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Article

Research on optimization and design of sports teaching actions based on biomechanics

Xiaojing Yang[1,*], Sunkai Qi[2]

[1] School of Physical Education, Shanxi Vocational University of Engineering Science and Technology, Jinzhong 030619, China
[2] College of Physical Education, Anhui Agricultural University, Hefei 230036, China
*** Corresponding author:** Xiaojing Yang, yangxj0351@163.com

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Abstract: The design of sports teaching approaches is an important part of improving athletic performance and skill development among players. As sports grow more competitive, the demand for new and effective teaching methods has never been higher. The limitations of conventional coaching techniques sometimes depend on anecdotal evidence and subjective assessments, which provide inconsistent outcomes for training. The purpose of this study is to enhance athletic performance and reduce injury risks by developing sports teaching actions based on biomechanics. The proposed novel chaos sparrow search fine-tuned efficient random forest (CSS-ERF) employed the relationship between biomechanical parameters and performance outcomes. Biomechanical data was gathered from athletes utilizing wearable sensors and motion capture technologies as they performed several sports-related activities. The data preprocessing will be cleaned to remove noise and outliers from the dataset. Ground Reaction Forces (GRF) are used to extract key features relevant to performance and injury risk from the preprocessed data. Findings show that training strategies and athlete performance have significantly improved, and the CSS-ERF model has demonstrated a high degree of accuracy in forecasting the best biomechanical configurations with an $F1$ value of 0.984, accuracy of 0.989, recall of 0.985, and precision of 0.986. By offering an innovative approach to enhancing sports actions through biomechanical insights and promoting a greater comprehension of movement mechanics and their impact on athletic performance, this research advances the area of sports science.

Keywords: sports teaching; actions; biomechanics; chaos sparrow search fine-tuned efficient random forest (CSS-ERF)

1. Introduction

Sports biomechanics is a physics-based field of today's study. It attempts to methodically examine several measures of human physical capacity in sports by applying cutting-edge science. Sports biomechanics uses complex motor systems in mathematics called dynamics, which accurately represent the body's motor functions and make it easier for people to analyze biomechanics in sports. Sports mechanics is becoming a commonly employed analytical technique in exercise training due to society's constant advancement, and it is essential to the growth of contemporary sports. Sports instructional actions include all of the tactics and approaches teachers use to help students learn and improve their physical education skills. These activities have a critical role in developing students' motor abilities, encouraging collaboration, and enhancing their overall health. In addition to improving athletic ability, good sports education instills in pupils valuable life lessons like self-control, tenacity, and teamwork [1]. Teachers in traditional classrooms typically direct students' movements. As a result, students are aware of the motions they should do but are unable to comprehend the rationale behind them. The evaluation method considers the multifaceted comprehensive assessment to build information-based instruction that emphasizes application, and foundation, and improves tracking. The intended teaching approach is intended to serve as a teaching reform guide for physics, biomechanics, and related courses. It also offers recommendations for developing applied skills [2]. The motion of humans is a precise series of movements involving several joints that follow a set pattern and timing that is distinct for each individual and grows into a phenomenon that is one-of-a-kind and non-repeatable. To complete tasks, the timing and sequencing have been incorporated and based on muscle synergies. Because these morphological and physiologic structures deal with how the human body responds to outside forces, they have applicable references in static electricity and kinematics. Athletic biomechanics is a subfield of applied kinematics whose main objectives are injury prevention, efficient training method creation, and athletic technique improvement through study and evaluation of experienced athletes' motions [3]. The enlargement and control of degrees of independence by the three processes of elimination, exploration, and capitalization would be associated with the improvement of skills. To elucidate using academic research along with educational and emotional persuasive deductions, the close connection among the processes that lead up to the degree of acquisition. This constitutes developmental motor skills fundamental to comprehend the methods and the mode of performance of a motor movement, which is of biological interest. The benefits and drawbacks of employing models for simulation are discussed in Conceptual Research, with instances spanning a variety of sports and intricate models. While this part will undoubtedly be insufficient, a commitment is made under Particular Sports to provide some sense of all the knowledge acquired in sports techniques [4]. Sport kinematics is a field of applied biological mechanics, where the key goals are to enhance sports tactics by examination and analysis of experienced entertainers' motions, devise efficient education methods, and limit the risk of injury. Bridging the gap between professionals and academics is one of the main goals of the International Societies of Biomechanics in Sports (ISBS). Using portable electronics, such as mobile devices such as tablets and smartphones, has become among the greatest common uses of information and communication technologies (ICTs) [5]. Students attending college frequently use mobile devices like tablets and cell phones. Studies of social media as a teaching tool have a favorable effect on learning studies, indicating that social media could enhance classroom atmosphere regardless of the location of the educational setting, as well as student learning, emotional learning, and creativity. The purpose is to measure the shift in perceptions among students regarding the usage of this platform as an instructional tool for qualitative biological analysis that is part of a higher education sports science program. To study knee joint damage, it is useful to know which portion of a muscle or muscles contribute to the movements of multiple muscles determined during the exercise, as well as the duration and level of expansion of each muscle determined in the exercise that finishes the organized work of all of the muscles in an identical scientific action [6]. It is hypothesized that after completing the assigned task, using Instagram would improve their perceptions. It has been an important topic in the profession of sports biological processes and determining sports abilities which are the distinctions in anatomy and structure among elite athletes and ordinary citizens. The public is more receptive to projects that allow for simple adjustments to the exercise burden. People from various areas of life are drawn to the sprinter movement because of its distinct benefits and fitness ideals [7]. The joint of the knee is the most susceptible, and athletes frequently suffer varying degrees of injury. Therefore, it is difficult to have a running motion without both contracted muscles and relaxation. No rapid connectivity sprinting is possible without regular alternating exercises of tense muscles and relaxing. The differences in torque produced about the longitudinal axes of the user's knee have been calculated from changes in foot position [8]. There are two types of models for the knee joint: Quantitative and physical. The theoretical model is further broken down into phenomena and anatomical models. The most often used physical representation to explain the movement of the thigh joint is a traversed four-bar connection. When the knee was bent, positive knee experiences were found in every situation. The entire action sequence is computed using the muscle in question activation characteristics. The population is more receptive to projects that allow for simple adjustments to the exercise burden. People from various areas of life are drawn to the sprint revolution because of its distinct benefits and fitness ideals. Certain dynamics investigations are restricted to analyzing ground response forces using dynamometers to assess specific aspects of motion innovation and the results of mobility approaches [9]. The increasing prevalence of these devices in educational settings has demonstrated their potential to be an excellent learning aid. The hypotheses of motor learning along with the different research methodologies will be cited to comprehend the elements, both external and internal, as well as the pharmacological and cognitive processes that result in the incorporation of motor abilities. The solution to this issue would be to reduce the extent of autonomy needed to concentrate on the key components of the exercise by preserving the non-essential portions during the early phases of skill development [10]. The objective of this study is to improve sports education practices by utilizing physiological concepts to maximize efficiency and minimize the likelihood of injuries. This entails examining patterns of movement and determining efficient teaching methods that complement kinematics to enhance athletes' effectiveness and ability to learn new skills. The ultimate objective is to develop a framework that enhances training results by incorporating biomechanics insights into athletics instruction.

