



Metaverse Technology Enabled Figure Skating Industry Upgrade

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Abstract. With the prevalence of ice and snow sports, figure skating is gaining more and more attention, and how to develop and promote this sport has become a key issue now. This paper attempts to combine meta-universe technology with figure skating to explore the feasibility of technical transformation of figure skating sports, analyzing the situations and problems that may be encountered before the competition, during the competition process, and how to make figure skating form a complete industrial chain to discover specific ways of role and channels for visibility enhancement. Ultimately, it is found that through the use of meta-universe technologies, such as blockchain, Internet of Things, and human-computer interaction, it assists figure skating to break through the problems related to restricted venues and blurred scoring standards encountered before and during the competition, making the competition more fair and visualized. Through sensors, body data analysis and other ways to enhance the analysis of figure skating data in future practice, more accurate to improve the athletes' personal sports level, and provide relevant sports support for figure skating fans.

Keywords: Figure skating · Metaverse · Ergonomics Virtual Reality · Sports and Technology

1 Introduction

In the era of mobile Internet, information technology is changing rapidly, and the wide application of new technologies is helping to transform and change various fields. Led by the fever of the Beijing Winter Olympics, more people have learned about ice and snow sports. Figure skating is the most artistic and infectious competitive sport in ice and snow sports, so it is given the beautiful name of ballet on ice, but because of the small range of audience groups, the high difficulty of completion and the lack of publicity, figure skating has been in a relatively low state. Most athletes learn because they need to compete professionally, while the number of those who learn only as a hobby is relatively small. Some spectators are far away from the figure skaters at the competition and are not able to appreciate their movements in detail, which also leads to poor perception and low attendance, thus making the development of ice and snow sports for all a challenge. Most of the skaters hope to find a coach who understands their bodies and can help improve their training ability while also trying not to hurt their bodies. A good coach is very necessary, so coaching is a position that is in short supply.

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In the field of sports events, meta-universe technology has given more possibilities for event communication, promoting event brands to innovate in product form, content marketing and audience experience to help optimize communication effects. This paper aims to solve the problems that figure skating industry chain often encounters before and during the competition through metaverse technology, and promote the high speed and high quality development of figure skating.

2 Literature Review

The current research on the application of the metaverse to figure skating is divided into three main blocks, the first being how to integrate technology into training to make it more scientific, the second being how to make scoring more fair with the use of AI algorithms and big data, and the last part being how event communication can become more infectious so that the audience can feel the live atmosphere and achieve an immersive experience.

Yilan Li from Shanghai Institute of Physical Education proposed how sports events will be disseminated in the context of metaverse, using 3D technology to replay the wonderful performance of figure skaters in 360 degrees through 3D reconstruction rendering, so that ice fans can fully feel the charm of figure skaters' performance [1]. Yan Zhenlong et al. proposed to help athletes train through a virtual platform to present visualized human movement, assist athletes in scientific training, and record and maintain movement data [2]. Japanese figure skating great Yuzuru Hanyu published a feasibility study on the utilization of wireless inertial sensors as a motion capture system in figure skating, which brought figure skating into the public eye through AI scoring [3]. Junchao Wai et al. published a study on I C T -J C N based motion detection algorithm for figure skaters to help judges overcome the influence of complex environmental backgrounds such as light height to identify and capture movements to assist judges in scoring subtle movements [4]. Huang Cainan et al. proposed the creation of scenes in the meta-universe, empowering the innovation of sports Beijing venues through 5G, artificial intelligence, big data and other technologies to create a kind of new scene that is not entirely based on the replica of the real scene, but a new scene with independence [5], and the Beijing Winter Olympics also added technology to the event broadcast, and the organizer created an almost identical virtual human with Chinese athlete Gu Ailing in front of the screen perform event analysis and broadcast, which greatly improved the efficiency of broadcast and reduced errors [6].

The above articles studied event communication, training methods, and enhanced spectator experience, respectively, and concluded that figure skating itself is a sport that needs to be balanced in many aspects and needs to be promoted for upgrading through multiple dimensions. Jumps and spins are the key to scoring in figure skating, and figure skaters in all countries are currently working to improve their jump weeks to achieve higher scores [7]. However, the improvement of weeks is often accompanied by injuries and it is also crucial to improve the safety of athletes' training [8]. However, the path of technological development is not only technical, but technology cycles through the audience role of arising from people and the passive role of serving them, driving the dynamic development of human beings, who also expand the connotation of human nature with the help of constantly updated self-awareness tools [9].

