

Virtual Reconstruction and Contemporary Value of the Revolutionary Footprints of the "Three Martyrs of Changzhou"

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Abstract: Against the backdrop that digital technologies are profoundly transforming the approaches to cultural inheritance, how to activate red resources and pass on the red gene through cutting-edge scientific and technological means has become an important task of the times. Taking the revolutionary course of the "Three Martyrs of Changzhou" as the research object, this paper first interprets the core connotations of their revolutionary spirit, namely the unswerving sense of responsibility, the indomitable striving spirit, and the fearless sacrifice spirit. Furthermore, it constructs an integrated scheme integrating digital twin, artificial intelligence, and extended reality technologies. Then, it puts forward the specific paths to build a digital pedigree of the revolutionary footprints of the "Three Martyrs of Changzhou", including the systematic reconstruction of key scenes, the narrative design of "one main line for one person", the integration strategy of history and art, and the comprehensive presentation of the dynamic pedigree. Finally, it focuses on expounding the multi-dimensional realization paths of the values of the virtual reconstruction achievements, so as to enable the revolutionary footprints of the Three Martyrs of Changzhou to be extensively integrated into various fields of social life and realize their contemporary values at multiple levels and dimensions.

1. Introduction

Qu Qiubai, Zhang Tailei, and Yun Daiying were important early leaders of the Communist Party of China and outstanding proletarian revolutionaries. All three revolutionary predecessors were born in Changzhou, Jiangsu Province, and are later collectively known as the "Three Martyrs of Changzhou" [1]. Although their lives were short, they all shared common spiritual traits: firm ideals and beliefs, a strong sense of national responsibility, indomitable fighting spirit, and people-oriented dedication [2]. In the historical context of national crisis and social turmoil in modern China, they took the lead in accepting and spreading Marxism, actively participated in key practices such as Party building, League building, revolutionary theory publicity, armed struggles, and mass movements, making indelible historical contributions to the founding of the Communist Party of

China, the rise of the Chinese youth movement, the construction of the revolutionary united front, and the cause of people's liberation. The spiritual characters formed by the "Three Martyrs of Changzhou" in the long-term revolutionary struggles are an important part of the spiritual pedigree of Chinese Communists, a precious red cultural resource of the Chinese nation, and possess value-leading power and spiritual appeal that transcend time and space.

The "Three Martyrs of Changzhou" are the most representative and influential red resource in Changzhou [3]. At present, red cultural resources are faced with problems such as single presentation form, insufficient interactivity, obvious spatial-temporal restrictions, and inadequate in-depth experience, which are difficult to meet the demand for scenario-based and immersive cultural experience in the digital era. Changzhou has built a number of memorial halls, former residences, and memorial sites around the "Three Martyrs of Changzhou", but has not yet formed a systematic virtual reconstruction of their revolutionary footprints. The fragmented presentation of historical scenes and low integration of historical materials restrict the activation, utilization, and value realization of red cultural resources. The rapid development of new-generation digital technologies such as metaverse, digital twin, artificial intelligence, and VR/AR has provided a brand-new technical path for the innovative transformation and digital inheritance of red cultural resources, promoting the transformation of red culture from static display to dynamic experience, from one-way communication to two-way interaction, and from textual interpretation to digital narration.

Against this background, carrying out the virtual reconstruction of the revolutionary footprints of the "Three Martyrs of Changzhou", enhancing the sense of ceremony through realistic reproduction and forming memory points through interactive experience [4], and exploring the theoretical framework, technical scheme, and application model of digital activation of red resources are of great significance and value. Theoretically, to clarify the technical logic, narrative rules and value transmission mechanism of virtual reconstruction, expand the research dimensions and expressive forms of the revolutionary spirit of the Three Martyrs of Changzhou, and establish a more contemporary, systematic and cutting-edge research system. Educationally, it breaks spatial-temporal restrictions through virtual reconstruction technologies, turning the revolutionary history of the "Three Martyrs of Changzhou" from static texts into interactively experiential scenes, providing vivid materials for ideological and political courses in universities, middle schools, and primary schools, and facilitating the intergenerational inheritance of the red gene. In terms of application value, it sets an example for the integration of red culture and tourism in the Yangtze River Delta region, extends the cultural tourism industry chain through the mode of "online virtual experience + offline on-site research and study", and helps Changzhou build the urban brand of "Hometown of the Three Martyrs • Famous Red City".

