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Article

Virtual reality technology in rural sports sustainable development reform research

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Abstract: Rural sports support unity among communities, encourage physical exercise in natural environments, and preserve regional traditions all of which are beneficial to sustainable development. Villages frequently encourage environmental stewardship and conservation initiatives, highlight cultural history, and promote local economies. By providing realistic practice environments and simulated games, we used virtual reality (VR) technology to improve rural sports and lessen the demand for substantial development infrastructure. A potential disadvantage of adopting VR technology for rural sports is the possibility of insufficient facilities and supplies available in remote areas. In this paper, we propose a novel World Cup Search-driven Quadratic Support Vector Machine (WCS-QSVM) method to enhance the performance of VR in rural sports. We use one of the Chinese traditional games dragon boating. We employ an immersive setup that replicates the kinematic and sensory subtleties of dragon boating through the use of virtual reality. To allow users to participate in real-world paddling activities, such as moving iron rods on a boat with a reasonably replicated resistance to water, we use a controller-based approach. As a result, we evaluate the performance of our proposal. According to the findings, the use of VR can enhance the growth of sustainable development in rural sports.

Keywords: Virtual reality (VR); rural sports; traditional game; World Cup search-driven quadratic support vector machine (WCS-QSVM)

1. Introduction

The advent of virtual reality (VR) technology has transformed numerous sectors, including education, healthcare, and entertainment. Recently, its application in rural sports has garnered attention as a potential catalyst for sustainable development [1]. Rural areas often face unique challenges, including limited access to resources, inadequate infrastructure, and declining participation in sports activities [2]. These issues not only hinder community engagement but also impede the overall well-being of rural populations [3].

Integrating VR technology into rural sports can address these challenges by providing immersive experiences that enhance training, skill development, and community involvement [4]. Through virtual platforms, individuals can access high-quality coaching, participate in simulated competitions, and engage in health and fitness programs, all from their local environment. This democratization of sports education empowers rural youth, fostering a culture of participation and promoting physical well-being [5].

Moreover, VR can serve as a tool for preserving and promoting traditional rural sports, enhancing their visibility and attractiveness to younger generations [6]. By showcasing these sports in a virtual setting, communities can cultivate pride in their heritage while also stimulating local economies through tourism and event hosting [7]. The potential for VR technology to facilitate remote coaching and mentorship further contributes to its significance in rural sports development. Coaches can guide athletes in real-time, irrespective of geographical barriers, thus democratizing access to quality training and expertise. This remote coaching capability can lead to improved performance levels, increased participation rates, and the establishment of sustainable sports programs that can thrive long-term [8].

The purpose of the paper is to use VR technology to improve rural sports and propose a World Cup search-driven quadratic support vector machine (WCS-QSVM) to enhance the performance of VR.

The remaining parts of this paper are, part 2 provides the related work, part 3 presents the methodology, part 4 represents the result as well as discussion, and part 5 discusses the conclusion of the paper.

2. Related works

Virtual reality (VR) technology can be used to greatly increase training effectiveness and prevent injuries in sports, as presented in the study [9]. It replicated sports training to prevent damages caused by ineffective training by building a digital human model with virtual reality (VR) technologies. To improve the quality of data extraction, computer approaches were integrated into an intermediate likelihood-based probabilistic framework to record and recreate sports training mobility data.

Study [10] focused on investigating how virtual reality (VR) technology can be used in football practice and how sports training can be combined with VR technology. Exploring virtual systems that were not impacted by outside environmental factors was the goal, as it was expanding the theoretical foundation for the creation and investigation of simulated football sports system software. It helped students grasp technical movement fundamentals and develop their football talents, which in turn led to better instruction and coaching methods.

Study [11] created adaptable virtual reality game software that may be utilized to create racket sports-specific workout routines. Players can easily modify the goals and levels of severity of the workout exercises by establishing cost terms that were associated with the gaming and game's mechanics, and by giving the player control over the cost concepts' characteristics. The findings suggest that a virtual reality game, like the augmented reality table tennis workout game under investigation, can be utilized successfully as a training and exercise assistance.

Virtual reality technology for environmental training games was created in the study [12]. Sensors and other systems for infrastructure gathered experimental data. To satisfy the requirements of footballers and improve the efficacy of their strategic performance and match outcomes, the experiment aimed to conduct a thorough investigation into the application of AI and VR technological advances to football individuals' strategic applications. When compared to the already recommended approaches in the literature on the subject, the outcomes of our suggested technique were remarkable.