Contribution of the study:

- Biomechanical Optimization: Implements biomechanics to enhance the efficiency and effectiveness of sports teaching actions.
- Injury Prevention Framework: Develop strategies for minimizing injury risks by improving movement techniques.
- Advanced Model Development: Introduces novel models for evaluating and optimizing sports actions based on biomechanical principles.

Organization for the study: Part 2 comprises the related works; Part 3 introduces the methodology technique; Part 4 analyzes the study's results; Part 5 offers a discussion, and Part 6 concludes the study.

2. Related work

Sports physiology was an applied field with a solid theoretical foundation. It served as a tool for the analysis of physical activity across several nations and was extremely important for the advancement of sports science and competitive sports [11]. Additionally, deploy a novel wireless transmission surface Electromyography (EMG) tester in the classroom setting as a learning aid for practical instruction. This tester allowed to gathering web surfing information for online courses and facilitated real-time contact between instructors and students. The teachers apply focused tailored education, contributing to the enhancement of students' learning abilities and fundamental traits. The human body's architecture has an impact on biomechanical motions, which were frequently investigated through the use of innovations that disrupt dynamics. As a result of Di Domenico [12], dynamics was ignored and biomechanics was reduced to statics and kinematics. Stress responses and personal decision-making processes impact the dynamic foundation of movement laws. Incorporation of mechanical stability information can aid in the assessment and management of issues about human mobility, but their successful implementation necessitates additional education and training. All things considered; biomechanical gains were essential to human existence [13]. The model was utilized for module validation, and specialists in the fields of substance, media, and communication gave the module high marks. Ninety students participated in the trial, and sixty percent said the product was useful. The usefulness of the module in the educational process was demonstrated by a regression analysis with a 54.1% factor of commitment, which shows that student answers strongly impact conceptual knowledge. The supports for sports biomechanics research programs were reviewed with an emphasis on electromechanical data and feedback loops. The athlete classification, inter-individual motion variability, and conventional motion models [14]. Motion-decision criteria for individual segment enrollment were also covered in the article. To close the knowledge gap between scholars and practitioners, it suggested conducting additional studies in the field of sport biophysics. Sport meteorology was advised to investigate the biomechanical concepts of human movement, comprehend instructional and educational aspects, and take part in techniques and athletic enhancement.

