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Strategy for improving the football teaching quality by AI and metaverse-empowered in mobile internet environment

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Abstract
The metaverse has influenced the development of science and technology since it was proposed. While artificial intelligence (AI) is still one of the important technologies to solve problems in metaverse. The success of AI in various fields and the development of information technology make the integration of sports industry and AI an inevitable trend. Currently, the traditional physical education is experiencing qualitative changes, and the demand of integrating AI and metaverse into physical education is becoming more and more obvious. Football teaching is an important part of physical education, and Virtual Reality (VR) has the characteristics of immersion, interaction and imagination, which can build virtual and realistic football teaching process. In this study, through 360-degree panoramic VR football teaching videos empowered by the metaverse and K-means algorithm based on machine learning under AI, we study the strategies for improving the quality of football teaching in the mobile Internet environment. Therefore, we propose K-means based optimized 360-degree panoramic VR football teaching video delivery strategy. In addition, we conduct simulation experiments under content delivery networks simulator, and the simulation results show that the proposed strategy is superior to the baselines in terms of proxy server hit ratio, byte hit ratio, mean response time and students quality of experience. Moreover, through the 360-degree panoramic VR football teaching videos learning, students can intuitively analyze the actions and improve the teaching quality. The reconstruction of football teaching environment is beneficial to promote the combination of football teaching and smart learning.

Keywords Artificial intelligence · Virtual reality · Metaverse · Mobile internet · Video delivery · Football teaching · Content delivery networks

1 Introduction

As a large-scale Sports program in the world, football is highly valued in the teaching of education. Football teaching is an important part of physical education in universities, which plays a key role in improving the quality of physical education in universities [1, 2]. At the same time, as a comprehensive and strong sports item, football is favored by undergraduates. With the continuous progress of the times, new requirements have been put forward for the teaching work, which requires that the teaching concepts held in the teaching work should be improved accordingly. At present, sports in the world presents many brand-new characteristics, but the teaching concept of physical education in universities still adopts the traditional teaching method, which is greatly out of line with the requirements of the whole era on physical education in universities, especially football teaching in universities [3, 4]. In football teaching, it is often carried out in the form of classes. Although this unified teaching method meets the requirements of football teaching hours in universities, the overall football teaching effect is inevitably not ideal due to the differences of football levels among undergraduates. At the same time, with the further implementation of quality teaching concept, the traditional football teaching content cannot meet the requirements of universities at the present stage, so it is imperative to

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completely renew the content of football teaching in universities [5].

The outbreak of COVID-19 has shifted teaching from offline to online. This poses a great challenge to physical education, especially football teaching. How to carry out football teaching online and improve teaching quality by combining online and offline are urgent problems to be solved [6, 7]. Football teaching is more colorful to meet the diversified needs of students for football learning. Teachers should integrate the difficulties, key points and relevant knowledge in football teaching, make corresponding videos and upload them to the Internet. Especially in the scenario of metaverse empowerment, teachers make 360-degree panoramic VR football teaching videos, which is more helpful for students to master football movements and devote themselves to training [8, 9, 10]. The core of the metaverse is a virtual space based on the real world, extending from pan-entertainment experience such as games and social interaction to offline and online integration of various realistic scenes. Its core elements include extreme immersion experience, rich content ecology, social system beyond time and space, and economic system of virtual and real interaction [11, 12]. Students can learn independently by watching 360-degree panoramic VR football teaching videos in advance before class, so as to realize the process of independent teaching and receiving. Students take the initiative to conduct online football testing in combination with teaching videos, so that the teaching content can be further digested and absorbed. Finally, they enter the classroom with what they do not understand. Through mutual communication and discussion between students and students, teachers and students, they can master the teaching content with a comprehensive understanding and further realize the learning process.

