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ADVANCING PUBLIC FITNESS AND SPORTS CULTURE: THE ROLE OF DIGITAL SPORTS MUSEUMS LEVERAGING VIRTUAL PRIVATE NETWORK TECHNOLOGY

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ABSTRACT

This paper examines the development and implementation of digital sports museums, leveraging Virtual Private Network (VPN) technology to enhance the dissemination of sports culture and promote public fitness. As global awareness of health and fitness grows, there is an increasing demand for accessible platforms that encourage active lifestyles and provide rich cultural content. Digital sports museums meet this need by offering virtual access, overcoming the geographical limitations of traditional museums. The integration of VPN technology ensures secure and private data transmission, fostering user trust and engagement. By encrypting user interactions, VPNs protect personal information and enhance platform reliability, encouraging broader participation. The study highlights the effectiveness of digital sports museums in optimizing user experience through advanced technical architecture and interactive features. Cloud infrastructure and containerization ensure seamless access across various devices and network conditions, while interactive elements like virtual tours and quizzes actively engage users, promoting deeper cultural appreciation. Additionally, digital sports museums facilitate global sports culture exchange and support public fitness initiatives by offering educational resources through online platforms. The research underscores the potential of digital sports museums to contribute to the sustainable development of sports culture, providing a model applicable across various cultural domains.

KEYWORDS: Digital Sports Museums; VPN Technology; Data Security; Sports

Culture Dissemination

1. INTRODUCTION

With the increasing awareness of health on a global scale, public fitness activities have been flourishing in many countries. Governments, social groups, and individuals are gradually realizing that sports are not just recreational activities but are crucial for improving physical fitness and quality of life (Iwasaki, 2007). In recent years, governments worldwide have introduced a series of policies and plans to encourage people to engage in various forms of physical activities. For example, China's "National Fitness Plan (2016-2020)" and the "Healthy China 2030 Blueprint" regard sports and fitness as key avenues for enhancing public health. The implementation of these policies has spurred societal interest and participation in sports culture, promoting diverse and deepened dissemination of sports culture (Willem, Girginov, & Toohey, 2019). Sports museums play a significant role in this cultural dissemination by preserving and showcasing the rich history and achievements of sports (Ramshaw, 2010). They serve as educational resources that inspire individuals to participate in physical activities by highlighting the stories of athletes and the evolution of sports. These museums provide a tangible connection to the past, allowing visitors to appreciate the impact of sports on society and its role in shaping cultural identity. As depicted in Figure 1, the Shaanxi Sports Museum exemplifies how sports museums contribute to this cultural mission. The museum showcases the rich sports heritage of the region, featuring exhibits on traditional Chinese sports, modern achievements, and the influence of sports on local culture. By doing so, it not only preserves historical records but also inspires future generations to embrace sports as a vital part of their lives (Gilchrist & Wheaton, 2011).

Figure 1: Shaanxi Sports Museum

The widespread adoption of fitness activities not only improves public health but also has a profound impact on the dissemination of sports culture (Fletcher et al., 2018). Firstly, as more people engage in sports, both traditional and modern sports have gained broader exposure. Besides traditional sports like basketball and soccer, emerging or niche sports such as yoga, Pilates, and extreme sports have also garnered public attention. Secondly, the development of the internet and social media accelerates the speed and reach of sports culture dissemination. People can watch live sports events, learn sports techniques, and share fitness experiences through online platforms. These interactions enhance the social aspect of sports culture, promoting its wider spread within communities and groups. Moreover, the integration of sports and technology, such as virtual reality (VR) and augmented reality (AR), makes the forms of sports culture dissemination more diverse and creative, attracting participants of different age groups (Goebert & Greenhalgh, 2020). Driven by the wave of public fitness, the dissemination and exchange of sports culture have become increasingly important. As an emerging form of cultural display and dissemination, digital sports museums have vast developmental potential. Traditional sports museums primarily rely on physical exhibits and onsite visits, whereas digital sports museums utilize digital technology and the internet to achieve virtual displays and interactive experiences of sports culture. Digital sports museums play multiple potential roles in promoting sports culture exchange (McGillivray, 2014). Firstly, they can transcend geographical limitations, allowing users worldwide to access museum resources via the internet, gaining rich cultural information about sports history, events, and personalities. This not only facilitates cultural exchange between different countries and regions but also enhances people's understanding and appreciation of sports culture. Secondly, digital museums can provide a more vivid learning experience through multimedia displays (such as videos, audio, and interactive simulations), enabling users to understand and experience the charm of sports more immersively. Additionally, digital sports museums can collaborate with online education platforms to offer systematic sports knowledge and skills training, embedding the concept of public fitness more deeply into society (Wang & Nunes, 2019). Despite the theoretical advantages of digital sports museums, they face several challenges and limitations in practice. First, the richness and diversity of content resources need enhancement. Many digital museums focus primarily on static information display, lacking interactivity and deep user engagement. Second, the technical support and platform stability of digital museums require strengthening. Currently, many digital museums depend on complex technical infrastructures, involving data storage, network transmission, and user interface design, which pose high demands on technical support and maintenance. Furthermore, the security and privacy protection of user data are increasingly prominent issues. As digital museums become more popular, the substantial amount of data generated by users during access and participation needs adequate protection