The examination of Newtonian mechanics and the physical properties of the human body was known as biomechanics [15]. The prerequisites in algebra, geometry, trigonometry, and physics could be difficult for college students majoring in kinesiology. Students integrate their knowledge with real-world situations as they work in small groups on completing five laboratory assignments and a final project. The method sought to enhance the abilities of learners to think critically as well as their proficiency with data collecting, processing, and analysis. Analyzing a special activity to avoid harm or improve efficiency was the final project. Sports mechanics use physics and physiological functions to study the technical regulations of sports. The mobility of the human body was difficult to simulate, and the modeling techniques used today are insufficient [16]. Muscle strength and bone force were predicted using straightforward mechanical stability measurements and a model of the bone-muscle system. The findings indicated that the average adduction and external rotation angles were approximately equal when the knee flexion angle was approximately 90 degrees and that females had somewhat higher interior and external rotation than males. For modern conditioning and the advancement of technology, strategies, and tournaments, sports biomechanicals were essential.

Although the use of biomechanical feedback technology in top athletic training was growing, it was indeed uncertain how beneficial these technologies would be in enhancing athletic results and technique [17]. The identification of athlete-specific optimal approaches was a challenging task due to the limited information regarding controlling and coordinating patterns provided by conventional quantitative and mathematical modeling paradigms. Alternatively, movement and kinetic data were used to lead competitors towards their own 'optimum' pattern of movement and control. This method was in line with the ideas of constantly changing systems analysis and Bernstein's research on skill learning. The goal [18] of sports biomechanics was to digitally reproduce essential characteristics by studying movements that were mechanical in biological movement. There was a dearth of new technologies for digital modeling and data measurements, and research concentrates on theoretical concerns. The simulation's outstanding performance was validated by system testing, and the system architecture was designed to increase the efficiency of data transfer, which might be a resource for scholars investigating sports biomechanics.

Due to the growing need for sports reconstruction, sports rehabilitation biomechanics was a prominent specialty in colleges and universities [19]. Teaching subjects have certain difficulties, though, such as identifying human motions in medical images. A novel technique called multi-feature medical image fusion can preserve original image information while removing unnecessary information. The research offered a support vector machine (SVM) technique constructed to transform the operating system operation for quicker and more precise motion recognition using conventional Chinese medical images. To investigated the mechanical equations that result from biological mobility was known as sports physical education [20]. Its main goal was to digitally and methodically recreate the essential qualities and traits of motion that use the badminton chopped motion as an investigation object and use genetic algorithms and edge computing to conduct biomechanical game design and simulator studies. The study would serve as a resource for academic circles looking to delve more into sports biometrics.

3. Methodology

This section presents data gathering, data preprocessing using noise removal to enhance athletic performance, feature extraction using ground reaction forces to reduce injury risks, and a novel chaos sparrow search fine-tuned efficient random forest (CSS-ERF) strategy for sports teaching actions as shown in **Figure 1**. A thorough methodology that integrates both quantitative and qualitative methods of research is used to examine sports teaching acts. Standardized tests of student achievement and participation, organized conversations with teachers, and personal evaluations of instructional techniques are a few examples of data collection techniques. This comprehensive method seeks to assess how well different teaching techniques improve students' sports skills and create an encouraging learning atmosphere.

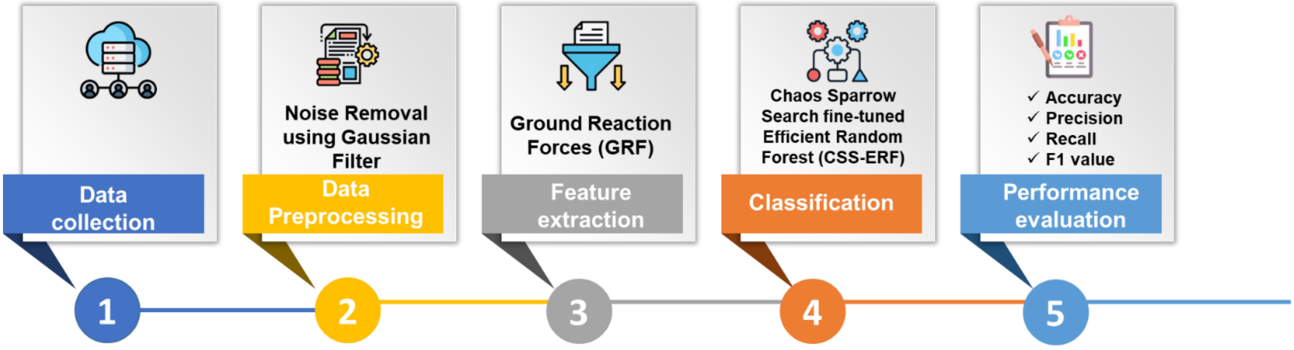

Figure 1. Flow of methodology.