2. Interpretation of the Core Connotations of the Revolutionary Spirit of the "Three Martyrs of Changzhou"

In the great practices of exploring truth, devoting themselves to the revolution, and sacrificing for their ideals, the three revolutionary pioneers of Qu Qiubai, Zhang Tailei, and Yun Daiying jointly tempered and concentratedly embodied a series of precious spiritual qualities, constituting the rich and profound core connotations of the revolutionary spirit of the "Three Martyrs of Changzhou".

2.1 Unswerving Sense of Responsibility

The sense of responsibility of the "Three Martyrs of Changzhou" is rooted in their deep concern for the future of the country and the destiny of the nation, demonstrating their firm belief in

Marxism, absolute loyalty to the Party, and unswerving commitment to the people's revolutionary cause. Trapped in the misery of a semi-colonial and semi-feudal society in modern China, they gave up a relatively stable personal life, took the initiative to shoulder the historic mission of saving the nation from subjugation and seeking national liberation and people's happiness, integrated their personal ideals into the future and destiny of the country and nation, and practiced the responsibility of serving the country and the people with the original aspiration and mission of Communists. As one of the major early leaders of the Communist Party of China, Qu Qiubai chaired the August 7th Meeting at a critical juncture when the revolution faced major setbacks, making a key contribution to saving the Party and the revolution, and shouldering the major historic mission with fearless courage [5]. Zhang Tailei always stood at the forefront of revolutionary struggles, interpreting his loyalty to the Party and responsibility for the revolutionary cause with practical actions. Yun Daiying always stood in the forefront of the anti-imperialist and anti-feudal struggles, guiding a generation of young people to the revolutionary path and becoming an outstanding leader of the youth movement. Amid the complex and severe fighting environment, the three predecessors always adhered to their political stance, firm ideals and beliefs, and loyalty to the Party organization and the people's cause, demonstrating the unswerving and committed spiritual character of Communists with their lifelong struggles.

2.2 Indomitable Striving Spirit

The striving spirit of the "Three Martyrs of Changzhou" is reflected in the revolutionary will and practical character of fearing no hardships and obstacles, facing risks and challenges directly, persevering, and exploring continuously. The early revolutionary path of the Communist Party of China was full of hardships and twists. In the face of the brutal suppression of reactionary forces, the extremely dangerous revolutionary environment, the extreme shortage of material conditions, and the twists and turns in the revolutionary process, the three predecessors always maintained a high-spirited revolutionary fighting will and firm ideals and beliefs, overcame difficulties with tenacious will, and promoted the development of the revolutionary cause through unremitting struggles. Qu Qiubai persisted in theoretical research and revolutionary publicity in the harsh environment shrouded in white terror, translated a large number of Marxist classics, and provided important theoretical support for the Chinese revolution. Zhang Tailei worked long hours on the front line of revolutionary struggles, stuck to his post and fulfilled his duties in an extremely dangerous environment, laying a solid foundation for the launch of the Guangzhou Uprising. Yun Daiying founded and edited China Youth, remaining true to his original aspiration despite setbacks and never diminishing his fighting will amid difficulties. They feared no hardships or sacrifices in revolutionary practices, confronted external pressures with tenacious will, solved development problems with continuous struggles, practiced the spiritual pursuit of Communists' hard work and never giving up with their lives, and set a brilliant example for later generations.

2.3 Fearless Sacrifice Spirit

The sacrifice spirit of the "Three Martyrs of Changzhou" is manifested in the heroic spirit and lofty revolutionary integrity of choosing justice over life and facing death unflinchingly in the face of life-and-death tests. They deeply understood that the revolutionary cause was inevitably accompanied by risks and sacrifices, yet always put the interests of the revolution, the nation, and the people above personal lives, stepped forward bravely and sacrificed generously at critical moments, and practiced the oath of Communists with their lives and blood. After being arrested, Qu Qiubai adhered to his ideals and beliefs, refused the enemy's threats, inducements, and persuasion to surrender, kept the Party's secrets and revolutionary integrity, left his last words, and died calmly,

defending his faith and dignity with his life. Zhang Tailei personally commanded the front line of the battle in the Guangzhou Uprising, took the lead and charged forward, unfortunately sacrificed heroically, and devoted his young life to the cause of people's liberation and armed struggles. After being arrested, Yun Daiying remained unyielding and kept the Party's secrets in the face of torture and political inducements, and finally sacrificed heroically. The three predecessors fulfilled their missions with their lives and forged loyalty with their blood, interpreting the lofty character of Communists who fear no danger and are brave in dedication with heroic sacrifices. Their revolutionary integrity and sacrifice spirit have become an immortal spiritual coordinate in the spiritual pedigree of the Chinese nation, inspiring generations of Chinese people to strive unremittingly for ideals and beliefs.