Teachers do not have to repeatedly demonstrate the key points of football. By carefully designing some 360-degree panoramic football teaching videos, students are required to study independently before class. Teachers will explain and guide students according to their learning situation in class, which greatly reduces a lot of classroom teaching time. However, due to the characteristics of long duration and large amount of data, 360-degree panoramic video has strict requirements on the network [13, 14]. Therefore, the latency, jitter, packet loss and other factors will affect the experience quality of students scattered around due to the pandemic, while some factors of the video itself will also lead to the decline of user experience quality. Improving the efficiency of video content distribution on the basis of the existing network is currently the focus of further improving user Quality of Experience (QoE).

As an overlay network running on the whole Internet, Content Delivery Networks (CDN) is a new way of network construction [15]. Its main mechanism is to push the data sent by the server to each edge server through intelligent strategy, so that the server closes to the user and with corresponding processing capacity can process the user's data request, which not only shortens the time for the user to wait for the data return, but also greatly reduces the pressure of the backbone network, realizes the dispersion of network load, and improves the speed and hit ratio of the server in response to the user's request [16]. Through the technical level, it can eliminate various problems caused by insufficient network bandwidth resources, user request overload and disordered node distribution. Specifically, CDN is to adopt more cache servers (CDN edge nodes) and deploy them in areas or networks with relatively concentrated user access. When the user visits the video, the global load technology is used to direct the user's access to the nearest cache server, and the cache server responds to the user's request. Unlike the full replication of the origin content server of the mirror server, CDN is the cache of some content, which is more intelligent [17]. The architecture for CDN is shown in Fig. 1.

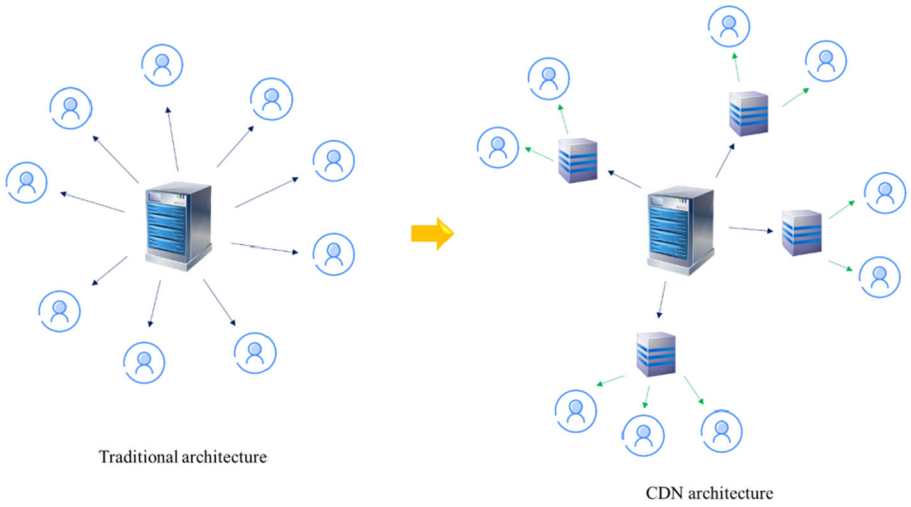
Social Internet technology is developing rapidly, especially the network technology represented by mobile Internet is rising rapidly [18]. In recent years, human society is becoming increasingly intelligent, which has started the research process of artificial intelligence technology and applied this technology to the development of mobile Internet. Accordingly, the contributions of this study can be summarized as follows. (i) We study the principle of CDN. High quality and low latency 360-degree panoramic VR football teaching videos can improve the quality of football teaching. (ii) In the context of mobile Internet, this paper optimizes the 360-degree panoramic football teaching video delivery strategy based on the improved K-means algorithm of machine learning and CDN, effectively reduces the load of the origin server, improves students' QoE and improves the quality of football teaching.

The remainder of this paper is organized as follows. Section 2 reviews related works. In Sect. 3, K-means based optimized 360-degree panoramic VR football teaching video delivery strategy is presented. Simulation results and analysis are presented in Sect. 4. Section 5 concludes this paper.