3.1. Data collection

The use of these cutting-edge technologies improves data collection accuracy while offering insightful information on how to best instruct athletes and avoid injuries. For further analysis and model construction in biomechanics, the dataset remains an important source. The biomechanical analysis involved in this study is to objectively assess and optimize athlete's movement proficiency during complex movement in sports activities, focusing on the forces and dynamics involved in sports activities. The 150 athlete's datasets were collected during different activities using wearable sensors and motion capture technologies. The athletes engaged themselves in different athletic events, which enabled the accurate assessment of movement data.

3.2. Data preprocessing using gaussian filter

Sports educational actions incorporate all of the activities and procedures used by trainers and coaches to teach sportsmen various sports. All these drive training effectiveness initiatives underpin skill development, performance enhancement, and safe working practices to prevent injury. They do this by using biomechanical concepts. By reducing deviations and noise from the dataset, data preparation is essential to improving the quality of biomechanics analysis. Image de-noising approaches are very pertinent here since they use different ways of filtering to remove unwanted signals from biological images without sacrificing their quality. Using the best filtering approaches, noise can be detected and reduced by utilizing neighboring knowledge and sophisticated algorithms. This procedure improves the smoothness of the images captured for analysis while maintaining their quality, resulting in assessments of sports instruction activities that are more accurate.

Creating and optimizing biomechanics-based sports instruction activities is useful when Gaussian noise, is frequently called unpredictability impulsively or enhancement noise. There are several origins of this kind of noise, such as electrical circuit vibration, sensor activity from high environments, and detector noise from insufficient lighting. It is a type of statistical noise with a Gaussian distribution-like probabilistic density function (PDF). It is important to comprehend how Gaussian noise affects motion capture data; it has an impact on the precision of biomechanical assessments and, in turn, the effectiveness of sports instruction approaches are denoted in Equation (1).

$$O(y) = \frac{1}{\sqrt{2\pi}\sigma} f^{\frac{-(y-\mu)^2}{2\sigma^2}} \quad (1)$$

3.3. Feature extraction using ground reaction forces (GRF)

Enhancing the effectiveness of training and athlete efficiency is the goal of this study, which uses technology like motion capture to analyze mobility biomechanics. Creating strategies based on data that support healthier and more effective sports instructional techniques is the aim. One common way that movement data is represented in biomechanical analysis is by looking at the magnitudes and behavioral characteristics of GRF. To be more precise, calculate three separate parts of GRF's highest and lowest GRF amplitudes as well as the proportion that indicates when each occurred. They determine the mean value of each characteristic overall stride during a walking session lasting three minutes. To combine the left and right data into a single mode value, which is the median for both sides, a thorough study is guaranteed and reduces any potential biases associated with limb domination. This method improves comprehension of the biomechanical guiding sports instruction.

3.4. Design of sports teaching actions based on biomechanics using chaos sparrow search fine-tuned efficient random forest (CSS-ERF)

The effective random forest model guarantees precise categorization and examination of biomechanical data. The hybrid approach of CSS-ERF capitalizes on the erratic behavior of the sparrow search algorithm to improve the optimization of sports instructing actions. Through insight based on data, the combination seeks to improve the effectiveness of instruction in sports instruction and modify movement patterns.

3.4.1. Efficient random forest (ERF)

The data gathered on different teaching strategies and athlete performance measurements is uniform in the biomechanics-based sports teaching actions to guarantee normalization distributions that closely resemble an ordinary distribution $N(0,1)$. This uniformity of method facilitates the improvement of instructional actions by providing precise comparisons and assessments across various competitors and approaches. The research's standardized formula is crucial for converting undimensioned data into indeterminate values, which improves the analysis of physiological performances and the efficacy of teaching is denoted as Equation (2).

$$z = \frac{z - \bar{z}}{\sqrt{\sigma}} \quad (2)$$

The averages of these measurements across different participants and events are indicated by $\bar{z}$ while the standard deviation $\sqrt{\sigma}$ reflects the variations of biomechanical metrics of achievement associated with sports instruction acts. They divided the biomechanical information gathered from different sports instruction acts into sets of training and tests depending on the built forecasting model. Using extensive research and accurate evaluation, this methodology validates the efficacy of various techniques, allowing for refinement of the design of instructional actions. The quantity used in an ERF technique is an important parameter to optimize the design of biomechanics-based sports instructional actions. They can improve the biophysical performance model's forecast accuracy by changing the amount of decision trees (DT). Both Mean Absolute Error (MAE) and Mean Squared Error (MSE) are evaluated to improve the model's assessment score. They offer a combination model referred to as the average MSE-MAE model, delivering a complete approach to evaluate the success rate of various educational acts and the formulation that illustrates the algorithm's construction, denoted as in Equation (3).