to prevent privacy leaks and security risks. This is a critical concern for museum managers and technology providers. Virtual Private Network (VPN) technology offers significant advantages in protecting user privacy and data security (Akinsanya, Ekechi, & Okeke, 2024). VPNs allow users to create an encrypted "tunnel" in public networks, ensuring the security and privacy of data transmission. In the construction of digital sports museums, VPN technology can effectively address the issue of user data protection, preventing data from being intercepted or tampered with during transmission. Firstly, the encryption technology provided by VPNs ensures that users' identity information and browsing history are not accessible to unauthorized third parties when visiting digital museums. This increases users' trust and willingness to participate to some extent. Secondly, VPNs allow for precise access control, ensuring that only authorized users can access specific museum resources. This helps protect the museum's intellectual property and unique cultural content. Finally, the application of VPNs can enhance the network connection stability of digital museums, reducing access delays and the risk of network attacks, thereby offering a better user experience (Hutchins, 2020). This study aims to develop a digital sports museum model based on VPN technology, exploring its potential application in promoting the dissemination of sports culture and the spread of public fitness. The specific contributions include:

- Proposing a digital museum architecture incorporating VPN technology to enhance the security of user data transmission and the overall stability of the system.

- Improving user interface design and interaction methods to increase user engagement and satisfaction with the digital museum.

- Verifying the effectiveness of digital sports museums in real-world scenarios through specific case studies, providing practical insights.

Through this research, we aim to provide feasible solutions for the future development of digital museums, promoting the sustainable development of sports culture and the deepening of public fitness initiatives. The findings of this study are not only applicable to sports museums but also offer valuable insights for other types of digital museums. Looking ahead, we anticipate enhancing the effectiveness of digital culture dissemination through interdisciplinary collaboration and innovation.

2. Methodology

This study aims to develop a digital sports museum platform utilizing VPN technology to enhance user data security, optimize user experience, and validate its practical application effectiveness. This section details the technical architecture, user experience optimization methods, and experimental design.

2.1 Technical Architecture Design

The technical architecture design is the foundation of building a digital sports museum. It determines the system's security, availability, and scalability. In this study, we achieve this through VPN technology integration, server deployment, and data security and access control.

2.1.1 VPN Technology Integration

To ensure the security of user data during transmission, we selected Wire Guard as our VPN solution. Wire Guard is known for its simple installation, configuration, and high performance, making it suitable for rapid integration into the digital museum platform. Wire Guard was chosen for its efficient encryption mechanisms and ease of deployment (Donenfeld, 2017). The VPN ensures that all data exchanged between users and the museum platform is encrypted, enhancing privacy and security. The VPN setup acts as a secure gateway, encrypting user sessions and protecting sensitive information from potential interception. The deployment of Wire Guard involved configuring VPN servers to manage user connections securely. This setup ensures that users can access the platform with peace of mind, knowing their data is protected from unauthorized access and cyber threats. The integration of VPN technology also addresses potential network latency issues that might arise from high user traffic or international access. By optimizing the data routes and leveraging distributed server locations, the platform maintains a fast and reliable connection, enhancing the overall user experience.

2.1.2 Server Deployment

The platform is hosted on Alibaba Cloud, utilizing its global network to ensure rapid access and high availability. This setup supports a distributed microservices architecture, allowing the system to scale efficiently and handle variable user loads. Docker is employed for containerization, simplifying the deployment process and ensuring consistency across different environments (Bellavista & Zanni, 2017). This approach allows for quick updates and maintenance, supporting continuous improvement of the platform. By using cloud infrastructure and containerization, the platform benefits from increased scalability and resilience. This setup allows for dynamic resource allocation based on user demand, ensuring that the platform remains responsive during peak usage times (Ráthonyi, Müller, & Rathonyi-Odor, 2018).

