data in chronological order based on a single skill practice, and constructs a sequence of motor skill learning behaviors for each research object. Each sequence contains feature data for the start, process, and end stages of the action, and

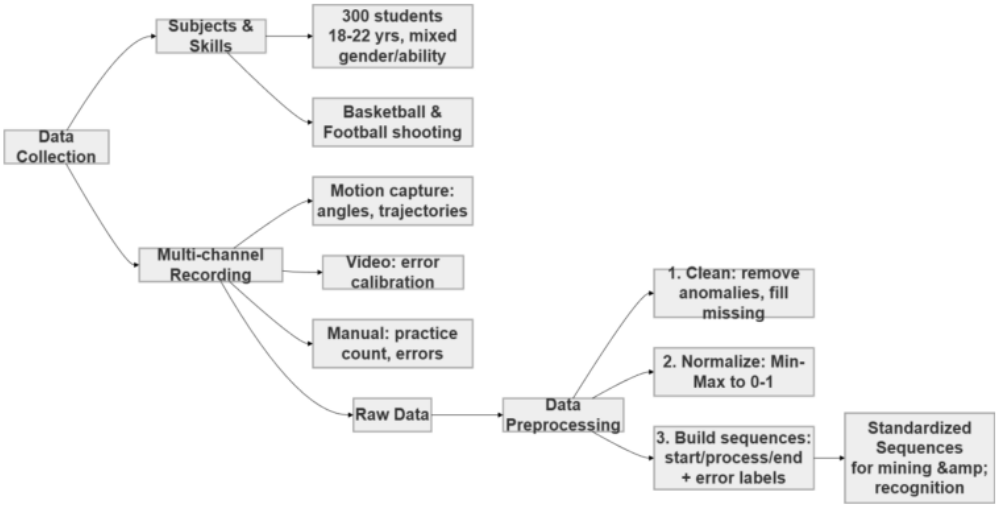

FIGURE 1. Data Collection and Preprocessing of Sports Skill Learning Behavior

is labeled with error action labels, laying the foundation for subsequent pattern mining and error recognition.

B. MINING THE LEARNING PATTERNS OF SPORTS SKILLS BASED ON THE PREFSPAN ALGORITHM

This article uses the PrefixSpanPrefixSpan algorithm to mine the rules of motor skill learning (as shown in Figure 2). The algorithm adopts a projection based depth first search paradigm, which does not require generating a large number of candidate sequences and can effectively improve mining efficiency. It is suitable for processing large-scale behavior sequence data and naturally supports the discovery of frequent sequences, which is in line with the temporal characteristics of motor skill learning behavior sequences.

The specific implementation steps are as follows: Firstly, determine the mining parameters, and based on research needs, Based on pre-experimental sensitivity analysis and the average duration of a single shooting cycle, the minimum support degree was set to 15%. Testing thresholds from 5% to 25% revealed that 15% provided the optimal balance between filtering noise and capturing significant behavioral transitions. The maximum sequence length was set to 10 to correspond with the key kinematic phases (preparation, execution, and follow-through), ensuring that mined sequences were long enough to be meaningful but short enough to avoid computational redundancy; Secondly, construct a behavior sequence database, import the preprocessed behavior sequences of all research subjects into the database, and store them classified by sports foundation and skill type; Then, the PrefixSpanPrefixSpan algorithm is used for frequent sequence mining. By recursively constructing prefix sequences and their corresponding projection databases, the frequent behavior sequences of college students with different learning stages and sports foundations are mined to extract common patterns and individual differences; Finally, the frequently mined sequences are analyzed and combined with the theory of motor skill learning to divide skill learning into three stages: cognition, connection, and automation. The core behavioral characteristics of each stage are clarified, revealing the dynamic laws of college students' motor skill learning, such as frequent erroneous action sequences in the cognitive stage and action connection sequences in the connection stage [12].