$$\mathrm{INDEX} = \mathrm{Average}\{\mathrm{MSE} + \mathrm{MAE}\} \quad (3)$$

The objective function in an optimization framework is defined as $\min\{\mathrm{INDEX}\}$. By carefully choosing the relevant data sources and classification factors, the most selected model can be derived for an improved random forest algorithm. This model will facilitate the analysis and enhancement of sports teaching actions, ensuring that biomechanical factors are effectively integrated into the design process. They use the grid search approach to assess the MSE and MAE for different decision tree variable combinations to find the best variables for biomechanics research. The outcomes show that the random forest approach performs exceptionally well in terms of prediction. In particular, the MSE and MAE values are lowest, measured at 0.0083 and 0.0608, accordingly, when the number of decision trees is set to 70. The optimal objective function is ultimately determined as $\min\{\mathrm{INDEX}_{\mathrm{RF}}\} = 0.03455$.

When examining biomechanical data, the forecasting outcome of exceedingly ERF regression shows remarkable accuracy. Particularly, when the quantity of decision trees is set to 40, the MSE is minimized. The MAE hits its minimum at 30 decision trees. When the prediction model's MSE and MAE evaluations are combined, it becomes clear that the variables related to 30 trees produce better outcomes. The best parameter arrangement, then, is determined to be 30 trees, yielding MSE and MAE values of roughly 0.0036 and 0.0462. Thus, $\min\{\mathrm{INDEX}_{\mathrm{ERF}}\} = 0.0249$. This represents the improved impartial variable that is computed. They create a new, ERF simulation that is specifically designed to improve sports teaching activities by using these improved parameters. This approach incorporates biomechanics insights to enable better athlete evaluations and more effective instructional methods.

3.4.2. Chaos sparrow search (CSS) optimization

The method of biomechanical optimizing has an immediate impact on the rapidity at which skills are acquired, convergence precision, and exploring the ability of the instructional actions. Choosing the right approach is essential for improving strategies for instruction because conventional methods are less flexible and less accurate. An adaptive balancing strategy can be used to overcome these restrictions and combine local and global methods of instruction exploration, improving the training procedure's effectiveness. Furthermore, by utilizing an adaptive modification operator, the risk of teaching approaches stagnating can be reduced by further enhancing both localized skill development and broad exploration.

- Single stochastic projection technique for starting population

To maximize the success of teaching methods in sports education, initializing parameters methodically is crucial. Although random initialization techniques can offer some flexibility, they have the potential to significantly deviate from best practices in instruction, which will eventually impact the precision and rate of skill development. Adaptive disorganized mapping presents a viable solution to this problem by producing pseudo-random numbers that are more sensitive to initial constraints and more unpredictable. To be more precise, the limits of traditional random approaches can be effectively mitigated by using a sine chaotic map for establishing characteristics in biomechanics optimization, which enhances the optimization procedure for sports instruction actions as a whole denoted as Equation (4).

$$w_{m+1} = \frac{b}{4} \sin\times (\pi w_m)\ b \in (0,4] \tag{4}$$

where the corresponding function's value is denoted by w_m and the management parameter by b. A unidirectional mapping having a value between $[-1, 1]$ is called sine mapping.

- Advanced dynamic weighting method

The inclination to jump too soon to a local solution during the early stages of improving sports teaching activities limits the investigation of efficient teaching techniques and compromises the precision of developing skills. This study changes the positions of teaching techniques by using the global ideal solution from earlier iterations, which improves the search process. This mitigates the risk of stagnating in local optima by guaranteeing that the modifications are impacted in addition to the previous training strategies but also by the best results from previous assessments. Moreover, a dynamic loading factor is included to enable better local searches; it starts at a higher value to promote exploration and gradually lowers it as the repetitions. The objective of this approach is to expedite convergence and augment the comprehensive efficacy of the optimization procedure in sports education initiatives denoted in Equations (5) and (6).

$$\omega = \frac{e^{2\left(1-\frac{s}{iter_{max}}\right)} - e^{-2\left(1-\frac{s}{iter_{max}}\right)}}{e^{2\left(1-\frac{s}{iter_{max}}\right)} + e^{2\left(1-\frac{s}{iter_{max}}\right)}} \tag{5}$$

$$W_{j,i}^{s+1} = \begin{cases} W_{j,i}^{s} + \omega\left(e_{j,h}^{s} - W_{j,i}^{s}\right).randQ_2 < ST \\ W_{j,i}^{s} + RQ_2 \geq ST \end{cases} \tag{6}$$

- *T*-distribution mutation approach

T-distribution, or student transportation, is an essential tool for calculating means of outcomes of instructional approaches on the grounds of scanty data derived from normally distributed populations with an indeterminable variance in exploring biomechanical and sports education activities. Certain degrees of freedom determine the nature of the *t*-distribution about their shape. More freedom allows *t*-distribution to closely mimic the normal distribution, while less freedom results in a flatter curve, implying more variability of the estimates. When analyzing data collected in the course of biophysical research, one needs to understand the specifics of *t*-distribution to judge the efficiency of various training strategies and their impact on skill acquisition.