Virtual reality tennis for developing perceptual-cognitive skills, and testing its usability and impartiality was established in the study [13]. The movement patterns of participants during tennis matches in virtual reality and the actual world were compared. The Tennis VR adequately captures the essence of tennis in real life. Despite not many adverse effects observed, participants' sense of being present in VR was high, as evidenced by high levels of participation, geographical presence, and ecological reliability and Tennis VR adequately captured the essence of tennis in real life.

A study [14] investigated how martial arts instruction might use virtual reality technology. It used a combination and controlled trials to gather data in response. A large proportion of players viewed virtual reality technology-assisted combative art instruction favorably, based on the results of the experiment, and both types of instruction greatly increased their enthusiasm to explore aggressive arts and produce better outcomes than conventional training.

A study [15] described the way young people's utilization of virtual reality sports games affects their health and sports engagement, as well as the possible connection between both of them. Measured by the Sport Engaged Score (SES) and Shorter Forms 36 (SF-36), correspondingly, the desired outcomes were participation in sports and health. According to the experiment, VR sports games have the potential to improve users' participation in sports and their overall health because of their energy and dedication.

A VR-based basketball training system that consists of a tablet computer and a stand-alone VR device was proposed in the study [16]. The goal of the approach was to help players become more proficient in comprehending and applying offensive strategies. An actual basketball court served as the model for the multi-camera person tracking apparatus, which was created to follow and examine every participant's running path as they executed their tactical moves. The findings show that mastering intricate strategies can be facilitated by using the suggested system.

3. Methodology

In this section, we provide a comprehensive explanation of VR setup, controller-based approach, immersion in vision, and proposed method. **Figure 1** shows the overall flow of Virtual reality technology in rural sports.

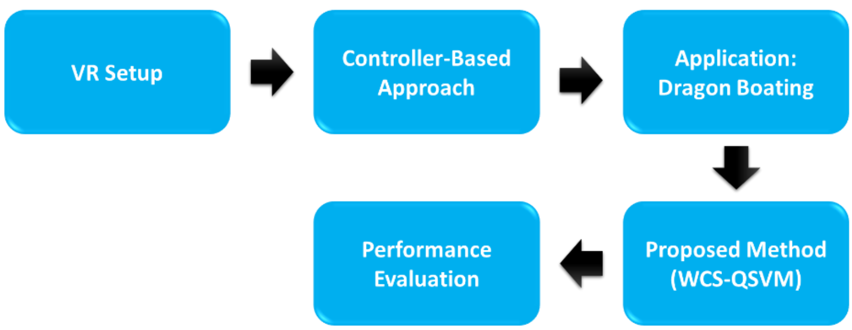

Figure 1. Overall flow of virtual reality technology in rural sports.

3.1. VR setup

We combined a true encoder with an adjustment wheel that presents a paddle in virtual reality to measure the user's rotating information. The true angular position of the paddles is precisely determined by this absolute encoder. After that, microcontroller unit (MCU) software suitable with Arduino processes the digital signals to produce voltage signals (high and low levels) that accurately operate a relay system. Our solution mimics real-world paddle resistance by using a DC-geared engine in brake gear and a resistor to simulate. It is controlled by an MCU via a relay network that operates in two modes: open and short system, which corresponds to low and maximum barriers, correspondingly. **Figure 2** represents the graphics for the procedures and responses. Handle movement to surface 1 in **Figure 2a** maintains the circuit opens, simulating low resistance similar to that of a paddle over water. The MCU modifies relay management for tactile input in surface 2 in **Figure 2b**, imitating resistance to water while pedaling. Particularly, the MCU's capabilities include encoding the rotary information of the wheels via a WiFi-enabled router within a User Data Gram Protocol (UDP) network information packet.