C. CONSTRUCTION OF SVM BASED MODEL FOR RECOGNIZING MOTOR SKILL ERROR PATTERNS

On the basis of mining learning patterns (as shown in Figure 3), an error pattern recognition model based on support vector machine (SVM) is constructed to achieve accurate recognition and classification of error patterns in the process of college students' motor skill learning [13]. Firstly, extract the features of erroneous behavior sequences, and combine them with the frequent erroneous sequences mined by the PrefixSpan algorithm to extract core features such as action trajectory deviation, joint angle abnormality, and force timing disorder. Construct feature vectors as inputs to the model; Secondly, divide the behavior sequence data into a training set (for model training) and a testing set (for model validation) in a 7:3 ratio. The training set contains the behavior sequence data of 210 research subjects, while the testing set contains the behavior sequence data of 90 research subjects; Then, an SVM error recognition model is constructed, and radial basis function (RBF) is selected as the kernel function. The model parameters (penalty coefficient C and kernel function parameter γ) are optimized through cross validation to minimize the classification error of the model; Finally, the model is trained and validated by inputting the training set feature vectors into the model for training. The recognition accuracy, recall rate, and other indicators of the model are verified through the test set data. At the same time, the model is optimized by combining manual annotation results to ensure that the model can

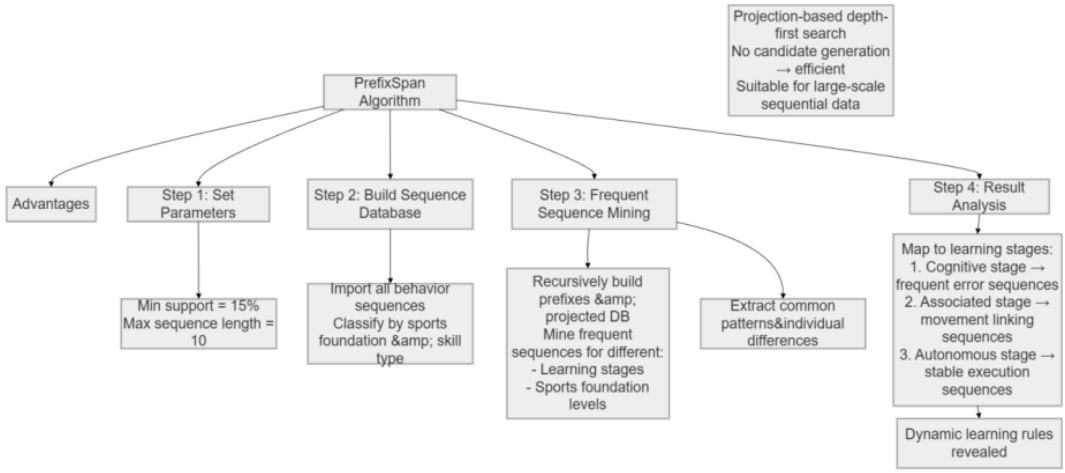

FIGURE 2. Construction of Error Pattern Recognition Model for Sports Skills

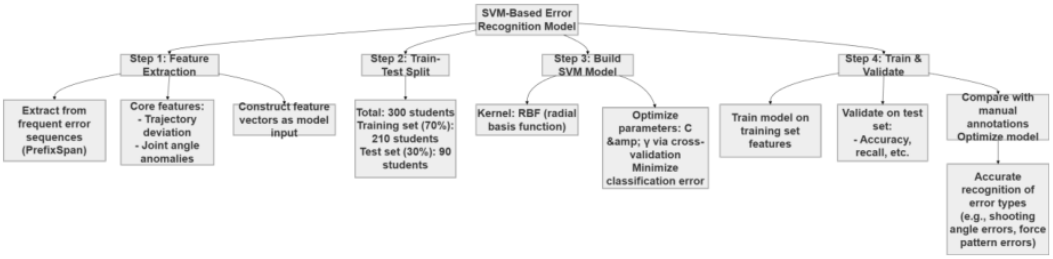

FIGURE 3. Construction of Error Pattern Recognition Model for Sports Skills

accurately identify different types of error patterns (such as incorrect shooting angles for basketball shots, incorrect throwing methods for football shots, etc.) [14].