2 Related works

Information technology promotes the classroom teaching reform of various disciplines in the educational field. By integrating innovative teaching means, it constantly changes the classroom teaching mode, grasps the law of classroom teaching development, and promotes the optimization and perfection of all links and processes of classroom

Fig. 1 Architecture for CDN



teaching. The application of smart teaching methods is the most obvious way to improve physical education teaching quality. Many strategies have been proposed to improve the football teaching quality. Chen et al. [19] introduced the theory of multiple intelligences into football teaching, which was conducive to expand and give full play to the multiple functions of football. Garcia-Angulo et al. [20] analyzed the impact of learning methods based on non-linear teaching method on the health-related physical activity (heart rate) level of adolescent football players. Aiming at the problem that the feedback of traditional teaching mode on training effect in college football teaching lags behind, Zhang et al. [21] constructed a college football practical teaching system model based on big data analysis, which can be found that college football practical teaching under big data was more conducive to improve students' football skills and theoretical level than traditional teaching. Lin [22] used convolutional neural networks to evaluate the accuracy of web2.0 technology in football teaching cooperative learning environment system. Li and Zhang [23] effectively improved the efficiency of football teaching and training by managing the training information of football players and the teaching information of coaches with intelligence. Xue and Liu [24] analyzed the effect of the combination of embedded sensor network and various indexes of football, and used this technology to provide guidance for football teaching.

Video delivery plays a vital role in CDN for 360-degree panoramic football teaching video. Using CDN technology and content caching system to distribute and cache online video can improve the quality of online video service, and has the characteristics of good scalability, reducing video access delay, saving transmission cost and meeting users' QoS needs. However, due to the continuous development of online video, how to distribute video more intelligently and effectively save the cost of video distribution and caching services, so that content distribution technology is still an active research field with many challenging problems to be solved. Li [25] proposed an event detection method based on improved dense trajectory and concept dictionary video feature extraction to identify the tags of short videos and generate a cached video recommendation list for CDN (SV-CDN). Sajithabanu et al. [26] developed a unique cloud based video content delivery model to improve the performance of video content delivery and improve the content placement and QoE in CDN, which was called cloud CDN based on shared storage (SS-CCDN). Dong et al. [27] proposed a multi-CDN assisted crowdsourced-live-streaming (MCACLS) architecture to improve user QoE. Taleb et al. [28] proposed an architecture that provided video CDN function as a multi-domain cloud service. De Cicco et al. [29] proposed a video control plane to monitor the QoE sent by any CDN in the CDN pool, and select the QoE with the best performance when receiving a new video request. Bannour et al. [30] proposed an adaptive continuous consistency model suitable for large-scale deployment of distributed software-defined networking controllers.

By reviewing the methods for improving football teaching quality and video delivery strategies in CDN, we propose the strategy for improving the football teaching quality by AI and metaverse in mobile Internet environment.

3 Optimized 360-degree panoramic VR football teaching video delivery strategy

3.1 Principles for CDN

CDN is based on adding a new layer of network architecture to the existing mobile Internet and pre-distributing

360-degree panoramic VR football teaching videos to the "edge" of the students' nearest network, so that students can access 360-degree panoramic VR football teaching videos requests nearby, which not only reduces the pressure of network congestion, but also reduces the response time of requests [31]. The advantage of CDN is not only that it can push content closer to the edge of students, reducing end-to-end latency of access, but also that CDN breaks through the bottleneck of C/S service mode, reduces the flow burden of backbone network and the load of central server in high concurrent access.

CDN mainly includes origin server, proxy server and client (smartphone). The client sends a 360-degree panoramic VR football teaching videos request to the proxy server. If the video request is satisfied, the content of the video request will be returned directly. If the request is not satisfied, the video request will turn to the origin server, and the origin server will return the video request content to the proxy server, and then the proxy server will return it to the client. The response time of the whole process will be longer, which will affect the quality of students' experience. Therefore, the main purpose of video content distribution strategy is to ensure that under the condition of higher QoE, the hit ratio of video request sent by the client to the proxy server is higher and the response time is shorter. The process of students sending video requests is shown in Fig. 2.

