

Research on Harbin Digital Ice and Snow Culture Based on All Season Experience

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ABSTRACT

This paper aims to use digital technology as a carrier, and through the application of cutting-edge digital presentation methods such as VR/AR, holographic projection, and motion sensing interaction, break through the development bottleneck of traditional ice and snow cultural activities limited by seasons and regions, and explore how to use interactive art forms with a sense of technology and futurism to create immersive and personalized new experiences for four season ice and snow tourism. By using digital means to construct a virtual real fusion of ice and snow themed scenes, tourists can "cross" to the virtual ice and snow world at any time and any place through intelligent terminals, deepening the public's understanding of the cultural connotation of Harbin's ice and snow. This innovative model can not only achieve uninterrupted display and dissemination of ice and snow culture throughout the year, but also extend the ice and snow industry chain, cultivate new formats of "digital+cultural tourism", inject sustained momentum into the transformation and upgrading of Harbin's tourism industry, and ultimately promote high-quality regional economic development.

Key words: Ice and snow culture and art; Virtual reality; Application of new materials; Somatosensory interaction; Ice-snow tourism

Harbin, a famous northern city renowned for its ice and snow culture, attracts global tourists every year with its unique ice and snow art and festival activities. However, traditional ice and snow tourism heavily relies on harsh climates and physical ice and snow landscapes, and its development is heavily constrained by seasonal factors. The brief operational window not only limits the sustained growth of industry scale and economic benefits, but also hinders the widespread dissemination and in-depth experience of ice and snow culture. How to break through the constraints of natural conditions and achieve full time and wide coverage of ice and snow culture and tourism experience has become a key proposition for promoting the innovative development of Harbin and even ice and snow tourism destinations.

The cutting-edge digital technologies represented by virtual reality (VR), augmented reality (AR), mixed reality (MR), holographic projection, and motion sensing interaction are reshaping the boundaries of cultural expression and tourism experience in unprecedented ways. These technologies have the unique ability to construct surreal scenes, achieve deep human-computer interaction, and provide strong immersive experiences, providing a revolutionary technological path for breaking the temporal and spatial limitations of ice and snow activities. Digital technology is not only a presentation tool, but also a core engine for deconstructing seasonal barriers and reconstructing cultural and tourism experiences. By constructing a highly simulated virtual ice and snow world, tourists can "stroll" on the snowy

central street in summer, or "touch" the crystal clear ice sculptures in warm spring, experiencing the eternal charm of ice and snow in the fusion of virtual and reality. This immersive roaming that breaks through physical limitations injects unprecedented temporal and spatial scalability into ice and snow culture.

Therefore, this study focuses on exploring how to use digital technology as a carrier to deeply integrate futuristic interactive art and innovate to create a year-round ice and snow tourism experience model. The core lies in the use of cutting-edge technologies such as VR/AR, holographic projection, and motion sensing interaction to construct immersive ice and snow themed scenes with virtual real symbiosis and dynamic interaction. Tourists can easily access the virtual world through smart terminals without seasonal or geographical restrictions, experiencing strolling in the snow, participating in ice sculpture creation, feeling extremely cold environments, and deeply appreciating the exquisite and unparalleled art of ice and snow. By this way, the spiritual core and regional characteristics of ice and snow culture can be deeply conveyed, and the cultural identity can be strengthened.

1. Research background and significance

(1) Current situation and characteristics of Harbin's ice and snow culture

Harbin, relying on its profound ice and snow cultural heritage, has gradually developed ice lantern making and ice and snow carving techniques into municipal intangible cultural heritage since the successful hosting of the first Ice Lantern Festival in Zhaolin Park in 1963. In 1999, it showcased its unique ice and snow art charm to the world through the Ice and Snow World project. Over the years, ice and snow culture has become the core engine driving the development of Harbin's winter tourism economy, covering various fields such as ice and snow sightseeing, sports experience, and cultural and creative product development. With strong support from government policies, Harbin's ice and snow tourism industry has long been at the forefront of the country.

The current ice and snow tourism in Harbin is

also facing multiple challenges: the number of tourists has shown a downward trend in recent years. Upon investigation, the severe cold climate is a key factor hindering many tourists from visiting Harbin. Local residents and most tourists from other places often find it difficult to adapt to extremely cold weather, which affects the overall tourist scale. The motivation of tourists presents diversity: some tourists only enjoy the sight of snow flying in the sky, some crave to feel the unique urban vitality of Harbin, and some are attracted by its profound cultural heritage. This difference in demand highlights the urgent significance of developing all season tourism projects. At the same time, industrial operations face practical difficulties: aging ice and snow art equipment, high and sometimes outdated maintenance costs, and difficulty in preserving ice and snow sculptures due to weather conditions, as well as short display periods, further restricting the richness and sustainability of tourist experiences. These factors collectively constitute the development bottleneck that urgently needs to be overcome in Harbin's ice and snow cultural industry.