IV. RESULTS AND DISCUSSION

A. RESULTS AND ANALYSIS OF THE EXPLORATION OF THE LEARNING PATTERNS OF COLLEGE STUDENTS' SPORTS SKILLS

By using the prefix span algorithm and combining it with the theory of sports skill learning, the phased patterns of college students' sports skill learning have been successfully revealed, and there are significant differences in the learning patterns of college students with different sports foundations. To track the full evolutionary process from cognition to automation, 'good foundation' students in this study refer to those who have mastered basic postural requirements but are learning specific advanced shooting techniques (e.g., three-point shooting or moving shots) for the first time. In the cognitive stage, the sequence patterns followed a trajectory of: [Observation → Demonstration → Imitation → Repeated Execution → Interruption (Stuttering) → Error Adjustment]. Among them, the frequency of erroneous action sequences of students with zero foundation (38.6%) was significantly higher than that of students with good foundation (12.3%), who benefited from positive motor skill transfer despite being in the initial cognitive phase of the new specific task.

The main errors were concentrated in unclear action essentials and disordered timing of force application, which is consistent with the characteristics of the cognitive stage of motor skill learning, that is, students form preliminary action representations through observation demonstration, and the neural processes are in a generalized state, with more redundant and erroneous actions; In the contact stage, the frequent behavior sequence is manifested as "action coherence local error feedback adjustment action optimization". The frequency of action coherence sequence for students with average foundation (27.9%) is higher than that of students with zero foundation (18.7%), indicating that students with good foundation can integrate action links faster and reduce unnecessary actions; In the automation stage, the frequent behavior sequence of students with good foundation is characterized by "smooth action precise completion slight adjustment", with an error sequence frequency of less than 8%. However, students with zero foundation still have many action deviations, making it difficult to achieve automated completion of actions.

In addition, research has found that there are significant individual differences in the learning of motor skills among college students. Female students have a slower

learning speed in motor coordination and detail control than male students, but have a higher enthusiasm for error correction than male students; There are also differences in the learning patterns of different skill types. The learning cycle of basketball shooting skills (average 4.2 weeks) was observed to be shorter than that of football shooting skills (average 5.7 weeks). This discrepancy is attributed to the difference in the Degrees of Freedom (DoF) involved in the primary kinetic chains of the two tasks; basketball shooting primarily focuses on upper-limb coordination and vertical force transfer, whereas football shooting requires complex dynamic balance on a single supporting leg combined with multi-segmental lower-limb coordination. These additional biomechanical constraints in football may lead to a more prolonged cognitive and associative phase compared to the specific basketball tasks studied. The above results indicate that the PrefixSpan algorithm used in this article can effectively explore the stage patterns and individual differences of college students' sports skill learning, providing accurate data support for personalized teaching guidance, and also confirming the applicability of the stage theory of sports skill learning in college students.

B. RESULTS AND ANALYSIS OF PATTERN RECOGNITION OF MOTOR SKILL ERRORS

The verification results of the SVM based error pattern recognition model show that the model has a recognition accuracy of 91.8%, a recall rate of 89.2%, and an F1 value of 90.5% on the test set, which is significantly higher than baseline models including Random Forest (accuracy 84.1%) and Gradient Boosting (accuracy 86.5%). Furthermore, it outperformed traditional manual recognition (accuracy 72.3%). The manual baseline was established by three senior sports coaches who evaluated synchronized video feeds without algorithmic assistance; their assessment served as the ground truth after resolving discrepancies through a majority vote. These results indicate that the SVM model, optimized with RBF kernels, provides superior precision for complex behavior sequences.

Through model recognition and manual calibration, six typical error patterns for college students' basketball and football shooting skills were identified. Typical errors were operationalized as follows: 'Angle deviation' in basketball was defined as an elbow flexion or release angle deviating $> \pm 5^{\circ}$ from the individual's established optimal range. 'Body imbalance' was quantified by a center-of-pressure (CoP) shift exceeding 15% of the base of support. For football, 'incorrect support foot positioning' was defined as the plant foot being more than 20cm away from the ball laterally or longitudinally. 'Insufficient force' was categorized by a terminal joint velocity 25% lower than the successful attempt mean. Further analysis revealed significant differences in error patterns across different learning stages: in the cognitive stage, fundamental errors were predominant (such as deviation in hand angle and incorrect stance of the supporting foot), accounting for 67.8%; The contact stage is mainly characterized by errors in the connection of actions (such as disordered timing of force application and stuttering of actions), accounting for 52.3%; The automation stage is mainly characterized by minor errors in details (such as slight angle deviation and uneven force application), accounting for 71.5%. At the same time, there are differences in the distribution of error patterns among college students with different sports foundations. Students with zero foundation mainly make basic errors, while those with better foundation mainly make detailed errors, which is consistent with the results of learning pattern mining. In addition, the consistency between the error patterns identified by the model and the manually annotated results is high (Kappa value=0.87), indicating that the model has strong stability and reliability, and can provide accurate support for timely correction of erroneous actions.