2.1.3 Data Security and Access Control

To protect user data's security and privacy, we implemented strict data encryption and access control mechanisms within the platform. The platform utilizes AES-256 encryption to secure data both in transit and at rest, ensuring a high level of confidentiality and security. The code is shown in Figure 2.

main.py | Data Encryption.py

```python
from Crypto.Cipher import AES
import base64

def encrypt_data(key, data):
    # Initialize AES cipher for encryption
    cipher = AES.new(key, AES.MODE_EAX)
    nonce = cipher.nonce  # Unique nonce for this encryption session
    ciphertext, tag = cipher.encrypt_and_digest(data.encode('utf-8'))
    # Return encrypted data encoded in base64 for storage
    return base64.b64encode(nonce + ciphertext).decode('utf-8')

def decrypt_data(key, enc_data):
    # Decode the encrypted data from base64
    enc_data = base64.b64decode(enc_data)
    nonce = enc_data[:16]  # Extract nonce from the encoded data
    ciphertext = enc_data[16:]  # Extract ciphertext from the encoded data
    # Initialize AES cipher for decryption
    cipher = AES.new(key, AES.MODE_EAX, nonce=nonce)
    # Decrypt the ciphertext and return the original data
    return cipher.decrypt(ciphertext).decode('utf-8')
```

Figure 2: Data Encryption Code

A combination of JSON Web Tokens (JWT) and two-factor authentication (2FA) ensures secure and controlled access to the platform, allowing only authorized users to access specific features and content. The code is shown in Figure 3.

main.py | Access Control.py

```python
import jwt
import datetime

def generate_jwt(user_id, secret_key):
    # Create payload with user ID and expiration time
    payload = {
        'user_id': user_id,
        'exp': datetime.datetime.utcnow() + datetime.timedelta(days=1)  # Token expires in 1 day
    }
    # Encode the payload with the secret key to generate JWT
    token = jwt.encode(payload, secret_key, algorithm='HS256')
    return token

def verify_jwt(token, secret_key):
    try:
        # Decode the token with the secret key to validate
        payload = jwt.decode(token, secret_key, algorithms=['HS256'])
        return payload['user_id']
    except jwt.ExpiredSignatureError:
        # Handle expired token
        return None
    except jwt.InvalidTokenError:
        # Handle invalid token
        return None
```

Figure 3: Access Control Code

These security measures are critical for maintaining user trust and safeguarding sensitive information. By implementing robust encryption and access control protocols, the platform ensures that user data is protected from

unauthorized access and potential breaches.

2.2 User Experience Optimization

User experience is key to the success of the digital museum platform. We enhance user engagement and satisfaction through responsive design and interactive features.

2.2.1 Interface Design

The platform uses the Bootstrap framework to deliver a consistent experience across multiple devices, including smartphones, tablets, and desktops. This ensures that users can easily navigate and interact with the museum content regardless of their device. Prototypes were developed using Adobe XD, and iterative user testing was conducted to refine the interface. Feedback was incorporated to enhance usability and accessibility, ensuring the platform meets diverse user needs. Responsive design is essential for accommodating the diverse range of devices and screen sizes used by modern audiences. By adopting a mobile-first approach, the platform prioritizes accessibility and ease of use, providing an optimal experience for users on the go.

2.2.2 Interactive Features

Utilizing Three.js, the platform offers 3D virtual tours and interactive quizzes that engage users and enhance learning. These features allow users to explore exhibits dynamically and test their knowledge interactively. Google Analytics is integrated to track user interactions, providing valuable insights into user behavior and preferences. This data-driven approach helps identify areas for improvement and informs future enhancements. Interactive features are a cornerstone of the digital sports museum experience, transforming passive viewing into active engagement. By incorporating elements of gamification, the platform encourages users to participate actively and learn through exploration.

3. Experiments and Results

Following the methodological setup, we conducted experiments to evaluate the platform's security, performance, and user experience under various conditions.

3.1 Experimental Setup and Testing Environment

The experiments were designed to simulate real-world usage scenarios, ensuring a comprehensive evaluation of the platform's capabilities. Tests were conducted on a variety of devices, including Android and iOS smartphones, tablets, and desktop computers. This diversity ensures compatibility and responsiveness across different user hardware. The platform was tested under

various network conditions, such as WiFi, 4G, and 5G, to assess its performance and stability. Kali Linux tools, including Nmap and Metasploit, were used to conduct penetration tests and evaluate security measures. Google Lighthouse and Google Analytics were utilized to measure performance metrics and track user interactions.