The special weather of ice and snow has also become the main reason why many tourists hesitate. Local residents and most foreign tourists are not accustomed to the special weather, which has affected the number of tourists. Some tourists may just want to see the snowflakes in the sky, some tourists may just want to feel the vitality and energy of Harbin, and some tourists may just love the strong cultural atmosphere. This is the significance of studying all season project facilities. Nowadays, the innovative development of virtual reality technology has broken through the limitations of geography, climate, environment, time, and space in ice and snow culture, and has broader development prospects. The continuous expansion of the viewer has led to the rapid expansion of the ice and snow culture industry, and the increasing demand for technology has promoted the transformation of scientific and technological achievements into economic and cultural benefits.

(2) Significance of studying Harbin's ice and snow culture

With the rapid development of digital technology, art

and design are undergoing profound changes. Traditional forms of artistic expression are blending with digitization, visualization, and interactivity, making art and design present more diverse and innovative characteristics. The innovative application of technologies such as virtual reality provides a breakthrough for industrial upgrading. Digital technology is breaking through the traditional constraints of geography, climate, time, and space, enabling ice and snow culture to achieve an immersive experience of "year-round". New formats such as virtual roaming and digital ice sculpture not only expand the viewer and promote rapid industrial expansion, but also generate significant economic, cultural, and social benefits through the efficient transformation of technological achievements, opening up broader development prospects for the ice and snow cultural industry. This transformation confirms the core value of technology empowerment for the sustainable development of the cultural and tourism industry.

(3) The application of digital ice and snow technology in the experience of all season ice and snow culture

Digital ice and snow technology has comprehensively innovated traditional design techniques, and works created using digital technology as tools such as digital images, animations, virtual images, etc. are called "digital media art". We are committed to creating visual effects throughout the seasons, allowing tourists to enjoy unique ice sculptures and ice culture experiences in different seasons of Harbin. An ice and snow exhibition hall can be set up in interior design, using digital technology to virtually present ice and snow landscapes. Tourists can use virtual glasses to feel the drifting snow, and add interactive design to deepen the winter experience. Outdoor, light foam materials are used to replace traditional ice sculptures. Traditional artificial ice harvesting in the Songhua River is not environmentally friendly, costly, and difficult to design. This move has low cost, easy carving, strong temporary design flexibility, and can change shapes according to seasons and periods, providing diverse experiences. The application of digital ice and snow technology in the all season ice and snow

cultural experience.

2.Feasibility analysis of digital ice and snow technology in all season ice and snow tourism

(1) Analysis of the current situation and demand for the development of all season ice and snow tourism

As the core area of China's ice and snow tourism culture, Harbin's industry exhibits significant seasonal fluctuations, with a sharp decline in tourists outside of winter. The cultural industry also faces problems such as a single format, weak interactivity, lack of characteristics, and insufficient experience. The rapid development of the tourism industry makes it difficult for a single season model to meet market demand, and tourists' pursuit of rich experiences brings significant opportunities for Harbin's ice and snow cultural tourism. The government supports the hosting of the 9th Asian Winter Games Harbin 2025 to empower ice and snow tourism with policies, improve transportation convenience, and accelerate its development driven by events. Ice and snow sculptures are the core carriers of ice and snow culture. The development of ice and snow projects needs to break through seasonal limitations and strive to present innovative ice and snow elements and culture throughout the season. The digital interactive experience is a key opportunity for current development. Interactive design can enhance tourists' immersive visual focus. Digital technology can generate highly attractive virtual ice and snow landscapes, allowing tourists to experience the fun of ice and snow in diverse scenes, and is applied to digital art creation such as promotional videos, thereby showing Harbin's ice and snow tourism resources to more potential tourists and enhancing the attractiveness of ice and snow tourism products. When tourists immerse themselves in the world of ice and snow, it also provides a new form of dissemination for ice and snow culture.

(2) Problems and solutions in the design process of all season ice and snow tourism based on digital ice and snow technology

Promoting sustainable development of all season ice and snow tourism requires strong policy support and widespread dissemination of Harbin culture.