3 Figure Skating with the Support of Meta-Universe Technology

3.1 Pre-competition Preparation for Figure Skating

3.1.1 Creating a Training Ground in Virtual Space

The training of figure skating requires high ice surface, but in the real world the number of ice rinks is very limited and the quality of the ice surface varies. Therefore, it is necessary to create a virtual training rink in the metaverse. Athletes can wear costumes equipped with sensory equipment and can train only in a relatively empty place. In the virtual metaverse, the temperature, wind speed, and the feeling of sliding on ice can be simulated to help athletes feel what it is like to skate on ice when there is no ice. In the metaverse concept, VR (VisualReality) and AR (AaugmentReality) glasses are used as the computing platform to build a virtual world that is infinitely close to the real world using holographic simulation technology. In simple terms, VR and AR glasses are a “free door” linking the real world and the virtual world, along with the wearing and taking off of glasses, people can switch between virtual and real environments [1]. For sports training, this new training method solves three problems for athletes. First, athletes’ needs for different training scenarios will be further satisfied and they will have a certain degree of autonomy in choosing scenarios; second, the training scenarios will change from the previous “excerpted imitation” of environmental elements to a full simulation of the whole environment, providing athletes with an immersive training experience to optimize their athletic performance in a more integrated and effective way; third, the virtual body provides all athletes with the ability to switch between virtual and real environments. Third, the virtual body provides the possibility of cross-spatial embodied interaction for all individuals and enables athletes to train with other athletes in the same space and time through the virtual body.

3.1.2 Sliding Resistance Simulation

Athletes in the pre-game preparation, through the wearable equipment to help them immerse themselves in the ice, muscle and psychological preparation in advance, to reduce errors on the field. For example, the 2022 Beijing Winter Olympics “wind tunnel” technology was used in the preparation for the Winter Olympics in a number of ice and snow sports training, for China’s Winter Olympics performance to make a key boost, the first gold medal of our team in the Winter Olympics with the help of the “wind tunnel The first gold medal of our team in the Winter Olympics came from the short track speed skating event which was trained with the help of “wind tunnel” technology [2]. Wind tunnels are the main devices for aerodynamic research and are traditionally used in aerospace, high-speed railroads, civil engineering, etc. If this technology is introduced into figure skating, it can help athletes to find the axis and improve the speed of incoming jumps by adjusting the wind speed level and varying the resistance when they do jumps as well as spins. The significance of carrying out multidisciplinary crossover is to enable athletes to optimize their competitive movements through training practice in different scenarios, and this optimization not only connotes finding the optimal competitive posture for the athlete, but also includes improving the stability of the optimal competitive posture display. In short, the conceived meta-universe to help sports will deeply compress

the spatial distance between athletes and training venues, then in the “two-dimensional” space-time “semi-simulation simulation scenes realized by technology will thus cross to the “multi-dimensional” “Full simulation” simulation world, sports training venues to achieve the infinite increment of space.

3.1.3 Bionic Trainer-Assisted Training

Coaches have multiple roles and their responsibility is not only to help athletes discover their strengths and avoid their weaknesses in training and preparation, but also to focus on the artistic development of the athletes [3]. Therefore, professional athletes or demanding figure skaters need professional coaches for guidance. Under the impact of the epidemic, many national athletes are unable to go abroad to find a senior coach for professional training, so they will miss the excellent training time. Metaverse technology can solve this problem by using holographic projection technology to project the coach in the real place where the athlete is training, and at the same time the athlete will also be projected in the space where the coach is, and then through the body’s sensory clothing to truly feel the coach correcting the athlete’s movements. With the help of metaverse, athletes can upgrade from video training to 3D holographic projection perception training, which will give better training conditions to every athlete who wants to perfect his or her movements (Fig. 1).