It can be seen from Fig. 2 that the quality of students' football teaching experience can be improved, on the one hand, because of the quality of requested video content. On the other hand, because of the length of video request latency. The shorter the response time, the better the quality of the content, and the better the needs of students, thus improving the quality of the student experience. In view of these aspects, this paper mainly studies the path optimization of video distribution.

3.2 K-means based video delivery strategy

The proxy node of the server is selected based on the K-means algorithm [32]. We first collect all sample data and process the data, so that it can be directly used in the algorithm process. The steps of using this algorithm to select proxy nodes are summarized as follows.

Step 1: Select K cluster centers according to the distribution of students, then traverse the rest of the centers to find the nearest cluster centers, and add it to the cluster. There is an initial clustering result, which is an iterative process.

Step 2: Each cluster center has at least one smartphone, so that the center of each cluster can be figured out as the new cluster center, and then traverse all smartphones to find the nearest cluster center and add it to the cluster. Finally, continue to run Step2.

Step 3: Repeat Step2 until the clustering centers obtained by two iterations are exactly the same.

At this time, the algorithm is relatively stable. K clusters are constructed by obtaining K cluster centers and the nearest observation points, that is, the positions of K proxy nodes.

According to the above steps, K-means algorithm is used to find the best proxy node location of students and optimize the video delivery strategy. The overall process of optimized 360-degree panoramic VR football teaching video contents delivery strategy can be summarized as follows.

(1) Process access records for students' 360-degree panoramic VR football teaching videos, eliminate bad data, retain available access data, and classify highly relevant video content according to keywords or attributes.
(2) Calculate the user interestingness of each video content.

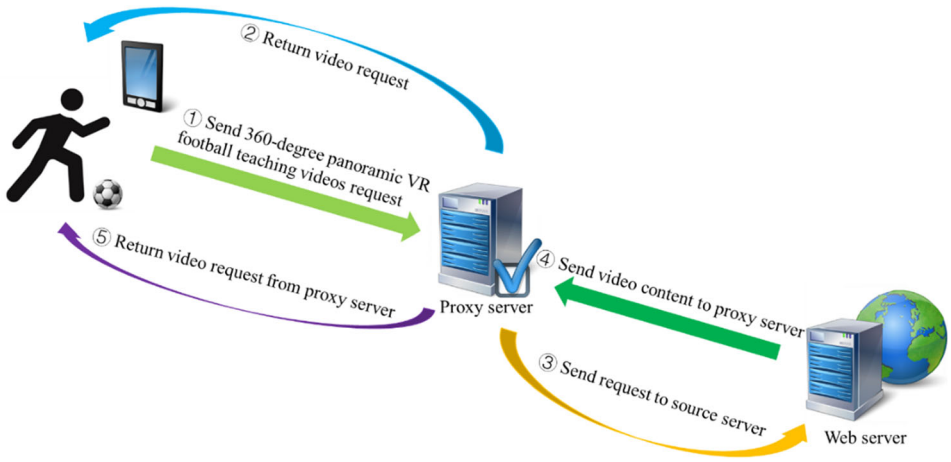


Fig. 2 Process of student request 360-degree panoramic VR football teaching videos

(3) K-means clustering algorithm is used to quickly iterate out the node location of the nearest proxy server for each student and optimize the path of 360-degree panoramic VR football teaching videos delivery.
(4) Finally, the obtained pushed video content is pre-distributed to the nearby proxy server of students, and the prefix cache function [33] is used to prefix each pre-distributed video content to complete the student's video request content.

The optimized 360-degree panoramic VR football teaching videos delivery strategy cannot only reduce the startup latency, but also shorten the response time of students' requests. The pre-distribution of videos with high interestingness of students improves the experience quality of students. K-means algorithm is used to obtain the proxy server nearest to students, which also increases the hit ratio of proxy server.