Expanding public awareness and participation is the key to promotion. The current development of ice and snow technology is relatively lagging behind, specifically, the application breadth of digital ice and snow technology is insufficient, the equipment and facilities are not yet perfect, and significant breakthroughs have not been made in its design and maintenance. In the field of ice and snow culture and art, facility defects can easily lead to poor experience, affecting the viewing effect of the viewer, thereby weakening the positive publicity effect of ice and snow tourism, and even producing negative impacts. The solution lies in exploring the use of digital facilities to achieve the organic integration of traditional art forms and future technological senses, expanding interactive design with innovative thinking and methods, and promoting the cultural characteristics of ice and snow. In addition, specialized cultural courses and design ability training can be offered in universities, and activities such as digital art, ice and snow culture design competitions, and interactive exhibitions can be held. Differentiated interactive forms should be adopted in different seasons to highlight the digital ice and snow characteristics in interior design styles, display works, and interactive experiences, thereby effectively promoting the development of ice and snow tourism throughout the season and the dissemination of Harbin culture.

3. Harbin ice and snow culture experience based on digital ice and snow technology

(1) Design of Harbin ice and snow culture experience scene based on digital ice and snow technology

The application of technology, especially virtual reality (VR), augmented reality (AR) and other technologies, has successfully broken the seasonal dependence of ice and snow art on winter. VR creates immersive skiing, skating, and ice and snow venue experiences indoors, and assists in teaching; AR allows tourists to interact with ice and snow elements overlaid with the real environment at any time and place; Holographic projection vividly reproduces the scenes and artistic forms of ice and snow culture. The combined effect of these technologies not only greatly enriches the

realism and novelty of the ice and snow experience, but more importantly, transforms it into an accessible activity throughout the year, significantly reducing the threshold for participation and allowing a wider group to enjoy the charm and culture of ice and snow anytime and anywhere, achieving the temporal and spatial extension of traditional ice and snow art.

① Immersive indoor ice and snow experiences provided by virtual reality technology

While deepening the interactive design of sound display, virtual reality technology can be deeply integrated to create the ultimate immersion of Harbin ice and snow culture for tourists in any season and indoor environment. By wearing VR headsets, tourists will be instantly transported to a virtual environment that is entirely digitally constructed and themed around Harbin's ice and snow landscapes such as the Ice and Snow World, Snow Village style, Songhua River winter scenery, or ice and snow industry scenes such as ice sculpture workshops and snow expo backstage. In this environment, sound is not only the carrier of information, but also the core element that shapes immersion: the triggered sound guidance device will be upgraded to an AI driven virtual ice and snow guide, whose explanatory sound is like the crisp sound of an ice knife crossing a mirror, the rhythm of an ice sculptor chiseling ice, and the howling of cold wind will be spatially rendered according to the position and line of sight of tourists in the virtual space, bringing a real sense of direction and distance; The concept of interactive sound walls has been expanded. When tourists "touch" virtual ice walls or snow sculptures in VR, they can not only hear realistic touch feedback such as the hard echoes of ice and the rustling sound of snow, but their actions can even trigger a sound chain reaction of virtual ice crystal fragmentation or snow sliding; Voice interactive games can be designed as VR experiences with more ice and snow characteristics, such as simulating blowing sounds to create cold winds to push virtual snowballs to roll, or simulating ice chiseling to "carve" virtual ice blocks and solve puzzles through specific rhythmic clapping sounds. The original sound navigation system and art installations have also been revitalized in VR. Spatial audio guides

tourists to shuttle through the magnificent virtual ice and snow world, while the sounds emitted by tourists themselves, such as astonishment, singing, and simulated ice and snow sound effects, may change the form of virtual ice and snow artworks in real time or trigger dreamlike sound and light symphonies. This VR based sound interaction design completely breaks the limitations of geography and seasons, condensing the unique charm of Harbin's ice and snow indoors. By combining multi-dimensional, high fidelity sound interaction with visual wonders, it provides tourists with a safe, controllable, and year-round immersive ice and snow sensory feast, greatly enhancing the depth and attractiveness of cultural dissemination.



Figure 1 Immersive Experience of VR Virtual Reality Technology

② Enabling seasonal unlimited experiences by augmented reality technology

In the interactive design of exhibition hall action display, in order to completely break through the limitations of physical space and seasonal cycles, and achieve a true "seasonal unrestricted experience", augmented reality (AR) technology can be deeply integrated. By overlaying AR content onto the viewer's real-life view, the exhibition hall can dynamically and personalized present virtual elements, scenes, or information related to specific seasons in any season. For example, in interactive projection walls or 3D interactive experience areas, when the viewer makes specific gestures or body movements, the AR system can "render" scenes of spring flowers, summer green leaves, autumn leaves,

or winter snow in real time on the exhibition items in front of them. It can even change the seasonal attributes of virtual objects, such as making virtual trees bloom or fall leaves instantly with the movements. The jumping, dancing and other movements captured by the motion sensing interactive device can not only trigger sound and light effects, but also drive the seasonal changes of AR scenes or summon virtual characters corresponding to the season to interact with the viewer. This action based AR experience allows the exhibition hall to transcend the constraints of time and physical environment, allowing tourists to immerse themselves in exploring, learning, and experiencing the unique charm of different seasons at any time of the year. It greatly enriches the dimensions and sustainability of the interactive experience, ensuring the year-round online appeal of the exhibition hall. This solution relies on powerful motion capture, spatial positioning, real-time rendering, and cloud data support, injecting unprecedented flexibility and imagination into the core motion interaction design.