C. DISCUSSION AND IMPLICATIONS OF RESEARCH RESULTS

Based on the above experimental results, this article further explores the inherent correlation between the learning patterns and error patterns of college students' sports skills, as well as the implications of the research results for university physical education teaching. From the perspective of learning patterns, the stage specific characteristics of college students' sports skill learning are significant, and there are obvious differences in the behavioral sequences of cognition, connection, and automation stages. This is consistent with the sports skill control theory proposed by Adams, Schmidt, and others, indicating that college students' sports skill learning follows the universal rules of skill formation, but there are also individual and skill type differences. This requires physical education teaching to abandon the "one size fits all" model and focus on personalized guidance. From the results of error pattern recognition, the SVM recognition model constructed in this article can effectively compensate for the shortcomings of traditional manual recognition, achieve accurate and efficient recognition of error patterns, and solve the problem of strong subjectivity and low efficiency in error recognition in traditional teaching.

The phased distribution characteristics of error patterns indicate that the teaching focus should be different in different learning stages: in the cognitive stage, emphasis should be placed on action demonstration and essential explanation to reduce the occurrence of fundamental errors; During the contact phase, attention should be paid to training and feedback adjustment of action coordination to correct errors in action coordination; During the automation phase, attention should be paid to optimizing details, reducing errors in details, and improving the accuracy of skills. In addition, the research results also reflect the problems existing in current university physical education teaching: some teachers have failed to develop differentiated teaching plans based on students' learning stages and physical education foundations, and the recognition and correction of incorrect

movements are not timely and accurate enough. Based on this, this article proposes the following teaching inspirations: firstly, combining learning laws, designing teaching content and methods in stages to adapt to the needs of students at different learning stages; The second is to introduce motion capture and error recognition technology to assist teachers in achieving accurate recognition and timely correction of erroneous movements; The third is to pay attention to individual differences among students, develop personalized teaching plans, and enhance the pertinence and effectiveness of teaching. Meanwhile, the method proposed in this article can also be applied to the teaching practice of other sports skills, providing technical support for the reform of university physical education teaching.

V. CONCLUSION

This article focuses on the learning rules and error pattern recognition of college students' sports skills. With behavior sequence mining technology as the core, combined with sports skill learning theory and machine learning algorithms, a complete research framework is constructed. The effectiveness of the research method is verified through experiments, which solves the problems of insufficient dynamic rule mining and low error recognition accuracy in traditional research. The study concludes that the learning of sports skills by college students follows a phased pattern of cognition, connection, and automation. There are significant differences in the behavioral sequence characteristics of different learning stages, and sports foundation, gender, and skill type have a significant impact on learning patterns; Based on the PrefixSpan algorithm, frequent behavior sequences of college students' motor skill learning can be effectively mined, and learning patterns can be accurately extracted; The SVM based error pattern recognition model can achieve accurate recognition of typical error patterns with an accuracy rate of 91.8%, which can effectively support timely correction of erroneous actions.

There are also shortcomings in this article, as the sample only selected college students from one university, the research scope is limited, and the universality of different sports projects has not been considered. In the future, the sample scope can be expanded to explore the learning rules and error patterns of different sports projects, and optimize the universality of the recognition model. The theoretical value of this article lies in the deep integration of behavior sequence mining technology and research on motor skill learning, enriching the research methods and theoretical system of motor skill learning; The practical value lies in providing precise legal support and technical tools for university physical education teaching, which helps optimize teaching modes, improve teaching effectiveness, promote the development of university physical education teaching towards refinement and individualization, and provide guidance for the efficient learning of sports skills for college students.

AUTHOR CONTRIBUTIONS

Yingqi Fan designed, collected and analyzed the data, and drafted the manuscript. Yingqi Fan conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Yingqi Fan participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

FUNDING

This research received no external funding.

ACKNOWLEDGEMENTS

Not applicable.