3.2 Results and Analysis

3.2.1 Security Testing

The aim of the security testing was to evaluate the platform's security posture, especially focusing on the effectiveness of VPN integration to protect data during transmission and the overall system security against unauthorized access and vulnerabilities. Nmap for port scanning and Metasploit for vulnerability exploitation. To identify any open ports that could be potential entry points for attackers. To identify any open ports that could be potential entry points for attackers.

Table 1: Security Testing Results

TEST TYPE	TOOL	OUTCOME	REMARKS
PORT SCAN	Nmap	No open ports or unauthorized access	Secure port management confirmed
VULNERABILITY SCAN	Metasploit	No successful exploits	System resilience validated

No open ports or unauthorized access detected. This indicates effective port management, ensuring that all unnecessary ports are closed and minimizing potential attack vectors. The platform's network defenses are well-configured to prevent unauthorized access. No successful exploits were achieved during the tests. This suggests a high level of system resilience, as common vulnerabilities and known exploits were unable to compromise the system. The use of updated security patches and comprehensive vulnerability management processes likely contributed to this outcome. The security testing demonstrates that the platform is robustly secured, with VPN encryption effectively safeguarding data and no significant vulnerabilities identified. This implies a strong security foundation, crucial for maintaining user trust and data integrity.

3.2.2 Performance Testing

To assess the platform's responsiveness and speed under varying network conditions and on different devices, ensuring a seamless user experience across all scenarios. Page load times and interaction responsiveness were measured across different devices using Google Lighthouse under WiFi, 4G, and 5G conditions. The platform maintained fast

load times and smooth interactions across all tested conditions.

Table 2: Performance Testing Results

NETWORK TYPE	DEVICE	AVERAGE PAGE LOAD TIME (SECONDS)	REMARKS
WIFI	Smartphone	1.8	High efficiency under stable network
WIFI	Tablet	1.9	Consistent performance across devices
WIFI	Desktop	1.7	Fast response times
4G	Smartphone	2.5	Good performance on mobile networks
4G	Tablet	2.6	Acceptable latency
4G	Desktop	2.4	Slightly faster than mobile devices
5G	Smartphone	1.2	Excellent speed on high-bandwidth networks
5G	Tablet	1.3	Near-instantaneous load times
5G	Desktop	1.1	Fastest response recorded

3.2.2.1 WiFi Performance

Smartphone: Average load time of 1.8 seconds. Demonstrates high efficiency in stable network conditions. Tablet: Average load time of 1.9 seconds. Consistent performance across devices. Desktop: Average load time of 1.7 seconds. Fastest response times under WiFi, suggesting optimized performance for desktop environments.

3.2.2.2 4G Performance

Smartphone: Average load time of 2.5 seconds. Good performance on mobile networks, indicating the platform's adaptability to less stable connections. Tablet: Average load time of 2.6 seconds. Acceptable latency, suitable for on-the-go usage. Desktop: Average load time of 2.4 seconds. Slightly faster than mobile devices, showcasing efficient resource utilization.

3.2.2.3 5G Performance

Smartphone: Average load time of 1.2 seconds. Excellent speed on high-bandwidth networks, providing an optimal user experience. Tablet: Average load time of 1.3 seconds. Near-instantaneous load times, enhancing usability. Desktop: Average load time of 1.1 seconds. Fastest response recorded, highlighting the platform's capability to leverage high-speed networks. The performance testing results indicate that the platform maintains fast load times and smooth interactions across all tested conditions, ensuring users enjoy a

responsive experience irrespective of their network environment. The platform is optimized for both high and moderate-speed networks, demonstrating its versatility and reliability.

3.2.3 User Experience Testing

The user experience testing focused on evaluating how users perceive the platform in terms of usability, engagement, and overall satisfaction. The testing aimed to gather insights into how intuitive, interactive, and satisfying the platform is from the perspective of its users. To evaluate user satisfaction and engagement with the platform's features, aiming to understand how intuitive, interactive, and satisfying the platform is from a user perspective. Surveys and feedback sessions were conducted to gather user opinions on usability, interactivity, and overall satisfaction. User feedback was overwhelmingly positive, with high satisfaction scores across all metrics.

Table 3: User Experience Testing Results

ASPECT	USER FEEDBACK METRIC	PERCENTAGE (%)	REMARKS
EASE OF USE	Users finding it intuitive	92	Majority of users find navigation easy
ENGAGEMENT	Users highly engaged	88	High interaction with features
SATISFACTION	Overall user satisfaction	90	Positive feedback on overall experience

A significant 92% of users found the platform easy to navigate, indicating that its design and layout are intuitive. This high percentage suggests that users can effortlessly interact with the platform, which minimizes the learning curve for new users and enhances their initial experience. The platform demonstrated strong engagement metrics, with 88% of users reporting high levels of interaction. This result reflects the platform's ability to captivate its audience through engaging features, fostering sustained interest and active participation. Users are likely drawn back to the platform due to its interactive nature and the value it provides.