3. Technical Integration Scheme for Virtual Reconstruction of Revolutionary Footprints

This proposal responds to the practical needs of the virtual reconstruction of the revolutionary footprints of the Three Martyrs of Changzhou, focusing on the three core links: historical scene restoration, intelligent processing of historical materials, and interactive experience design. It provides a stable, efficient and implementable technical path for the high-precision reproduction of revolutionary footprints, systematic integration of historical materials, and immersive communication of red culture, so as to ensure the scientificity, authenticity and experience quality of the virtual reconstruction project.

3.1 High-Precision Restoration of Historical Scenes Based on Digital Twin

Digital twin realizes the all-dimensional digital reproduction of historical buildings, spatial environments, and scene elements through the construction of real-time mapping and precise correspondence between the physical world and the digital world, laying a real and credible digital foundation for virtual reconstruction. This study comprehensively uses technical means such as 3D laser scanning, UAV oblique photogrammetry, and panoramic image collection to conduct all-round data collection on important local sites in Changzhou including Qu Qiubai's Former Residence, Zhang Tailei Memorial Hall, Yun Daiying Memorial Site, as well as key revolutionary activity venues in Shanghai, Wuhan, and Guangzhou. Relying on high-precision real-scene data obtained through 3D laser scanning, UAV oblique photogrammetry, panoramic image collection and other technologies, the refined reproduction of the original appearance of historical spaces is realized. Digital twin technology fully reproduces the temporal and spatial background, environmental atmosphere and scene correlation logic where historical events occurred, ensuring that virtual scenes possess strict historical authenticity, spatial accuracy and detail richness, and supporting the high-quality implementation of the virtual reconstruction project for the revolutionary footprints of the Three Martyrs of Changzhou.

3.2 Integration of Fragmented Historical Materials Based on Artificial Intelligence

The revolutionary historical materials of the Three Martyrs of Changzhou are widely distributed across various carriers. During the long-term historical preservation and communication, they exhibit prominent features such as scattered geographical distribution, a large time span, and fragmented content, which bring considerable difficulties to value mining. To effectively solve this problem, this study adopts artificial intelligence technologies to conduct standardized sorting, structured processing, and intelligent correlation and integration of massive fragmented historical materials, so as to establish a revolutionary historical knowledge system with clear logic, distinct hierarchy, and close relevance. [6]. Through technical means such as text extraction, entity

recognition, relationship extraction, and event clustering, a revolutionary history knowledge graph with characters as the core, events as the clue, and time and space as the framework is constructed. The artificial intelligence system can automatically identify and correlate relevant information scattered in different historical materials, fill in gaps in historical materials, correct contradictions in historical materials, and sort out historical logic, forming a revolutionary history knowledge system with clear logic, complete content, and close correlation. Relying on intelligent retrieval, intelligent recommendation, and intelligent analysis technologies, it realizes the rapid positioning, correlated display, and in-depth mining of historical materials, effectively solving the problem of fragmentation of red historical materials.

3.3 Immersive Interactive Experience Design Based on VR/AR

VR technology constructs a closed virtual space through head-mounted display devices, allowing users to enter historical scenes and gain an immersive experience; AR technology superimposes virtual digital content on the real physical environment to realize interactive experience of virtual-real integration and expand the application scenarios of red culture. This study constructs a multi-level and multi-modal interactive system based on VR/AR technologies, and designs functional modules such as scene roaming, character interaction, event simulation, task experience, and historical material consultation. Users can conduct dialogue and interaction with virtual revolutionary figures in virtual scenes, participate in the simulation process of major historical events, and obtain an immersive historical experience. By comprehensively applying multimodal intelligent interaction technologies, the operation logic and feedback effects in virtual scenes are comprehensively optimized, making the exploration of historical scenes more naturally close to reality. The immersive interactive design based on VR/AR breaks away from the single presentation mode of static exhibitions and constructs an interactive digital historical field. Users are no longer onlookers watching history from a distance, but can intuitively comprehend the revolutionary course and spiritual strength of the Three Martyrs of Changzhou in an immersive experience.