In figure skating training, the coach will judge whether the training style is suitable for the athlete based on the feedback from long-term training and competition, so as to correct and improve the training style, but this training style will also waste time to a certain extent, and may even hurt the athlete by overtraining and doing movements that are beyond the athlete’s body’s acceptance range in order to improve the level. The body of the athlete. Therefore, we need more scientific and effective training methods, in the Intel 3DAT (3D Athlete Tracking) technology experience area, it is like an “invisible coach” [4]. This technology enables athletes to train in a more immersive and disciplined manner. 3DAT combines computer vision and AI technology to capture multiple key



Fig. 1. Analysis chart of athletes’ jump cycles

Table 1. Analysis of jumps of female figure skaters [5]

name	jump	Number of jumps	Success rate	Serious Mistakes
Alexandra Vyacheslavovna Trusova	3A, 3A + 2T	24	More than 50%	
Anna Shcherbakova	4S	16	50%	
Alexandra Vyacheslavovna Trusova	4T	40	50%	40%
Kamila Valieva	4T	5	60%	
Rika Kihira	3A, 3A + 2T	26	50%	

skeletal points of athletes and accurately analyze their sports posture, helping athletes achieve breakthroughs in sports performance through more scientific means.

Russian women's single figure skater Trusova opened the era of the Triple Axel and quad for women's singles at the 2022 Winter Olympics in Beijing, a challenging jump for women around the world.

In the statistics (Table 1), it can be seen that currently 3A and four-week jumps are still a difficult challenge inside female singles players [5], 3DAT can calculate the difficulty limit of the best movement and the most suitable movement posture for each athlete by collecting and analyzing the big data of athletic posture, which can help them to complete the difficult jumps in a more scientific situation, which can ensure the quality of jumps on the one hand, and reduce the damage of multi-week jumps to athletes' bodies on the other hand.

3.1.4 Intelligent Assisted Psychological Adjustment

Finally, before the competition, the physical and psychological changes of the athletes can be intelligently analyzed by artificial intelligence to develop a suitable competition strategy and pre-competition training by measuring heart rate blood pressure, muscle and bone tolerance, etc., so that they can prepare more scientifically for the competition and achieve the purpose of relieving psychological stress and preparing for the competition with full attention. There is a technology Halo sport that can achieve this auxiliary function, which is a head-mounted device that helps athletes to activate their body and boost neuronal excitement before going on the field [6].

3.1.5 Using the Technology of Creating Avatars to Increase the Heat of the Event

As a niche sport, figure skating should not only assist athletes in training, but also increase the publicity of figure skating events to attract people to watch figure skating competitions, increase their understanding of figure skating, attract more people to learn figure skating, provide more talents for figure skating, and promote the development of

figure skating. In the 100-day countdown to the Winter Olympics, China Mobile MIGU released its first sports figure skater, Meet GU, based on freestyle skiing champion Gu Ailing, officially launching the “Figure Skater Program” [7, 8]. Meet GU is a perfect replica of Gu Ailing’s real person, and can achieve a variety of immersive real-time interaction with users directly, for example, through the video ringtone medium, users can interact with Meet GU through the cell phone screen after setting it with one key. The atmosphere is getting more and more heated, and people’s expectations for the event are getting higher and higher. This is similar to virtual idols, which can satisfy the need of our psychological close contact with idols. Technicians can use digital twin technology to create a layer of relationship in the metaverse for them to get to know each other, and even let the audience’s own favorite figure skaters act as their coaches in the metaverse to assist skating enthusiasts to do some figure skating training in the metaverse and increase the public’s enthusiasm for the sport.

3.2 Intelligent Scoring to Promote the Transformation and Upgrading of Figure Skating

3.2.1 Smart Scoring Current Overview

Figure skating is still scored manually and cannot be completely objective. With technology leading the Winter Olympics, the footsteps of technology are spread all over the Winter Olympics, including AI and 3D motion capture. The traditional scoring mechanism of figure skating competitions is divided into scoring teams and judges, firstly, the technical team judges the plus and minus points of the skaters’ movements through live video, and then it is given to the judges for final scoring [8]. “A lot of Chinese figure skating, including international events, are using foreign scoring products.” Jia Hao, secretary general of the Zhongguancun Digital Intelligence Industry Alliance, told China Electronics News. In January this year, the China Figure Skating Association and the Zhongguancun Artificial Intelligence Industry Alliance jointly released the self-research “Figure Skating AI Aided Scoring System 1.0”, which uses computer vision technology algorithms and deep learning methods to track the overall movement of athletes in real time, according to professional scoring standards, the video The human skeleton and form movements of the data are captured and recognized to achieve stability and visualization of the competition judging [8]. The figure skating auxiliary scoring system adopts a cloud computing architecture and is divided into infrastructure layer, application platform layer, support platform layer, and application terminal, involving technologies such as human posture estimation, target tracking algorithm, ReID algorithm, and video action recognition. Driven by the concept of metaverse, 3D motion capture technology is more widely used. In the field of sports events, 3D motion capture can overcome complex factors such as height and light to capture the subtle movements of athletes [9], and further integrate metaverse technology on the basis of existing technology, so that athletes’ movements can be presented more clearly and three-dimensionally in the eyes of AI judges, and everyone can see the magnified presentation of athletes’ put subtle movements, so that figure skating scoring becomes more objective and fair.