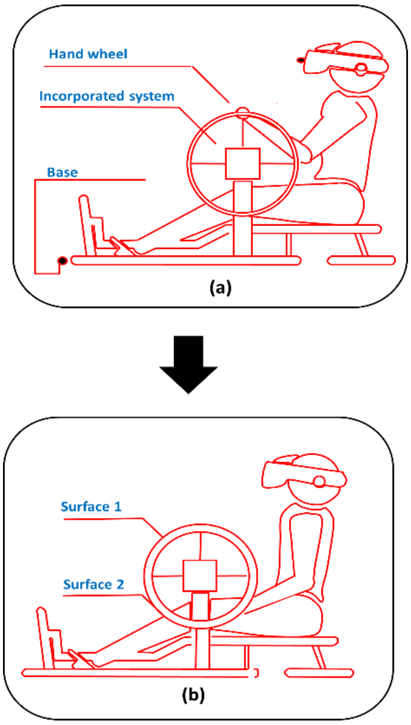

Figure 2. The graphics for the procedures and responses: **(a)** Handle movement; **(b)** relay management.

3.2. Controller-based approach

To enable players to participate in sensible paddling activities, together with transferring iron rods on a boat with appropriately replicated water resistance, we use a controller-based approach. This technique involves simulating the bodily resistance encountered when paddling through the water with the aid of dynamically adjusting the pressure remarks at the paddles. The resistance pressure F_r experienced by using the person is modeled as a function of the paddle's velocity V and the medium's resistance coefficient K. The dating may be defined by using the equation:

$$F_r = K \times V \tag{1}$$

In which K is a constant that represents the resistance of the water and V is the instant speed of the paddle. A feedback control gadget continuously displays units of the paddle's velocity and adjusts the resistance pressure F_r as a consequence. This ensures that because the person paddles quicker, the resistance they experience will increase proportionally, mimicking the feeling of paddling through the water. The controller set of rules may be implemented with the usage of a proportional-by-product (PD) controller, which helps in offering clean and practical comments by way of considering both the present-day speed and the price of trade of pace. The PD controller's output can be expressed as:

$$F_C = K_P \times E(t) + K_D \times \frac{DE(t)}{D(t)} \tag{2}$$

F_C is the control force,

$E(t)$ is the error between desire and true velocity,

K_D is the derivative gain K_P is the propagation gain,

The device can ensure a realistic and responsive paddling experience as it should simulate actual international water resistance.

3.3. Create with immersion in vision

The goal of VR is to increase authenticity and engagement. Because of this, the multi-modal information VR experience provides sensory experiences (such as visual, auditory, and tactile input) and generates accurate impressions of a boat race.

3.3.1. Movements of the body

Players using paddle mechanics in virtual reality can simulate boating authentically by manipulating a physical iron stick. Considering the heaviness and movement typical of boating, this kind of equipment offers tactile sensations that nearly resemble actual paddling. Users can also sit in a real-world mock-up of a dragon boat, which allows for realistic body motions like bending forward and backward.

3.3.2. Virtual replicas

Players of Dragon Boat VR can explore incredibly realistic replicas of well-known places. As they paddle around the virtual surroundings, individuals will have a compelling impression of interacting with their real-world counterparts because of the careful design.

3.3.3. Challenge

With the use of tactile input, the VR dragon boat provides a sophisticated experience of navigating through a variety of obstacles. A direct current (DC) motor continually adjusts for path, velocity, and rotations to imitate paddle pressure.

3.4. Proposed method

We proposed a hybrid of the World Cup search optimization algorithm with a quadratic support vector machine, which is named the World Cup search-driven quadratic support vector machine (WCS-QSVM).

3.4.1. World Cup Search

WCS promotes sustainability through lowering infrastructure demands and fostering network engagement in rural sports activities. The WCS algorithms arrange teams according to their ranks, allocating the more powerful teams to the initial seed, the weaker teams to the following seed, and so on. During the first period, teams with more strength manage to outlast and advance to a higher level through mutual competition. The difficulty begins with the seeding step. Usually, a preparatory task is given to teams in small groups all over the world to begin the competition. After the first games, the two best teams in each group move on to the next round, with the bottom teams being relegated. The WCS technique can be summarized as the following:

Initialization, choosing the teams and regions

It should be noted that in aM variables dimensionality (M_{var})optimization issue with various regions, every continent is going to have an array of $1 \times M_{var}$ indicating the teams that are currently competing in the competitions. The resulting array can be shown as follows:

$$Continent = [Country_1, Country_2, .., Country_{M_{var}}] \tag{3}$$

$$Country_j = [w_1, w_2, \ldots, w_{w_l}] \tag{4}$$

Here w_j represents the nation's jth squad. The contents of the constant $(w_1, w_2, \ldots, w_{M_{var}})$ appear to be floating point numbers. One way to determine the position of the continental is to value the rank functional e_q at the continent level of $(w_1, w_2, \ldots, w_{M_{var}})$:

$$Rank = e_q(continent) = e_q(w_1, w_2, \ldots, w_{P_{var}}) \tag{5}$$

$$P = M \times N \tag{6}$$

where M the total is the amount of continents and N is the dimensions of the parameters. An interval is chosen, given arbitrary values, and divided into sections that make up each continent to speed up the convergence process. This feature allows the method to converge more quickly than the other algorithms.

Assessment of the cost factor

This stage involves calculating the points on the continent. The points attained might not be entirely evident because there might be a continent where some teams have the highest point total while others might have weak points. As a result, this method additionally takes into account the continent's average values and standard deviation:

$$\overline{W} = \frac{1}{m}\sum_{j=1}^{m} W_j \tag{7}$$

$$\sigma = \sqrt{\frac{1}{1-m}\sum_{j=1}^{m}\left(W_j - \overline{W}\right)^2} \tag{8}$$

where s represents the region $\overline{W}$ variance, m characterizes its members, and W displays the continent W's average value.

Rating

Organizations receive a ranking using a particular equation in this step:

$$W_1 = [W_{11}, \ldots, W_{1m}]^S$$
$$W_2 = [W_{21}, \ldots, W_{2m}]^S \tag{9}$$

$$W_5 = [W_{51}, \ldots, W_{5m}]^S$$
$$W_{Total} = [W_{11}, \ldots W_{1m}, W_{21}, \ldots W_{2m}, \ldots W_{51}, \ldots W_{5m}]^S \tag{10}$$

Repeat the group contest phase

Following the first team tournament, additional continents and the groups that compete in them will be created again using the results of previous championship games and the team rankings. Two-part vectors can be used in this situation as follows:

$$Pop = W_{Total} = [W_{Best}, W_{Rand}] \tag{11}$$

Both the exploration and the extraction

The procedure of examining regions of a search space next to places that have been explored previously is known as W_{Best}, while the process of thoroughly inspecting newly discovered sections within a search area is known as W_{Rand}. Cross Point (CP) divides the sizes of W_{Best} and W_{Rand} as follows:

$$W_{Best} = Pop(DO + 1: M, N) \tag{12}$$

End the method if the requirement is satisfied, if not, repeat the program.

3.4.2. Quadratic support vector machine

It complements overall performance by successfully classifying data points and optimizing predictive accuracy in immersive settings. QSVM aids in replicating real-international dynamics like paddling resistance in VR, thereby improving practice simulations and promoting sustainable improvement in rural sports activities. To address the classification issues, SVM was developed. Structural risk reduction and the theory of statistical learning provide the foundation of the SVM approach. By projecting input values onto a high-dimensional region, the SVM seeks to determine the line of separation between the two classes. The data set needs to be divided into linear segments for Linear SVM to be the largest possible class. Finding the optimal separating hyper-plane (OSH) among the proximal hyper-planes, where the separation to the proximal point is maximal, is the first goal of the SVM.

A set of training variables $w_j \in Q^c$ with values from $(w_j, z_j) 1 \leq j \leq M, w_j$ values for input, and, c indicates the size of the values that were entered, should be used. The output values are given by the z_j values. Making sure that every point with the same set is on the identical side of the hyperplane and creating hyperplanes are the goals of SVM.

$$z_j(x \times w_j + a) > 0, j = 1, \dots, M \quad (13)$$

A hyper-plane (1) indicates that a linear separation of the data set is possible. In this instance, Equation (14) is derived by continuously resizing w and b.

$$min_{1 \le j \le M} z_j(x \times w_j + a) \ge 0, j = 1, \dots, M \quad (14)$$

Stated otherwise, $1/|x|$ is the distance that exists between the nearest point and the hyperplane. As a result, the Equation (13) becomes the Equation (15).

$$z_j(x \times w_j + a) > 1 \quad (15)$$

The optimization issue optimizes $\propto_j$ and has a restriction $\sum_{j=1}^{M} z_j \propto_j = 0$ if we choose$(\propto) = (\propto_1, \dots, \propto_M), M$, without any adverse Lagrangian multiplier, Equation (14). To make sure of this, conventional linear programming needs to be applied.