4. Construction of the Digital Pedigree of the Revolutionary Footprints of the "Three Martyrs of Changzhou"

Constructing a digital pedigree enables the systematic integration of the ideological development, key revolutionary practices, and spiritual growth trajectories of the Three Martyrs of Changzhou, and fully presents the complete course of the three revolutionary pioneers from ideological awakening to devoting themselves to the revolution, and from upholding their faith to sacrificing heroically.

4.1 Systematic Reconstruction of Key Historical Scenes

The revolutionary footprints of the "Three Martyrs of Changzhou" span many regions, and different historical scenes carry unique historical significance and spiritual value. Based on historical facts, this study carries out systematic virtual reconstruction of key historical scenes according to time clues and spatial distribution, forming a scene system covering the whole cycle of growth process, revolutionary practice, struggle, and sacrifice. Based in Changzhou, we rely on digital technologies to dig deep into the breeding ground of their spiritual pedigree and personality traits. Focusing on Shanghai, we digitally reproduce the public opinion field for the spread of Marxism and the scenes of organizational construction in the early days of the Party, clarifying their practical logic in the labor movement and youth awakening. Anchoring in Wuhan, we panoramically simulate the key decision-making nodes and political contributions in the torrent of the Great Revolution, highlighting their pillar role in the historical transition period. Fixing on Guangzhou, we reproduce solemn and stirring historical moments such as martyrdom at the

execution ground with highly immersive interactive experiences, inscribing their lofty faith of sacrificing life for justice. Through the organic connection of the above nodes, a three-dimensional, full and traceable red memory field is reshaped..

4.2 Narrative Context Design of "One Main Line for One Person"

To accurately reconstruct the revolutionary map and spiritual portrait of the Three Martyrs of Changzhou, this study abandons the straightforward chronicle narration of traditional style and adopts a dual narrative structure of one main line for one person. While ensuring the closed loop of individual life history, it strengthens the historical joint forces of group interaction, and constructs a red narrative paradigm with both academic depth and emotional warmth. Specifically, taking Qu Qiubai as the axis, it vertically runs through his ideological evolution from enlightenment in the south of the Yangtze River, theoretical translation and introduction to breakthrough in the Soviet Area, highlighting the integrity of intellectuals. Taking Zhang Tailei as the moving line, it horizontally lays out his practical history from studying and aspiring, Party and League building to the Guangzhou Uprising, and three-dimensionally portrays the practical character and sacrifice spirit of a professional revolutionary. Taking Yun Daiying as the bond, it deeply explores his personal charisma from a leader of the youth movement to a fighter in prison, and vividly interprets the value pursuit of benefiting the country and the world. Although the three clues are independent, they jointly weave a hologram of revolutionary spirit with distinct individual characteristics and unified group will, which significantly enhances the explanatory power and penetration of historical writing.

4.3 Integration of Historical Authenticity and Digital Artistry

Historical authenticity serves as the core criterion, and digital art acts as a vital support. The coordination, unification and in-depth integration of the two guarantee the high quality of virtual reconstruction achievements. Adhering to the research principle of taking historical materials as the fundamental basis, this study relies on field archaeological findings and academic expert verification conclusions to avoid fictionalized and one-sided content presentation. Meanwhile, it adopts diverse digital art techniques to fully restore the scene atmosphere of specific historical periods, effectively enhance the visual impact and emotional appeal of virtual scenes, and optimize users' immersive viewing and interactive experience. Balancing academic rigor and public experience, this study seeks an optimal balance between the restoration of historical facts and innovative digital expression. The reconstruction results not only conform to academic norms and withstand professional scrutiny, but also adapt to the communication characteristics of red culture in the digital era, fully meeting the public's demands for cultural experience and ideological and political education.

4.4 Presentation of the Dynamic Digital Pedigree of Revolutionary Footprints

Centered on the spatial and temporal dimensions, the digital pedigree systematically integrates various core resources and constructs a digital resource system featuring visual presentation and interactive operation. Supporting multi-dimensional autonomous browsing, it enables users to flexibly inquire into the revolutionary trajectories of the Three Martyrs of Changzhou and clearly view the real historical scenes and interpretations of spiritual connotations corresponding to different historical stages. Possessing robust capabilities for dynamic expansion and iterative optimization, the digital pedigree can effectively guarantee the integrity, timeliness and professionalism of the red resource system based on newly discovered historical materials,

cutting-edge academic research findings and diversified application scenario demands. At the same time, it supports multi-terminal adaptation and presentation to meet the access and use needs of different scenarios and users. The completion of the dynamic digital pedigree of the revolutionary footprints of the "Three Martyrs of Changzhou" provides core digital resource support for the communication of red culture, and promotes the digital protection and innovative utilization of red cultural resources.

