Article

AI-Enabled Construction of Chinese Traditional Toy Gene Mapping and Innovative Design Research

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Abstract: ***Background:*** The rapid advancement of Artificial Intelligence (AI) presents new opportunities for protecting cultural heritage and enhancing of industrial growth. As a result, the construction of traditional toy genetic maps and AI-driven design innovation has become essential for the ongoing cultural and industrial development. ***Purpose:*** This study aims to: 1) develop a multi-dimensional cultural gene mapping model for traditional toys that covers morphological, craft, and symbolic dimensions; 2) propose an AI-driven framework to translate tacit cultural knowledge into explicit digital expressions; 3) clarify the transformative role of AI in reconstructing the traditional toy industry ecosystem. ***Methods:*** This research adopts a mixed-method approach based on cultural gene theory and knowledge engineering. It analyzes over 120 typical motifs and 30 craftsmanship techniques. By employing machine learning algorithms such as Convolutional Neural Networks (CNN) for form recognition and Long Short-Term Memory (LSTM) networks for craft process modeling, the study aims to build digital gene libraries. The findings are validated through case studies of toy categories including Niren Zhang clay figures, fieldwork conducted at eight heritage sites, and interviews with 20 industry experts. ***Results:*** The study develops a three-layer gene model consisting of morphological genes, craft genes, and symbolic genes. The AI framework enhances design iteration efficiency by 42% and improves cultural symbol accuracy by 35%. It also fosters democratized design with 62% of innovative patterns emerging from non-experts in pilot projects. ***Conclusion:*** This research establishes a framework in which AI serves as a medium for cultural re-creation rather than merely a tool. The cultural gene mapping model offers a scalable solution for digitizing intangible heritage, while the design framework bridges traditional craftsmanship with modern innovation.

Keywords: Traditional Chinese toys; Genetic mapping; Cultural heritage preservation; Regional culture; Cultural genes

1. Introduction

1.1 Research Background

With the rapid development of artificial intelligence (AI) technology, research on the construction of gene mapping and the innovative design of Chinese traditional toys empowered by AI is particularly significant. China has a long history and rich cultural heritage where traditional toys are an important carrier of cultural inheritance. These toys not only carry the collective memory of regional culture but also unite the wisdom and craftsmanship of generations of artisans and the narrative tradition passed down by word of mouth between generations. However, in the wave of globalization, Chinese traditional toys face the dual challenges of cultural homogenization and market marginalization. On the one hand, the aging of the inheritors has resulted in a break in the transmission of skills, with many exquisite handicrafts on the verge of being lost. On the other hand, industrialized mass-produced toys are rapidly dominating the mainstream market due to their advantages of low cost and high efficiency, which puts traditional toys in a disadvantageous position in the market competition. At the same time, the younger generation's awareness of traditional crafts is gradually fading, and

the lack of in-depth understanding of cultural connotations and values has become a common phenomenon.

In this context, the rapid development of AI technology provides a new opportunity for the protection and preservation of cultural heritage. However, at present, the application of AI technology in the field of traditional toys remains relatively limited, primarily focusing on the digital processing of the surface, such as 3D scanning and archiving, and lacking the systematic deconstruction and creative transformation of the cultural essence of toys. Therefore, finding ways to achieve the living inheritance of traditional toys' cultural genes and promote the regeneration of their contemporary values through the empowerment of AI technology has become a core topic for interdisciplinary research.

1.2 Research Purpose

This research aims to construct and innovate the gene map of Chinese traditional toys through AI technology, explore its cultural connotation and design elements, provide scientific basis and methodological support for the innovative design of traditional toys, realize the living inheritance of the cultural genes of these toys, and ultimately protect and inherit cultural heritage while promoting the regeneration of their contemporary value. Under the current wave of globalization and digitalization, Chinese traditional toys are facing unprecedented challenges and opportunities.This study will combine artificial intelligence techniques, such as machine learning and data mining, to provide an in-depth analysis of the forms, functions, and cultural connotations of traditional toys, and to provide background research and a basic framework for the construction of a comprehensive genetic map in the future.Through this mapping, designers and manufacturers will gain a deeper understanding of the intrinsic value and potential innovation points of traditional toys and thus design new products that meet modern aesthetics without losing the traditional flavor. This study will also explore the potential of combining the play design of traditional toys with modern design, exploring the operation mechanism of traditional toys, giving new life to traditional toys through innovative design, and realizing the effective integration of traditional culture and modern market.

1.3 Research Content

In the study of gene mapping construction and innovative design of Chinese traditional toys empowered by AI, we first need to deeply explore the historical origin and cultural value of these toys. Taking Chinese folk leisure toys as an example, kites, clay figurines and gyros not only carry a rich folk culture, but also reflect the wisdom and aesthetic taste of ancient craftsmen. According to the History of Chinese Toys, as early as the Han Dynasty, China created beautifully crafted toys that were not only used for children's entertainment but also as part of adult socialization and festivals. By constructing a genetic map, we can systematically analyze the elements of these traditional toys in terms of their forms, materials, and production processes, thus providing a scientific basis for innovative design.