It is important to note that as the freedom of *t* decreases, the tails rise and become wider, and approaches to the zero level are very slow in contrast to the steep declines of the Gaussian and Cauchy populations. This feature suggests that the *t*-distribution is more variable, and it can be influenced, which makes it a nice tool for analyzing biomechanical data. To adopt the improved feature of the increased disturbance's ability of the *t*-distribution alteration into the target location update calculation to enhance the optimization effectiveness internationally. The placements of the represented activities in sports coaching are then updated using the adaptive distribution called mutation mechanism, which leads to enhanced learning when proposing instructional strategies are denoted as Equation (7).

$$w_j^s = w_j + w_j . s(iter) \tag{7}$$

In this study, let w_j stand for the model's initial position and w_j^s for the particular location of the educational action model following mutation. The degree of freedom variable is the $s(iter)$, which represents the *t*-distribution dependent on the number of iterations. The data gathered from the current sample can be efficiently utilized by adding a *t*-distribution random disturbance term. The t-distribution mutation first resembles the Cauchy distribution mutation when the number of repetitions is low, offering strong global discovery potential. Local optimization is improved as the algorithm advances by causing the *t*-distribution modification to shift towards a Gaussian distribution mutation. Algorithm 1 shows that the process of CSS-ERF. By combining the advantages of Gaussian and Cauchy mutations, this hybrid technique enhances both regional and global refinement when optimizing physical teaching activities using biophysical.

Algorithm 1

```
initialize chaos sparrow search_size, max_iterations
initialize random forest_mse, best_mae = ∞
function evaluate_ERF(data, dt_count):
  model = RandomForest(data, dt_count)
  return calculate_MSE(model), calculate_MAE(model)
function chaos_sparrow_search():
  initialize sparrow_population
  for each iteration in 1 to max_iterations:
    for each sparrow in sparrow_population:
      update sparrow.position
      mse, mae = evaluate_ERF(training_data, decision_tree_count)
      if mse < best_mse and mae < best_mae:
        best_mse, best_mae = mse, mae
        decision_tree_count = adjust_count(decision_tree_count)
  return best_mse, best_mae
function main():
  best_index = ∞
```

Algorithm 1 (*Continued*)

```
    best_mse, best_mae = chaos_sparrow_search()
    index = (best_mse + best_mae)/2
    if index < best_index:
      best_index = index
      return { "decision_tree_count": decision_tree_count, "index": best_index }

optimized_model = main()
print(optimized_model)
```

The study of biomechanics-based sports instructional action improvement and design uses a hybrid technique that combines a refined ERF model with CSS. To improve the investigation and use of abilities in refining the ERF's parameters and raise the predicted accuracy of biomechanical performance indicators, this methodology first uses CSS. When evaluating different teaching tactics, MSE and MAE are minimized and the quantity of decision tree branches is changed to optimize the ERF model.

4. Result

To optimize and construct sports instructional actions using biomechanics, a research environment necessitates a computer system with a least 16 GB RAM to execute mechanical stability analysis programs efficiently and manage data processing. For real-time captured motion research and visualization, a specialized graphics processing unit (GPU) with at least 4 GB of VRAM is advised. Comparing the suggested method, chaos sparrow search fine-tuned efficient random forest (CSS-ERF), with existing approaches such as Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM), and Inception + LSTM [21] and the parameters are accuracy, precision, recall, and F1 value.

Accuracy: The exactness with which teaching strategies and movement patterns conform to biomechanical principles, leading to efficient skill execution and a lower risk of injury, is referred to as accuracy. The degree to which the acknowledged activities conform to the anticipated biomechanical model, thereby improving training results and sports performance, is how it is evaluated. **Table 1** and **Figure 2** present the results of the proposed method (CSS-ERF) with 0.989, which is higher than the existing methods such as CNN of 0.963, LSTM of 0.954, and Inception LSTM of 0.981.

Table 1. The result of the accuracy rate.