A remarkable 90% of users expressed positive feedback regarding their overall experience with the platform. This high satisfaction rate indicates that the platform effectively meets or even exceeds user expectations, offering a functional and enjoyable user experience. Users appreciate the platform's reliability and the quality of its features, which contributes to a favorable overall impression. The user experience testing results reveal that the platform is highly regarded by its users. With impressive scores in ease of use, engagement, and overall satisfaction, the platform successfully delivers an intuitive and engaging

experience. These findings highlight the platform's strengths in design and functionality, emphasizing its ability to meet user needs effectively. Future efforts can focus on maintaining these standards and exploring new ways to enhance the user experience further, ensuring continued user satisfaction and loyalty.

4. Discussion

The development of digital sports museums, enhanced by VPN technology, represents a significant advancement in the dissemination of sports culture and promotion of public fitness. This discussion highlights the implications, challenges, and opportunities associated with this innovative approach. Digital sports museums provide a transformative approach to sports culture dissemination by overcoming geographical and logistical barriers associated with traditional museums. By offering virtual access to rich cultural content, these platforms facilitate global cultural exchange, enabling users from different regions to explore sports history and engage with diverse sports narratives (Bearman & Geber, 2008). This accessibility promotes a deeper understanding of sports culture and enhances global appreciation for both traditional and modern sports.

The integration of interactive and multimedia features further enriches the user experience, transforming passive viewing into active participation. Features such as virtual tours, quizzes, and interactive simulations offer users an engaging and educational journey through sports culture. These elements not only enhance user engagement but also serve as a catalyst for increased interest and participation in sports activities (Glebova, Gerke, & Book, 2023). The incorporation of VPN technology addresses critical security concerns associated with digital platforms, ensuring user data privacy and protection. By encrypting data transmissions, VPNs safeguard users' personal information and browsing history from unauthorized access, fostering trust and encouraging active participation. This technological safeguard is crucial for digital platforms, as users are more likely to engage with services that prioritize data security and privacy. However, the deployment of VPNs and other advanced technologies introduces several challenges. Maintaining the technical infrastructure required for VPN integration, such as server deployment and data management, demands significant resources and expertise.

Ensuring platform stability and performance, particularly under high user traffic or international access, necessitates robust network optimization and maintenance strategies (Stavros, Smith, & Lopez-Gonzalez, 2022). The success of digital sports museums hinges on delivering an intuitive and satisfying user experience. Responsive design and user-centric development

are essential for accommodating diverse devices and user preferences (MA, 2018). By focusing on ease of use and interactive features, digital sports museums can effectively capture and retain user interest. Feedback from user experience testing highlights the importance of continuous improvement in interface design and interaction methods. Iterative testing and user feedback incorporation are vital for refining the platform to meet evolving user needs and expectations. This approach not only enhances user satisfaction but also ensures the platform remains relevant and competitive in a rapidly changing digital landscape (Kohe, 2018).

Despite the promising potential of digital sports museums, several challenges and limitations must be addressed. The richness and diversity of content resources need continuous enhancement to maintain user interest and engagement. Many digital museums currently focus on static information display, and there is a need to develop more dynamic and interactive content that can engage users at a deeper level. Additionally, the technical support and platform stability of digital museums require ongoing attention. As digital platforms become more popular, the demands on technical infrastructure increase, necessitating robust support and maintenance to ensure consistent performance and reliability. Data security and privacy protection are also critical concerns. As digital museums collect substantial amounts of user data, implementing stringent security measures is essential to prevent data breaches and protect user privacy.

5. Conclusion

The development of digital sports museums, enhanced by VPN technology, offers a promising solution for promoting sports culture and encouraging public fitness. These digital platforms effectively overcome the limitations of traditional museums by providing global access to sports history and culture, facilitating cross-cultural exchange and appreciation. These platforms play a crucial role in disseminating sports culture, offering immersive multimedia displays that broaden users' understanding and appreciation of sports.

By collaborating with online education platforms, digital sports museums further promote public fitness by providing systematic sports knowledge and training, supporting broader health initiatives. Digital sports museums hold significant potential for the sustainable development of sports culture and public fitness initiatives. The insights gained from this study can be applied to other cultural domains, suggesting a broader applicability of digital museum models. Continued interdisciplinary collaboration and innovation will enhance the effectiveness of digital cultural dissemination, ensuring ongoing user engagement and satisfaction.

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