In addition, what we should consider most is the fluency of 360-degree panoramic VR football teaching videos in transmission. The current mobile Internet is characterized by large bandwidth and low latency, so such a large bandwidth makes it easier to play VR videos [34]. Although the bandwidth of the current mobile Internet has been greatly improved, the network still has fluctuations. When students play 360-degree panoramic VR football teaching videos in real-time, if they directly transmit 360-degree panoramic VR football teaching video, the video may not be smooth. When the latency is greater than 20 ms, students will feel dizzy, which is contrary to the real-time of football teaching videos. In traditional 360-degree video transmission, viewpoint prediction and bitrate selection are usually processed locally. In deep learning of artificial intelligence, complex neural network can obtain the area of visual attention by analyzing historical frames to further improve the prediction accuracy of viewpoint. Reinforcement learning can make full use of network bandwidth to allocate bitrates for tile. High frame rate and high resolution 360-degree panoramic VR football teaching videos can bring better visual experience, thus improving the quality of teaching.

As the rapid development of broadband wireless access technology and mobile terminal technology, people are eager to obtain information and services from the Internet anytime, anywhere or even in the process of mobile. Mobile Internet emerges at the historic moment and develops rapidly. In the Internet era, various training modes based on the mobile Internet environment come into existence.

Video transmission over the mobile Internet can select to transmit only the student's view area when the bandwidth is low. The low latency nature of 5G allows the transmission of the next segment to be suspended in the event of a viewpoint error, ensuring timely transmission of tiles of high coding quality to compensate for the viewpoint area. 5G can reduce client cache in traditional transmission schemes, improve viewpoint prediction accuracy, and improve viewpoint area quality through viewpoint error correction. In addition, CDN can minimize network latency.

4 Simulation and performance analysis

4.1 Simulation parameters

In this paper, a simulation environment was built under Ubuntu 20.04, and the CDN Simulator (CDNSim) was used to conduct simulation experiments on the K-means based optimized 360-degree panoramic VR football teaching video delivery strategy proposed in this paper, and the experimental results were analyzed.

CDNSim is developed based on OMNeT++ simulation environment and INET framework, in which OMNeT++ based on discrete events is an open-source network simulation platform. As a discrete event simulator, CDNSim has a perfect simulation core and is mainly used in the fields of network communication and distributed system. CDNSim simply uses basic network operations in OMNeT++, such as scheduling of discrete events transmitted by TCP/IP. Request routing, content distribution and management, and all the features of the CDN are handled by CDNSim itself.

This paper selects CDN strategies in two collaborative environments: closest surrogate and random surrogate. The network topology in CDNSim is constructed by routing files, each integer represents a node ID, each row represents a link between two network nodes, and the default link type is bidirectional. The network topology of the simulation in this paper uses waxman method. Table 1 shows the network topology parameters.

4.2 Simulation data and steps

To simulate the distribution effect of 360-degree panoramic VR football teaching videos as much as possible, this paper selects 20,000 real-time data of a high-resolution video clips within 5 days.

(1) K-means algorithm is used to find the node location of proxy server and determine the student's request proxy server.
(2) The video content in student access record is manually classified according to title and keyword.

Table 1 Parameters setting

Parameter	Setting
Links speed	1000 Mbits/sec
Clients	100
Number of retries	10
Mean waiting time per retry	5
Number of surrogate servers	10
Number of origin servers	1
Outgoing connections for clients	1000
Outgoing connections for Surrogate servers	1000
Incoming connections for Surrogate servers	1000
Incoming connections for Origin Servers	1000
Number of edge proxy servers	100, 1000
Students	100–1000
Number of requests	10,000

(3) 10,000 pieces of training set data are distributed to 10 proxy servers, and each proxy server has 1000 pieces of data. As the historical access data of the students on the server, and the students' interestingness in the 360-degree panoramic VR football teaching video content on each server is calculated.
(4) The test data was randomly distributed to proxy servers, and each server had 50/100/200/300/400/500 access data. We simulated 50/100/200/300/400/500 user access requests, and recorded proxy server hit ratio, byte hit ratio, mean response time and students QoE.