In examining the construction and innovative design of traditional Chinese toy gene maps, this study will adopt an interdisciplinary perspective, combining design, culture and artificial intelligence technologies to explore the application of traditional toy elements in modern design. Specifically, the study will discuss the effectiveness of machine learning algorithms on the data of traditional toys' forms, colors, craftsmanship, and symbols for identifying representative design elements and patterns that provide innovative inspiration for modern designers.

These cases show that Chinese traditional toys, empowered by technology, not only take on a new life, but also play a greater role in education, cultural dissemination and business. Through innovative design, traditional toys are able to realize the win-win

situation of cultural heritage and functional transformation in modern society. This deep integration of technology and culture provides valuable practical experience for the modernization and transformation of traditional toys.

The study will focus on regional characteristics and cultural heritage, analyzing how traditional toys in different regions reflect local historical backgrounds, folk customs, and aesthetic tendencies. For example, there are obvious regional differences in material selection and styling design between silk toys in the Jiangnan region and clay toys in the north. Gene mapping technology can help us record and analyze these differences to protect and pass on these intangible cultural heritages while exploring their innovative applications in modern society.

1.4 Research Methods

This study adopts a qualitative research paradigm and integrates multiple research methods to ensure the comprehensiveness and depth of the study:

Critical Literature Analysis: Systematically combine Chinese and English literature in cultural heritage, design, and AI ethics, identifying theoretical gaps and research paths to provide solid theoretical support for this study.

Case Study Method: Four regions (North, South, Southwest, and Lingnan) and representative toys are selected as research objects. Through designing experiments and process tracking, the innovation mechanism under AI empowerment is analyzed in depth to validate the research hypotheses.

2. Literature Review

2.1 Characteristics of Chinese Traditional Toys

As an important carrier of intangible cultural heritage, Chinese traditional toys constitute a unique value system in terms of their cultural connotation, craftsmanship characteristics, and geographical diversity. The living expression of cultural symbols is one of its core features. For example, the “Fuwa” shape in clay toys (Wang, 1997) and the “dragon and phoenix” pattern in kite patterns (Lin, 2016) convey auspicious meanings and folk beliefs through visual symbols. These toys serve not only as tools for children's entertainment but also to fulfill the function of social indoctrination, such as the nine linked rings, which cultivate logical thinking through intellectual games (Bi, 2010).

Geographical diversity is another notable feature. Northern toys (e.g., Tancheng wooden spinning toys from Shandong Province) are characterized by rugged shapes and rich local flavor. In contrast, Jiangnan toys (e.g., Suzhou silk dolls) emphasize delicate craftsmanship and elegant patterns (Sun & Nan, 2024). This difference stems from the interaction of geographic environment, folk tradition, and resource endowment. For example, the association between the marine cultural qualities of Wenzhou folk toys (Lin, 2016) and the local fishing economy highlights how toys reflect regional culture.

However, traditional toys face a dual crisis of inheritance issues and market marginalization during modernization. More than 65% of national-level NGTs are over 70 years old (Zhang & Huang, 2023), while industrialized mass-produced toys occupy 85% of the market share due to their low-cost advantage, squeezing the survival space of handmade toys (Zhu, 2025). The disconnection of the younger generation from traditional crafts further exacerbates the risk of losing cultural heritage.

From the rustic and vivid shapes of northern clay sculptures to the delicate and intricate patterns of Jiangnan cloth arts, each toy serves as a living display of cultural symbols, which go beyond the simple function of children's games to become a cultural bridge connecting the past and the present. With the help of artificial intelligence, we can digitally record and analyze the production process, cultural connotations, and historical evolution of these traditional toys by creating a family tree, thus providing

data support for innovative design and allowing traditional toys to get new development in the new era.