Fig. 2. Body structure labeling diagram [12]

3.2.2 Smart Tags

The accuracy of AI judges can be improved by continuously training AI algorithms. First, a fine-grained labeled figure skating dataset needs to be constructed. Second, a multi-task label detection framework is developed to predict and score the names of action-like segments, combined with a graph convolutional neural network based on 3D skeleton information to further improve the accuracy of more complex jump action name recognition (Fig. 2).

Finally, an event detection framework is built, based on image and action features, using a proven temporal action segmentation network for cutting out highlights in the complete match video, combined with a tag detection framework to achieve end-to-end processing capability for the complete match video. A high accuracy rate of AI scoring was derived in the research analysis, but there is still room for improvement (as shown in the Table 2).

3.3 Industrialization of Figure Skating

If you want to promote the high-quality development of figure skating, you should adapt to the new normal of economic development. First of all, we should optimize the layout of figure skating industry, insist on improving the level of figure skaters in the first place, use meta-universe technology to improve the training efficiency of athletes, and protect the physical safety of athletes to the greatest extent. Grasp the characteristics of figure skating beautiful, high ornamental, and promote the high-speed development of figure skating. Secondly, to grow the figure skating market body, highlighting the importance of enterprise in promoting the figure skating industry, the current ice rink is still dominated by the champion and Century Star, the manufacturing industry to the ice

Table 2. AI scoring accuracy statistics [12]

AI scoring accuracy statistics [10]				
Serial number	Timecode	AI recognition	Actual Action	Correct statistics
1	00:02:09:07–00:02:13:19		Camel spin	0
2	00:05:17:07–00:05:22:19	Camel spin	Camel spin	1
3	00:05:25:07–00:05:32:07	Camel spin	Camel spin	1
4	00:05:35:19–00:05:51:19	Sit spin	Sit spin	1
5	00:06:33:19–00:06:53:19	Combination Spin	Combination Spin	1
6	00:08:07:01–00:08:12:01	Unrecognized	Playback-Camel spin	
7	00:08:23:19–00:08:32:19	Combination Spin	Combination Spin	1
8	00:11:07:07–00:11:14:19	Camel spin	Camel spin	1
9	00:11:46:01–00:11:46:20	Unrecognized	Jpstraight spin	
10	00:12:19:07–00:12:32:07	Sit spin	Sit spin	1
11	00:12:43:07–00:12:49:07	Combination Spin	Combination Spin	1
12	00:12:51:19–00:13:00:19	Combination Spin	Combination Spin	1
13	00:14:50:01–00:14:58:01	Unrecognized	Playback-Combination Spin	
14	00:17:27:07–00:17:35:07	Sit spin		1
15	00:18:46:07–00:18:59:19	Camel spin	Camel spin	1
16	00:19:02:07–00:19:15:19	Combination Spin	Combination Spin	1
17	00:23:32:07–00:23:41:07	Sit spin	Sit spin	1
18	00:24:09:19–00:24:26:07	Camel spin	Camel spin	1
19	00:25:11:19–00:25:29:19	Combination Spin	Combination Spin	1
20	00:26:47:19–00:27:06:07	Sit spin	Sit spin	1
21	00:27:08:07–00:27:25:19	Combination Spin	Combination Spin	1
22	00:30:04:19–00:30:17:07	Camel spin	Camel spin	1
23	00:30:54:07–00:31:06:07	Sit spin	Sit spin	1
24	00:31:43:07–00:31:49:19	Toeloop	Combination Spin	0
25	00:33:52:01–00:33:58:01	Not full	Combination Spin	