We used different video content delivery strategies to test the performance of each strategy. The video content delivery strategies used in this paper were SV-CDN [25], SS-CCDN [26], MCACLS [27] and the proposed K-means based optimized 360-degree panoramic VR football teaching video delivery strategy (K-VR-VDS) respectively.

4.3 Simulation results analysis

The hit ratio of proxy server refers to the number of videos that the proxy server responses to students' requests divided by the total number of videos requested by students. As can be seen from Fig. 3, the hit ratio of proxy server of the K-VR-VDS strategy proposed in this paper is very high. Even when the number of video requests is low, the hit ratio of proxy server is over 90%. This is because K-VR-VDS calculates the interestingness of each video content first, which is very helpful to improve the server hit ratio. SS-CCDN also has a high hit ratio due to cloud computing and video content delivery as a service playing a key role in improving content delivery standards. The byte hit ratio is considered from the perspective of byte, which is defined by the ratio of the number of bytes requested to the number of bytes in the proxy server. The byte hit ratio reflects the performance of the network. Therefore, the higher the byte hit ratio, the better the network performance and hence the higher QoE. The byte hit ratio and students QoE are shown in Figs. 4 and 6 respectively. It can be seen that the byte hit ratio and evaluated QoE of the K-VR-VDS strategy are very high. This paper aims to improve the quality of football teaching and makes students immerse themselves in the joy of learning football through 360-degree panoramic VR football teaching videos. However, there is no guarantee of good QoE without a good video distribution strategy. Therefore, the proposed strategy has strong practicability through simulation verification. Moreover, response time refers to the time difference between students' request for video content and their access to the video content after receiving the response from the server. In general, there is an upper limit to students' tolerance of response time. The shorter the response time, the higher the QoE of students. As shown in Fig. 5, with the increasing number of 360-degree VR football video requests, the mean response time of K-VR-VDS strategy is also increasing, but it is always lower than 100 ms. In contrast, the mean response time of other baselines show a significant upward trend. We improve teaching quality through K-means based optimized 360-degree panoramic VR football teaching video delivery strategy, and in 360-degree panoramic VR football teaching videos, the mean response time is an important metric. Lower mean response time will improve the continuity of learning, which is very necessary for football sports with high requirements of action and technology and tactics (Fig. 6).

To sum up, in the mobile Internet environment, the K-VR-VDS strategy proposed in this paper uses the K-means algorithm under the machine learning of artificial intelligence to significantly improve the quality of football teaching empowered by the metaverse.

5 Conclusions

This paper studies the strategies to improve the quality of football teaching based on AI and metaverse in mobile Internet environment. We transform the improvement of football teaching quality into the research of 360-degree panoramic football teaching video distribution strategy under CDN. With the continuous development of video media and CDN, how to make more efficient use of network resources, provide students with better services, and make the students QoE higher is one of the hot issues in CDN research. So how to improve the hit ratio of proxy