$$x(\propto) = \sum_{j=1}^{M} \propto_j - \frac{1}{2} \sum_{i=1}^{M} \propto_j \propto_i z_j z_i w_j \times w_i \quad (16)$$

The $OSH(x_0 a_0)$ corresponds to Equation (17) when the vector's $\propto^0 = (\propto_1^0, \dots, \propto_M^0)$ resolution of the maximizing issue is found in Equation (16).

$$x_0 = \sum_{j=1}^{M} \propto_j^0 z_j w_j \quad (17)$$

The reference point that supplies Equation (17) is the support vectors. Where$\propto_j^0 z_j w_j$, the coordinates are supporting vectors. Equation (18) illustrates the hyper-plane choice function by considering the expansion factor of a_0.

$$e(w) = sgn\left(\sum_{j=1}^{M} \propto_j^0 z_j w_j \times w + a_0\right) \quad (18)$$

3.4.3. WCS-QSVM

The integration of current artificial intelligence techniques with event-stimulated optimization is achieved through the hybrid of World Cup Search (WCS) with quadratic support vector machine (QSVM) for VR in rural sports for long-time period growth. This method improves VR packages which include immersive athletic education and rural cultural protection by way of optimizing QSVM parameters with WCS. With the help of QSVM's classification abilities and the tournament dynamics of WCS, the hybrid version seeks to increase the precision and efficacy of VR solutions that assist network involvement and sustainable rural sports.

4. Result and discussion

The current paper focuses primarily on quantitative measurements of movements and interests, which are valuable for understanding user interactions. However, insights into the subjective user experience in virtual reality (VR). Understanding factors such as ease of use, discomfort, and emotional responses is crucial for a holistic view of user satisfaction. Incorporating qualitative surveys would enrich the research by gathering insights from 173 users about their personal experiences, identifying potential discomfort, and uncovering limitations in the VR environment. We considered four movements, including paddling, steering, balancing, and team coordination. **Tables 1** and **2** represent the performance before using VR in pretest. Paddling (best—15, average—25), steering (best—11, average—20), balancing (best—18, average—22), and team coordination (best—14, average—19) are depicted in **Figure 3**. Before using VR, the participants performed the movements at an average level compared to the best level.

Table 1. Demographic details.

Demographic Category	Subgroup	Sample Size	Percentage of Total Sample	Notes
Age	18–24 years	58	33.5%	Focus on youth engagement in VR sports.
	25–29 years	58	33.5%	Young adults exploring VR applications in sports.
	30–35 years	57	32.9%	Older young adults with potentially different engagement levels.
Gender	Male	58	33.5%	Representation of male participants.
	Female	58	33.5%	Representation of female participants.
	Non-binary/Other	57	32.9%	Inclusion of non-binary individuals.
Cultural Background	Indigenous	29	16.8%	Incorporating traditional perspectives.
	Local ethnic minorities	29	16.8%	Representing diverse cultural practices.
	Mainstream rural population	115	66.4%	Majority representation from the local community.
Economic Level	Low-income	58	33.5%	Understanding barriers to access in VR sports.
	Middle-income	58	33.5%	Typical representation of the rural economy; may afford some VR options.
	High-income	57	32.9%	Insights from higher socioeconomic status; greater access to technology and resources.
Geographical Location	Coastal regions	47	27.1%	Assessing VR adaptation in maritime climates (e.g., dragon boating).
	Mountainous areas	47	27.1%	Evaluating adaptability in terrains with difficult access.
	Agricultural plains	79	45.7%	Flat land and farming communities with moderate climates.
Familiarity with Technology	High Familiarity	58	33.5%	Participants familiar with advanced technology (e.g., smartphones, computers).
	Moderate Familiarity	58	33.5%	Participants with average knowledge of technology, some experience with VR.
	Low Familiarity	57	32.9%	Limited exposure to technology and low familiarity with VR.
Acceptance and Concerns	High Acceptance	58	33.5%	Participants enthusiastic about adopting VR technology for sports.
	Moderate Acceptance	58	33.5%	Participants with cautious optimism toward VR, with some concerns about usability and cost.
	Low Acceptance	57	32.9%	Participants skeptical of VR or concerned about accessibility in rural areas.
Economic Feasibility	Cost-effective options	58	33.5%	Participants interested in affordable VR solutions that provide value for money.
	Moderate cost consideration	58	33.5%	Participants willing to invest if benefits are clear but concerned about potential costs.
	High cost concerns	57	32.9%	Participants who feel VR systems may be too expensive for rural communities to sustain.