Methods	**Accuracy rate**
CNN [21]	0.963
LSTM [21]	0.954
Inception + LSTM [21]	0.981
CSS-ERF [Proposed]	0.989

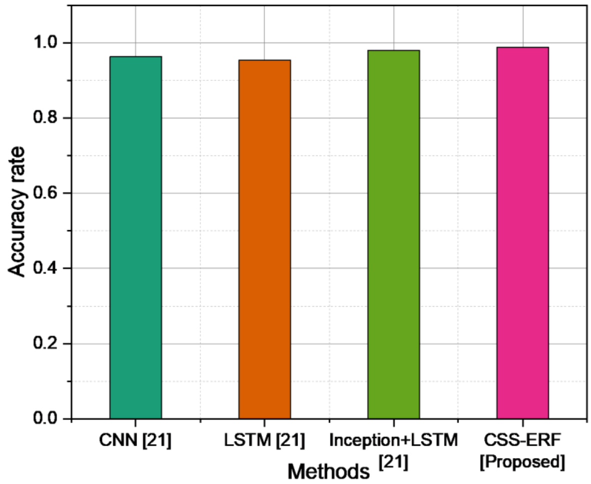

Figure 2. Outcome of the accuracy rate.

Precision: In training activities based on biological mechanics, precision refers to the measure to which biological operations are completed properly and frequently according to set achievement standards. Athletes execute moves efficiently when taught with high precision, which reduces mistakes and improves overall performance in athletics. **Table 2** and **Figure 3** show the comparison of precision rates in the existing and proposed model. An accuracy rate of 0.962 was acquired by CNN, LSTM achieved 0.955, and Inception-LSTM reached 0.973. The suggested CSS-ERF approach achieved an accuracy rate of 0.986. Although compared to traditional and hybrid DL techniques, it suggests that CSS-ERF is more effective in improving classification precision since it is more precise in recognizing real positive performance.

Table 2. The result of the precision rate.

Methods	Precision rate
CNN [21]	0.962
LSTM [21]	0.955
Inception + LSTM [21]	0.973
CSS-ERF [Proposed]	0.986

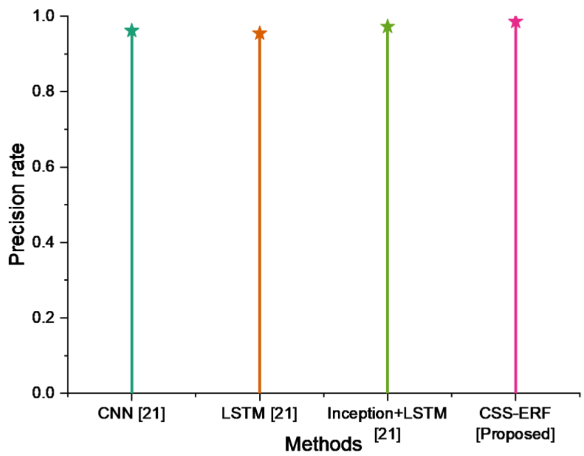

Figure 3. Outcome of the precision rate.

Recall: Recall is the term used to describe the model's capacity to correctly recognize and categorize the pertinent biomechanical characteristics and athlete motions throughout training. It measures how well the system learns the intended activities by comparing the percentage of true positive results to all the actual positive results. **Table 3** and **Figure 4** compare recall rates in the existing and proposed model. The suggested CSS-ERF method achieved the highest recall rate (0.985), with the existing methods such as CNN offered 0.957, LSTM (0.963), and Inception LSTM (0.982).

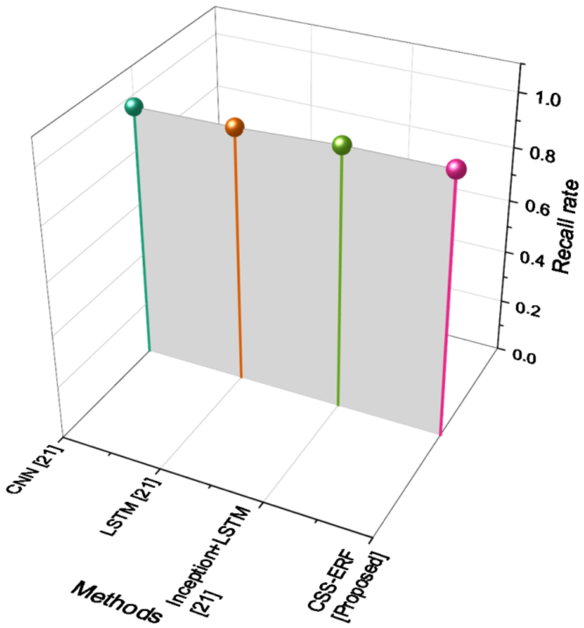

Figure 4. Outcome of the recall rate.

Table 3. The result of the recall rate.