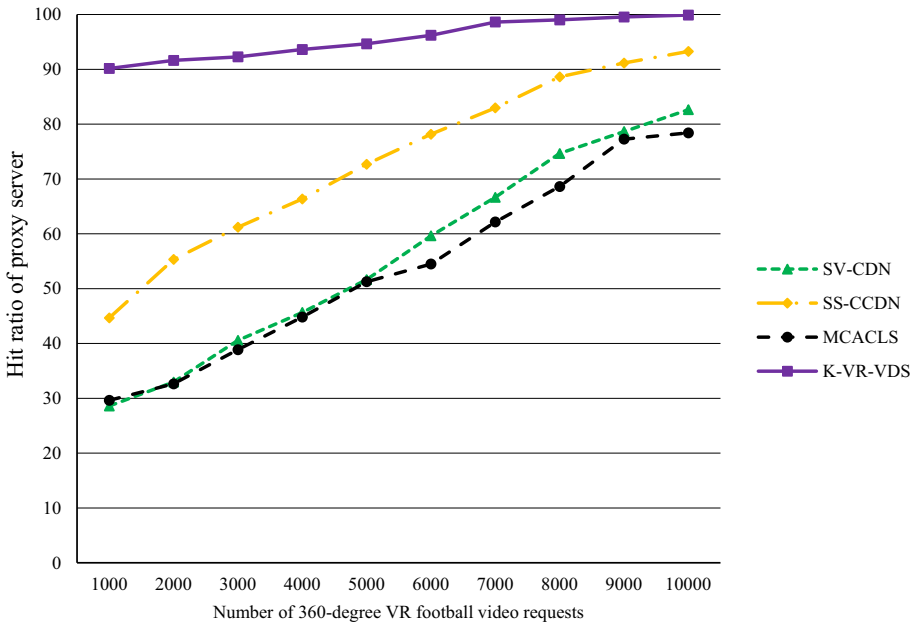


Fig. 3 Hit ratio of proxy server

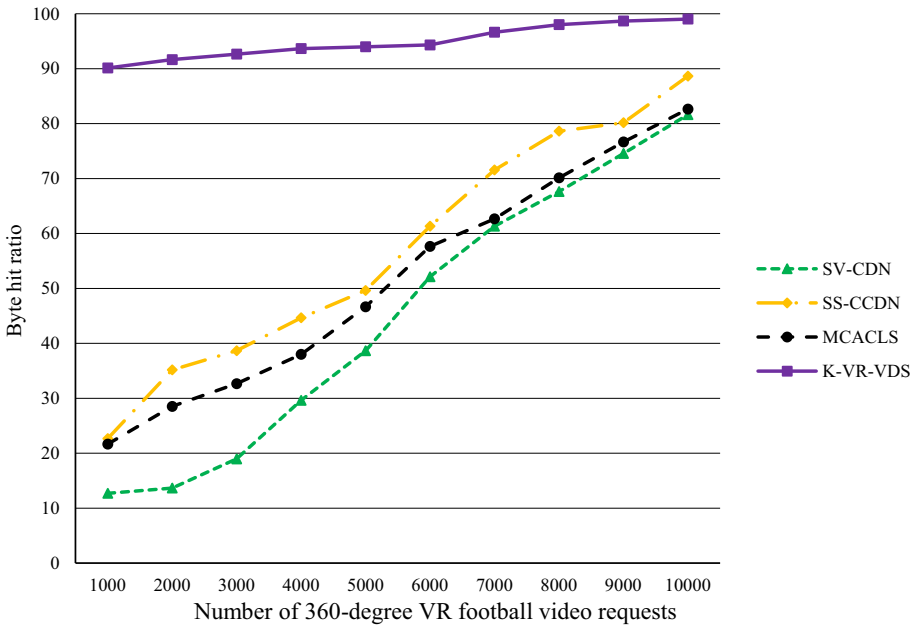


Fig. 4 Byte hit ratio

server, reduce the load pressure of origin server, reduce the latency of student requests and optimize the utilization of proxy server caching resources are the key issues of CDN research. Based on above, we put forward the K-means based optimized 360-degree panoramic VR football teaching video delivery strategy. Through the simulation experiment of CDNSim, the delivery strategy of 360-degree panoramic VR football teaching videos is analyzed. The simulation results also show that the improved strategy proposed in this paper has good performance in hit ratio and response time, and the students have better experience effect in football teaching.

However, there are still some areas that need to be improved and promoted in this paper. Due to the limitation of time, there is no further in-depth study, and the existing problems and prospects are as follows.

(1) The K-means based optimization of 360-degree panoramic VR football teaching video delivery strategy proposed in this paper is only simulated on CDNSim. However, there are certain differences with the transmission process and delivery path in the actual system. At the same time, the experimental data is inconsistent with the actual 360-degree