Table 1. (*Continued*).

Demographic Category	Subgroup	Sample Size	Percentage of Total Sample	Notes
Infrastructure	Reliable power supply	58	33.5%	Participants from areas with consistent electricity, supporting VR usage.
	Limited power supply	58	33.5%	Participants in regions with intermittent electricity, potentially impacting VR performance.
	High-speed internet access	58	33.5%	Participants with access to stable, high-speed internet for VR operations.
	Limited internet access	58	33.5%	Participants in areas with slow or unreliable internet, impacting VR effectiveness.
	Availability of technical support	58	33.5%	Participants with access to local tech support for VR maintenance and troubleshooting.
	Lack of technical support	58	33.5%	Participants lacking access to technical help, potentially creating barriers to effective VR usage.
Long-term Effects of VR	Positive community cohesion	58	33.5%	Participants believe VR can foster community ties through shared experiences and activities.
	Improved health outcomes	58	33.5%	Participants feel VR can enhance physical health through increased activity and exercise.
	Enhanced lifestyle	57	32.9%	Participants expect VR to provide diverse recreational options and promote healthier lifestyles.
	Concerns about isolation	58	33.5%	Participants worried about VR leading to reduced face-to-face interaction within the community.
	Potential addiction issues	58	33.5%	Participants concerned about overreliance on VR technology affecting real-life engagement.

Table 2. Performance of movements before using VR.

Movements	Pre-test		post-test	
	Best	Average	Best	Average
Paddling	15	25	20	34
Steering	11	20	19	27
Balancing	18	22	16	31
Team coordination	14	19	21	34

Table 3 and **Figure 4** display the performance after using VR. In **Figure 4**, pre-test paddling (best-25, average-18), steering (best-22, average-13), balancing (best-27, average-16) and team coordination (best-28, average-12) are displayed. According to the findings, after using VR, the participants showed their best performance in performing movements.

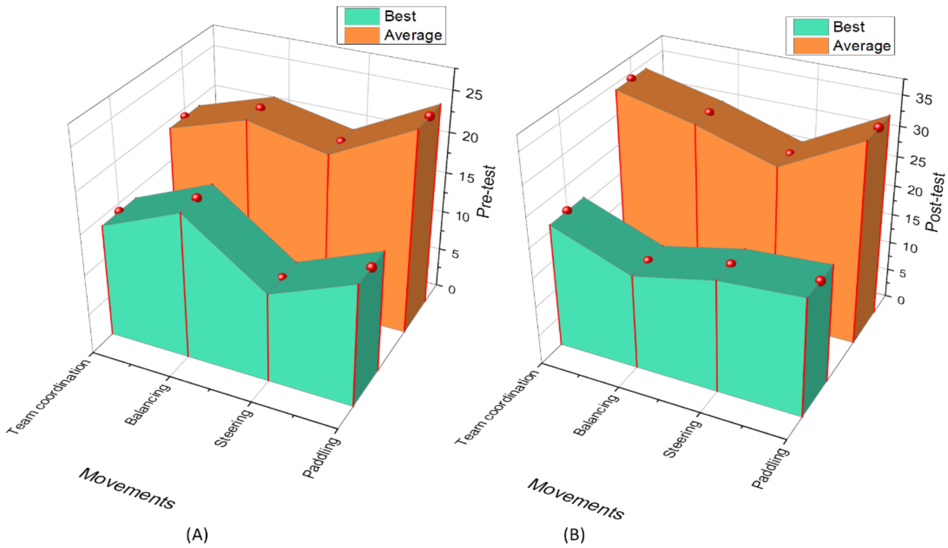

Figure 3. Performance of movements before using VR.

Table 3. Performance of movements after using VR.