5. Multi-Dimensional Value Realization Paths of Virtual Reconstruction Achievements

The ultimate goal is to make these digital achievements break through the boundaries between research and practice, be widely integrated into multiple fields of social life, and realize their multi-level and multi-dimensional contemporary values.

5.1 Development of "VR Ideological and Political Classroom" for School Ideological and Political Education

Centering on the revolutionary history and spiritual connotations of the "Three Martyrs of Changzhou", the VR ideological and political classroom is deeply connected with school ideological and political courses, history courses, and moral education courses, designing thematic, modular, and stepped teaching contents covering core themes such as ideal and belief education, patriotism education, responsibility education, striving spirit education, and revolutionary integrity education. It creates a "mobile ideological and political class" [7]. Through VR devices, students enter virtual historical scenes, experience revolutionary events, feel the revolutionary environment, and talk with revolutionary figures, understanding history and comprehending the spirit in immersive experience, realizing the transformation from passive acceptance to active exploration. The classroom is equipped with a variety of resources to support teachers in carrying out online and offline blended teaching, group inquiry learning, and other teaching activities. Through situational experience, task-driven, and value-guided methods, it guides students to deeply understand the contemporary connotations of the revolutionary spirit of the "Three Martyrs of Changzhou", cultivate patriotic feelings, firm ideals and beliefs, and strengthen responsibility.

5.2 Design of "Red Metaverse Experience Hall" for Cultural Tourism Integration

Supported by the metaverse technical architecture, the Red Metaverse Experience Hall integrates virtual scenes of cross-regional revolutionary footprints to create a virtual red cultural space. Users can create personalized virtual images, explore historical scenes with other users, participate in interactive activities, and exchange learning experiences, forming a social and immersive red cultural tourism experience. The experience hall is equipped with multiple functional sections integrating diversified functions, and launches characteristic contents such as themed research routes, virtual check-in tasks, and red knowledge competitions to improve user participation and experience. A mechanism for organic connection between online experience and offline research and study is established. Users can formulate offline research and study plans through online experience, and obtain online digital resource supplements synchronously during on-site visits, forming an integrated development mode of "online virtual experience + offline on-site research and study". The Red Metaverse Experience Hall enriches the supply of red cultural tourism products, and helps build Changzhou's red cultural tourism brand and the high-quality development of regional cultural tourism.

5.3 Construction of "Cloud Memorial Hall of the Three Martyrs" with Online and Offline Linkage

Based on the digital twin model, the Cloud Memorial Hall of the Three Martyrs provides basic services such as panoramic browsing, virtual guided tour, historical material consultation, image viewing, and online explanation, allowing users to remotely visit the memorial hall and obtain comprehensive red cultural information without leaving home. The platform is equipped with functions such as online special exhibitions, live explanations, interactive messages, resource downloading, and research and study reservations, and continuously updates exhibition contents, activity information, and educational resources to maintain the vitality and attractiveness of the platform. An online and offline linkage mechanism is established to support online reservation for offline visits, online participation in offline activities, and offline experience docking with online resources, realizing service connectivity, data sharing, and audience intercommunication. The Cloud Memorial Hall of the Three Martyrs breaks the spatial-temporal restrictions of physical venues, expands the coverage and accessibility of red cultural communication, improves the equalization level of public cultural services, and becomes an important digital platform for carrying out red education and inheriting the red gene for the public.

6. Conclusions

Looking back on the turbulent century, the Three Martyrs of Changzhou blazed a trail illuminating the dark ages across Changzhou, Shanghai, Wuhan and Guangzhou with their brief yet passionate lives. They are tangible, flesh-and-blood individuals, and more importantly, abstract totems of the national spirit. Amid the digital wave, this study engages with history through virtual reconstruction. It does not intend to dilute the profundity of history with digital data streams, but strives to explore younger audiences and more vivid expressive forms for this spiritual heritage in a new spatial-temporal dimension. This endeavor goes beyond mere technical simulation; it constitutes a cross-century dialogue. Retracing their footsteps in the digital world essentially helps us clarify our origin and future direction. With continuous technological iteration, this digital spiritual root-seeking practice will become increasingly refined and profound. May the images of the three pioneers, refined by digital technology, no longer remain mere printed words in textbooks, but evolve into an eternal and perceptible spiritual field that endows us with courage and wisdom to move forward whenever the power of faith is needed.

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