Fig. 5 Mean response time

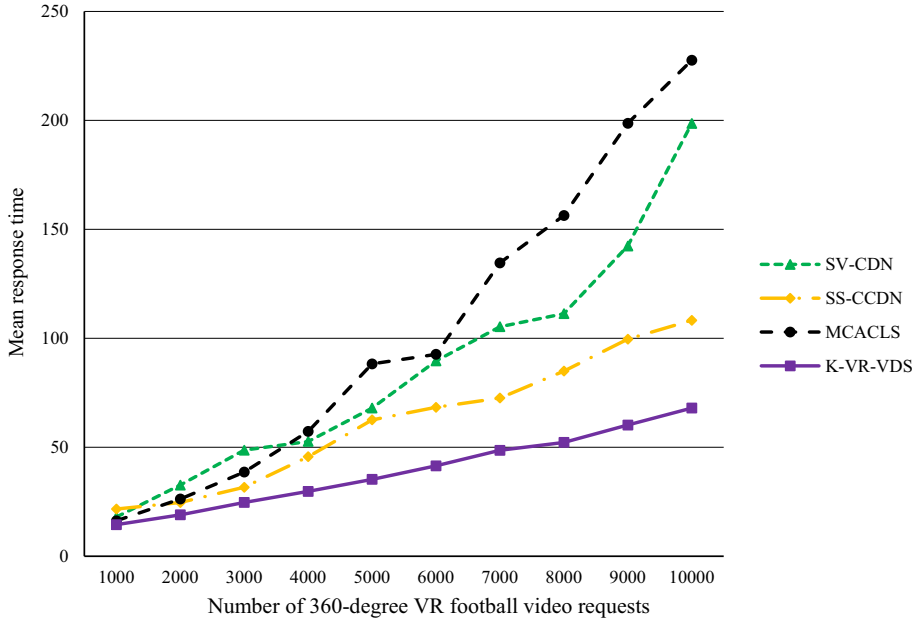
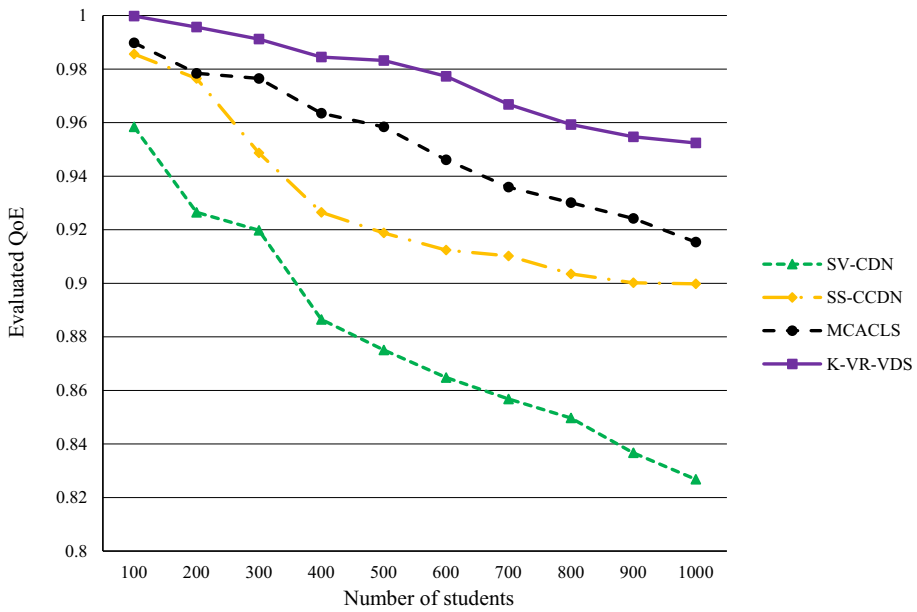


Fig. 6 Evaluated QoE



panoramic VR football teaching videos in resolution, immersion and bandwidth requirements, and cannot represent the real experience of all students in football teaching, thus causing deviations from the actual experience.

(2) The proxy server considered in this paper is single-layer, while most CDN systems in reality are multi-layer proxy server mode, so it is necessary to further study the multi-layer proxy server mode.

Declarations

Conflict of interest Hongyi Li declares that he has no conflict of interest; Chunhai Cui declares that he has no conflict of interest; and Shuai Jiang declares that she has no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Data availability The data used to support the findings of this study is available upon the reasonable request.

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