skates manufacturing enterprise Black Dragon ice skates, for example, as China's only independent production of ice skates, "Black Dragon ice skates" has experienced a lot of glory. The gold and silver awards show the excellent quality of its products. However, it has stopped production three times because of its unclear positioning and lack of innovation. It also reflects the lack of innovation in China's ice equipment manufacturing enterprises, the lack of planning for their own development and a series of problems. There are also some ice rinks that do not pay attention to the quality of teaching and ignore the training of the foundation, which makes it difficult to raise the difficulty later, so figure skating lacks athletes who have both strength and expressiveness [11]. With the addition of meta-universe technology, it can help athletes lay a solid foundation and achieve higher quality in the process of rising difficulty of jumps in the future. In addition, the management of some ice rinks is not scientific, on the one hand, lies in the problem of not being able to meet the allocation of ice hockey and figure skating venues, and on the other hand, lies in the safety management of ice rinks, if there is not enough protection measures, there are not a few people injured in the ice rink. This is caused by the growth of skating personnel in recent years, so in the absence of a manual approach to completely scientific and rigorous management of ice rinks, an efficient calculation system can be trained through the analysis and calculation of big data, which can calculate the demand for field area for hockey training and figure skating in the case of different numbers of people and different training, so as to carry out scientific field allocation, and also through the production of bionic man, which is coaches are not only limited to real-life coaches, reducing the cost of figure skating coaching classes, but also can create ice rink safety officer bionic man, so that the professionalism and safety of the ice rink is improved, thus making figure skating a more low-priced sport with a broader audience. Therefore, there is a need for more relevant enterprises to join and support, and to always maintain the innovative vitality. There are a large number of virtual enterprises in the meta-universe, which can enhance the technology of figure skating through technical support and scene creation, and ornamental. At present, the existing chain is more complete only the mature large ice clubs such as Century Star and Champion, the vast majority of small and medium-sized clubs are still in the pure figure skating training link [12]. But figure skating training is only one of the links in the industry chain, if we can use the resources accumulated in training to gradually extend to other links of the industry chain, we can extend the overall value of the industry chain, which is beneficial for the club and the whole industry. Figure skating is extremely artistic and can be promoted by holding ice shows, selling related derivative products, and strongly supporting the integration of ice shows with emerging technologies such as Internet big data and artificial intelligence [13]. In addition to this, the ice show stage can be beautified to make the audience immersive and interactive through VR glasses. To give more meaning to figure skating, to make it a unique form of embodied art, so that each ice show can leave a good memory in the hearts of the audience or not. In terms of IP expansion, new figure skating industries such as digital publishing, digital art, and digital creativity need to be cultivated to continuously expand the supply of high-quality figure skating products.

4 Conclusion and Outlook

This paper aims to improve the visibility of figure skating and combine the technology related to metaverse to empower the transformation of figure skating. Through the method of thesis analysis, we study the problems including the restricted venue before the competition, how to promote the event, how to prepare athletes scientifically, and how to use the existing technology combined with metaverse for fair and objective scoring during the competition. Because the metaverse is compatible with sports event communication in terms of technology, user needs and product form orientation, sports event brands can use the metaverse to achieve innovative communication layout. However, metaverse is an emerging concept, and the development of sports event communication innovation naturally faces challenges such as technical limitations, user circle limitations and regulation yet to be completed. In the face of these challenges, sports event brands should remain rational, grasp the technical characteristics of metaverse, and realize the benign interaction between technology and event communication; improve event product content development and stimulate users' creative motivation. Government departments should grasp the development trend of metaverse, improve relevant laws and regulations, and fully activate the vitality of sports event communication innovation and development. Before the competition should focus on the improvement of athletes' physical quality, through the analysis of athletes' body composition, tailor-made training methods for them, and create unique expressions of athletes to the program for different farmer's different body types, physiques, and heights. Make the least injury-prone and more efficient training decisions based on the athlete's different bone density and growth patterns[14]. In terms of event promotion, we should use 3D projection technology, modeling plus scenes plus applications to create digital intelligence, virtual idols and other ways to promote figure skating events to promote the dissemination of the event. In the process of the competition, scoring is a very critical part, through AI and 3D motion capture, to achieve the analysis of video data on the human skeleton, body movement to capture recognition, to achieve stability, visualization of the competition judging, figure skating scoring to the era of artificial intelligence [15]. In addition to events, figure skating should also focus on the development of industrialization, by holding ice shows to produce Kausten, production of derivatives and other ways to continuously inject momentum into the development of figure skating industrialization, and can be combined with the premise of metaverse technology, through the virtual world of the virtual industry to promote the creation of more visualization, more immersive performance, make full use of the metaverse information dissemination quickly, the dimension is more high The show is a great opportunity to promote the basics of figure skating and its high artistic quality. The improvement of science and technology is to meet the higher demand of people in all walks of life, so that figure skating through the use of metaverse technology into a rare combination of competitive and ornamental artwork.

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