Figure 2Real Time Rendering of AR Scene

③ Breaking the seasonal limitations of ice and snow art by mixed reality technology

The visual display interactive design of the exhibition hall is not only a window for presenting information, but also a core means of using cutting-edge technology to completely break the natural seasonal shackles of ice and snow art. By innovatively integrating multiple visual interaction technologies, the venue can create eternal and vivid ice and snow art wonders for the

viewer at any time and in any region. The multimedia display wall is no longer limited to static images, but dynamically interprets the flow of ice and snow in Harbin throughout the four seasons: the crystal clear melting of ice in spring, the translucent ice sculptures in summer, the shape of frost flowers in autumn, and the most iconic winter scenery. Viewers can switch seasonal perspectives and experience the complete life cycle of ice and snow art through touch or gestures. Holographic projection display allows exquisite ice sculptures and snow castles that can only exist briefly in the cold winter to remain suspended in the air "forever". Viewers can see through their complex internal structures from 360 degrees, and even use gestures to "disassemble" and reassemble virtual ice crystals, understanding the mechanical and aesthetic codes of ice and snow art. The 3D printing display transforms fleeting ice and snow masterpieces into permanent tangible models, replicating the fragile textures of ice flowers or the majestic contours of snow sculptures. The viewer rotates and plays with the room, experiencing the eternal charm of frozen ice and snow art. The interactive projection floor simulates the softness of snow and the smoothness of ice surface. When the viewer steps on it, virtual ice flowers bloom in real time or trigger the "ice cracking" effect wherever their "footprints" reach. Even in non snow seasons, they can immerse themselves in the physical touch and visual feedback of the ice and snow world. The smart glasses navigation system has become the ultimate "seasonal filter". After the viewer wears it, the ordinary exhibits in front of them are instantly overlaid with dynamic ice and snow effects - the glass of the display cabinet condenses frost, ice crystals grow on the edge of the booth, snowflakes fall on the surface of cultural relics, and even the entire exhibition hall can be "transformed" into a silver wrapped ice and snow kingdom in real time, and the deeper ice and snow art creation process demonstration can be triggered by scanning. The comprehensive application of these technologies fundamentally transcends the constraints of natural climate, elevating ice and snow art from a temporary seasonal gift to a technology empowered cultural treasure that can be accessed at any time, deeply

interacted with, and experienced for a long time, ensuring that its stunning visual expression and artistic value touch every viewer year-round.



Figure 3 Deep Experience of MR Scene

4. Conclusion and prospect

(1) Conclusion and implications

In the context of the development of ice and snow art, digital art and design has become an important innovation in promoting ice and snow art forms. At the same time, this is also a new way of communication in the digital art world, representing the integration and win-win of tradition and technology. Currently, the main form and driving force of tourism and art development is the integration of tradition and technology.

The digital ice and snow art in Harbin, as a form of all reason tourism, effectively enhances the cultural level of tourism in the region. By utilizing interactive projection exhibition hall design, tourists can immerse themselves in experiencing ice and snow elements and ice and snow sports projects in different seasons. This move breaks through the limitations of time and space, uses technological means to improve the shortcomings of the traditional winter tourism model in Harbin, and provides new directions for the tourism culture of Harbin in different seasons.

(2) Shortcomings and future research directions

Digital art, an emerging form of art, originates from the integration of multiple fields such as digital technology, computer science, and visual communication design. With the continuous advancement and

popularization of digital technology, the position of digital art in the cultural and creative industry is becoming increasingly important.

The continuous advancement of technological innovation will continuously break through climate constraints and provide more possibilities for the application of digital art in ice and snow culture. In order to expand the design and dissemination of seasonal ice and snow culture, in addition to innovation and improvement of digital art technology, it is also necessary to strengthen talent cultivation and technology popularization. The government and enterprises can provide more training opportunities and technical support to encourage more young people to participate in the research and application of digital art. In addition, we can combine the historical, cultural, and natural elements of ice and snow culture for digital art to create more personalized and culturally meaningful works, attracting more tourists to come and enjoy and participate.

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