Movements	**Pre-test**		**Post test**	
	Best	**Average**	**Best**	**Average**
Paddling	25	18	35	17
Steering	22	13	28	13
Balancing	27	16	25	17
Team coordination	28	12	38	19

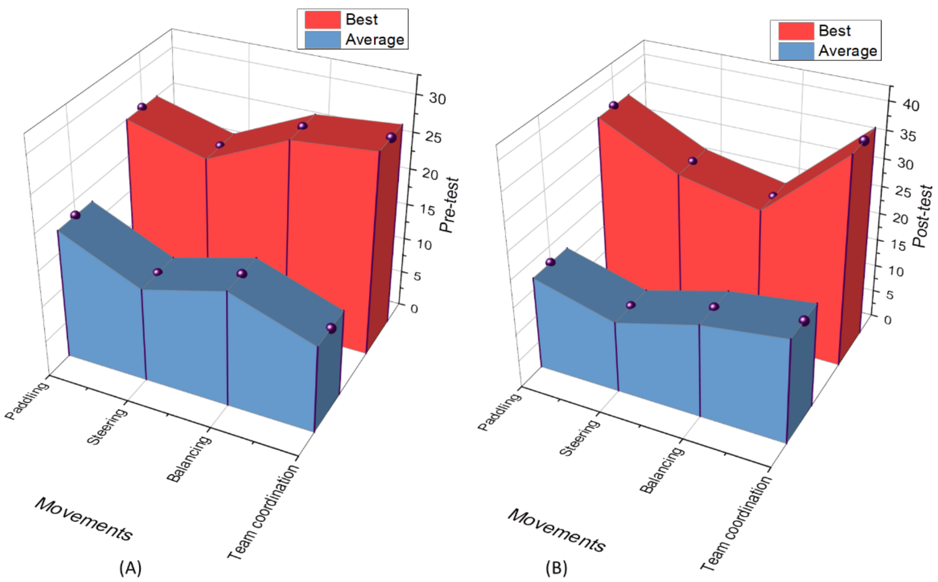

Figure 4. Performance of movements after using VR.

Table 4 and **Figure 5** represent the participant's interests. In **Figure 5**, we evaluate the participant's interest in VR dragon boating based on the matrices, including very curious (50%), interested (25%), doubtful (11%), uninterested (9%), and bored (5%). Regarding the findings, the participants are more interested in using VR for dragon boating.

Table 4. The participant's interest.

Participant's interest	Percentage (%)
Very curious	50
Interested	25
Doubtful	11
Uninterested	9
Bored	5

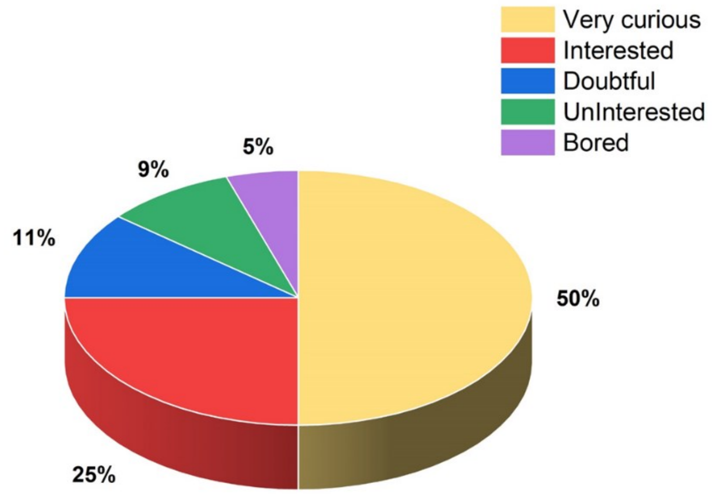

Figure 5. The participant's interest.

During dragon boating, injuries occur. We identified four main injuries including shoulder strain, lower back pain, wrist tendonitis, along hand and arm fatigue, and evaluated these four in both VR and physical dragon boating. **Table 5** and **Figure 6** represent the injuries level in both physical and VR. Physical dragon boating attained shoulder strains (45%), lower back pain (40%), wrist tendonitis (45%), and hand as well as arm fatigue (55%). VR dragon boating attained lower back pain (5%), hand and arm fatigue (13%), shoulder strains (10%), and wrist tendonitis (8%). Regarding the findings, VR has a low level of injuries compared to physical.

Table 5. Injuries level in both physical and VR.