Methods	**Recall rate**
CNN [21]	0.957
LSTM [21]	0.963
Inception + LSTM [21]	0.982
CSS-ERF [Proposed]	0.985

*F*1 value: The sports education acknowledging actions model based on biophysics is evaluated by a statistic ratio known as F1 value, which measures the efficiency of the model by combining the precise rate and the rate of recall. It provides a good assessment of how effectively the model identifies the correct action and minimizes wrong outcomes and undesired outcomes, which ensures the best training methods. **Table 4** and **Figure 5** present the results of the F1 value in the existing and proposed model. CNN demonstrated a respectable level of accuracy with an F1 rate of 0.959. The LSTM achieved 0.958, Inception + LSTM at (0.977), and the proposed method CSS-ERF outperformed earlier approaches with the greatest F1 value of 0.984.

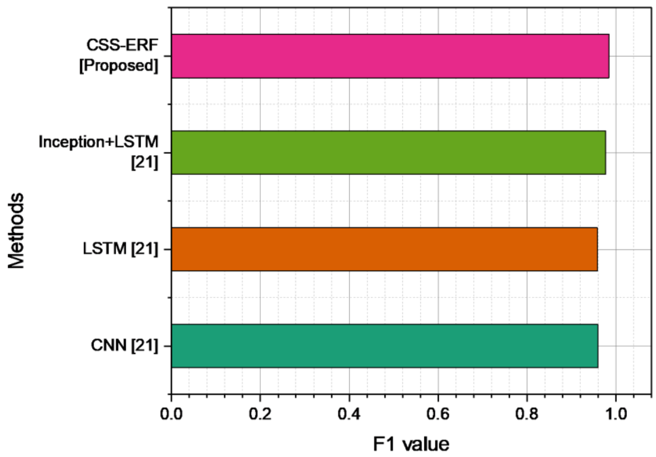

Figure 5. Outcome of the F1 value.

Table 4. The result of the F1 value.

Methods	F1 value
CNN [21]	0.959
LSTM [21]	0.958
Inception + LSTM [21]	0.977
CSS-ERF [Proposed]	0.984

5. Discussion

The generalization and construction of biomechanics-based sports teaching actions are under debate, and it is possible to see how advantageous it is to employ deep learning (DL) algorithms such as CNNs, LSTMs, and the Inception LSTM. The model can visualize in motion by adding CNNs for feature extraction, which are then passed to LSTMs that excel at analyzing complications across temporal semantics. Evaluating a model using the proposed loss function found that introducing the Inception LSTM as the next level of abstraction improves the model's ability to learn differences in athletic movements, as it can not only register but also attend to several frames. Besides enhancing the recognition of actions to improve the model's precision, this combination seems to help athletes gain a better understanding of biological concepts in sports conditioning. CNNs' primary drawbacks are their famously challenging optimization and their high training data and processing power requirements. The optimal CNN model includes the requirement for a sizable collection of labeled images and the increased computational expense of training. CNN design and operation are difficult and resource-intensive because of these problems. Regression with LSTM in machine learning (ML) is usually a time series problem. The fact that the data samples in time series follow a sequence sets it apart from other ML challenges. The sequence either clearly or implicitly depicts a temporal dimension. Because the LSTM design is more intricate than a basic RNN, it may be more difficult to comprehend and execute. LSTMs are susceptible to overfitting because of their intricate design and high number of parameters, particularly in situations when there is a shortage of training data. Inception + LSTM might have trouble capturing relationships across longer temporal data because of decreasing gradient problems over lengthy sequences. Therefore, these changes enhance more specialized and efficient teaching practices that eventually help to enhance the performances of athletes and reduce the probability of injuries. The proposed CSS-ERF method used proved to be more accurate and efficient in improving sports instructional actions, as it consistently beat other approaches. Predictive performance measures were significantly improved by integrating chaos sparrow search with the effective random forest model. This development demonstrates how well the mixed optimization method works to improve educational design and mechanical evaluation.

6. Conclusion

The aspect of biomechanical use in the planning and enhancement of sports lessons also enhances the student's athletic skills and efficiency of education. When human movement principles are applied to teach instructional strategies, it becomes easier to allow for improved motions, minimize risks of injuries, and individualize the training process as per an athlete's need. This study signified the need to close the theory-practice divide in the current method of teaching sports instruction by applying a scientific and biomechanical approach. Based on the results of the present analyses to enhance the presented athletic abilities and to modify existing instructional tactics, future efforts should focus on applying technologies and appropriate data. In the light of the current work, the suggested method CSS-ERF was compared with some classical models like CNN, LSTM, and Inception + LSTM, for which the following performances with recall of 0.985, accuracy of 0.989, the F1 value of 0.984 and precision of 0.986 were obtained. Subsequent studies should look at how the use of AI analysis can be integrated with real-time biomechanics feedback to further fine-tune sports teaching activities. Moreover, the advancement of wearable technologies generates more correct information regarding movement correction. Perhaps a broader scope of the study, including other sports domains, would improve the generalizability of these results.

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