HUMAN RESEARCH SUBJECTS

This study was approved by the Ethics Committee of Guangzhou College of Commerce, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

REFERENCES

[1] S. Chang, Z. Shi, F. Xiao, et al., Privacy-Enhanced Frequent Sequence Mining and Retrieval for Personalized Behavior Prediction. Information Forensics and Security, IEEE Transactions on. vol. 19, no. 000, pp. 4957-4969, 2024. doi: 10.1109/TIFS.2024.3391928

[2] A. Prakash and R. Rajendran, Decoding Learner Behavior in Virtual Reality Education: Insights from Epistemic Network Analysis and Differential Sequence Mining. Visualization and Computer Graphics, IEEE Transactions on. vol. 31, no. 5, pp. 2675-2683, 2025. doi: 10.1109/TVCG.2025.3549899

[3] I. Kelly and E. Carter, New media's influence on college students' sports injury prevention and treatment skills. Cambridge Sport Science. vol. 2024, no. 3, pp. 21-27, 2024. doi: 10.62852/css/2024/79

[4] B. Sun and L. A. Espeso, The Transformative Teaching Practice of Teachers and Cultivation of 21st Century Skills of College Students in Selected Sports Universities in China. International Journal of Education and Humanities. vol. 16, no. 2, pp. 296-299, 2024. doi: 10.54097/zvf61b89

[5] R. D. Hussein, Designing a model for physical abilities and basic skills for ground tennis according to the emotional characteristics of female students of the College of Physical Education and Sports Sciences. International Journal of Physiology, Health and Physical Education. vol. 6, no. 2, pp. 06-11, 2024. doi: 10.33545/26647265.2024.v6.i2a.65

[6] O. I. Al-Nedawi, R. I. Al-Nedawi, and H. A. Yass, The impact of visual tracking exercises on improving some basic handball skills among students at the college of physical education and sports sciences, Al-Mustansiriya University. International Journal of Sports, Exercise and Physical Education. vol. 6, no. 2, pp. 160-163, 2024. doi: 10.33545/26647281.2024.v6.i2c.120

[7] T. R. Hassan, K. A. Hussein, and M. A. Tahir, The contribution of the mental motivation in knowledge achievement of some basic skills in volleyball for the students of the second stage in the college of physical education and sports sciences University of Diyala. Mustansiriyah Journal of Sports Science. vol. 1, no. 2, pp. 280-298, 2024. doi: 10.62540/mjss.2019.01.02.453

[8] T. A. Alrazaq and J. Baseem, The effect of the Bransford model according to the cognitive levels of cognitive development on the development of critical thinking skills among students of the second academic year at the College of Physical Education and Sports Sciences at the University of Mosul. Al-Rafidain Journal For Sport Sciences. 2023; 26(83 suppl): 44-59. doi: 10.33899/rjss.2023.182960

[9] J. Lahinda and P. Riyanto, Cognitive Improvement Of Students Through Empowerment Of Physical Education Technology Based On Interactive Gysternal Learning Media. Journal of Physical and Outdoor Education. vol. 4, no. 2, pp. 195-204, 2022. doi: 10.37742/jpoe.v4i2.174
[10] M. Ahsan, The Use of Modern Technology in Physical Education Teaching and Learning Process. International Journal of Sports and Physical Education. vol. 10, no. 1, pp. 14-16, 2024. doi: 10.20431/2454-6380.1001003
[11] L. Lu, The Transformative Impact of AI Technology on Physical Education. Journal of Higher Education Teaching. vol. 1, no. 5, pp. 309-314, 2024. doi: 10.62517/jhet.202415550
[12] T. Ha, Using Technology to Promote School-Based Physical Activity: Beyond the Physical Education Classroom. Journal of Physical Education, Recreation & Dance. vol. 95, no. 1, pp. 51-53, 2024. doi: 10.1080/07303084.2023.2273225
[13] E. V. Bogdanovskaya and A. V. Andreichenko, The use of technology in physical education of students: prospects and challenges. Scientific and educational basis in physical culture and sports. vol. 13, no. 1, pp. 10-14, 2024. doi: 10.57006/2782-3245-2024-13-1-10-14
[14] J. Krause, T. Ha, and B. Dauenhauer, Facilitating Alternative Assessment with Technology in Physical Education. Strategies. vol. 35, no. 2, pp. 36-39, 2022. doi: 10.1080/08924562.2022.2031379