Injuries	Physical (%)	VR (%)
Shoulder strains	45	10
Lower back pain	40	5
Wrist tendonitis	45	8
Hand & arm fatigue	55	13

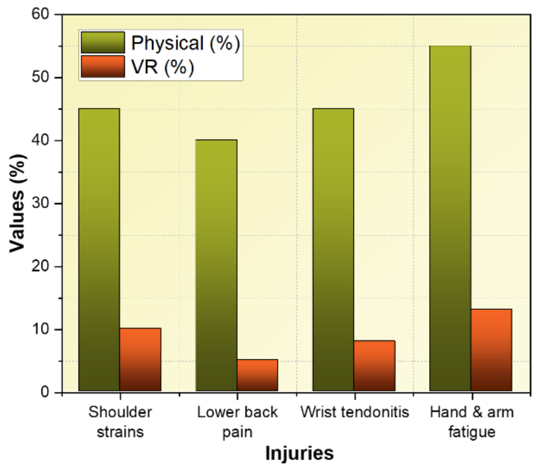

Figure 6. Injuries level in both physical and VR.

We evaluate the participant's fulfillment, such as self-confidence and satisfaction in both physical and VR. **Table 6** and **Figure 7** represent the level of self-confidence and satisfaction, in both physical and VR. Self-confidence scored in physical (80%) and VR (83%), and satisfaction scored in physical (82%) and VR (86%). When compared to the physical and VR, VR has superior performance in both self-confidence and satisfaction.

Table 6. The level of self-confidence and satisfaction in both physical and VR.

Personal fulfillment	Physical (%)	VR (%)
Self-confident	80	83
Satisfaction	82	86

Figure 7. The level of self-confidence and satisfaction in both physical and VR.

5. Conclusion

The findings of this study suggest that incorporating virtual reality (VR) into rural sports, specifically dragon boating can significantly enhance participants' performance and overall experience. As a result, we used 173 participants to evaluate the performance of VR based on the matrices such as movements before using VR and after using VR, participants' interest, injuries, self-confidence, and satisfaction. According to the findings, VR has superior performance in rural sports to sustainable development. The data indicated average scores for movement performance, with paddling at 25, steering at 20, balancing at 22, and team coordination at 19 before engaging with VR. Following the VR training, the movements showed remarkable improvements, with paddling achieving a best score of 35 and an average of 17, steering reaching a best of 28 and an average of 13, balancing with a best of 27 and an average of 16, and team coordination improving to a best of 38 with an average of 19. These results clearly demonstrate the effectiveness of VR in elevating performance across all assessed movements. These results demonstrate the effectiveness of VR in elevating performance across all assessed movements. Moreover, participant interest levels were notably positive with 50% expressing that they were "very curious" and 25% indicating they were "interested" in using VR for dragon boating. Additionally, VR significantly reduced injury rates compared to traditional physical dragon boating. Pre-test injury levels in physical dragon boating were considerable, with shoulder strains at 45%, lower back pain at 40%, wrist tendonitis at 45%, and hand and arm fatigue at 55%. In contrast, post-test injury levels in VR dragon boating were much lower, with shoulder strains at 10%, lower back pain at 5%, wrist tendonitis at 8%, and hand and arm fatigue at 13%. Finally, evaluations of personal fulfillment metrics revealed that VR provided superior outcomes compared to physical dragon boating, with self-confidence levels increasing from 80% in the physical setting to 83% with VR, and satisfaction levels rising from 82% in physical activities to 86% with VR. In conclusion, the integration of VR technology in rural sports not only enhances performance and reduces injuries but also fosters greater community engagement and cultural preservation. Future research should continue to explore the application of advanced AI algorithms, such as the proposed World Cup search-driven quadratic support vector machine (WCS-QSVM) method, to further enrich immersive VR experiences and promote traditional sports within rural communities. The WCS-QSVM may face limitations in virtual reality technology for rural sports sustainable development due to limited data availability, potential overfitting with complex models, inadequate computational resources in rural areas, and challenges in integrating VR technology into existing sports infrastructure. Furthermore, user engagement and accessibility issues may hinder effective implementation and impact. Further investigations into the WCS-QSVM method and immersive VR environments to encompass other traditional rural sports might make stronger cultural conservation projects and foster community engagement. By combining present-day AI algorithms with haptic feedback technology, education reports ought to be optimized by enhancing realism and personal engagement in virtual environments.

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funding acquisition, WL. All authors have read and agreed to the published version of the manuscript.

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