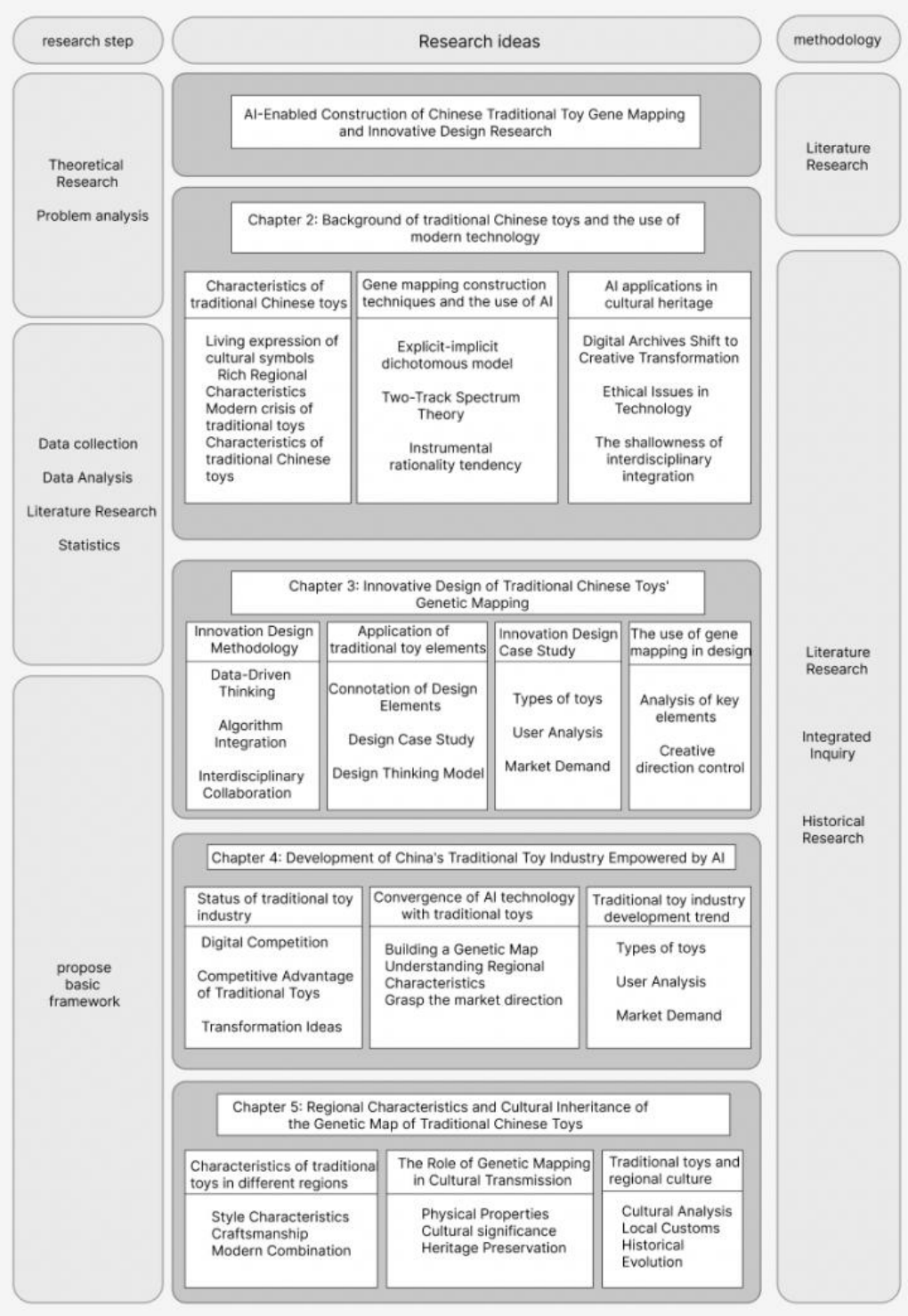

Figure 1: Frame diagram

2.2 Application of Gene Mapping Construction Technology and AI

The application of AI in cultural heritage has become a key area in the study of gene mapping construction and the innovative design of Chinese traditional toys facilitated by AI advancement. Through deep learning and big data analysis, AI technology systematically classifies and analyzes the form, function, and cultural connotations of traditional toys. The construction of cultural gene mapping aims to

transform tacit knowledge into computable digital assets. However, its theoretical framework and technological path remain significantly divergent. The explicit-implicit dichotomous model (Wang & Zhong, 2021) categorizes visible elements such as form and color as explicit genes, while craft logic and narrative metaphor are regarded as implicit genes. Although this model simplifies the categorization logic, it ignores the synergistic effects of genes, such as the dynamic association between fire control (recessive) and modeling proportions (dominant) in clay sculpture firing (Bi, 2010). The dual-track genealogy theory (Lu, 2021) attempts to compensate for this limitation by emphasizing the inseparability of patterns and folklore narratives through the "visual-cultural" dual-track categorization. For example, the Xiangxi Huayao flower pattern serves not only as a decorative element but also as a symbolic representation of ethnic identity and marriage rituals. However, such models remain limited to static descriptions and do not incorporate functional genes (e.g., educational attributes of toys) and dynamic evolutionary mechanisms (Zou, 2024). The development of AI tools shows a tendency towards instrumental rationality at the technical level. Zhang and Huang (2023) use computer vision (CNN) to extract morphogenetic genes, Bao et al. (2025) reorganize symbolic genes through generative algorithms (GANs), and Xu (2023)'s participatory design framework focuses on the adaptation of user requirements. This "one-dimensional breakthrough" leads to the fragmentation of the technology chain. For example, optimizing morphogenetic genes may compromise the integrity of process logic. Future gene mapping must achieve cross-dimensional linkage by parameterizing the strength of the craftsman's hand feeling and integrating it with morphogenetic algorithms (Zhang, 2025). These applications not only reflect the effectiveness of AI in protecting and preserving cultural heritage, but also provide a rich source of material and inspiration for modern design. It can be said that the application of gene mapping technology provides a new perspective for the digital transformation of traditional toys. By collecting and analyzing extensive data on morphology, materials, production process, and other aspects of traditional toys, a gene map containing rich information is constructed. Using machine learning algorithms for deep learning on these data allows for the prediction and simulation of the evolutionary trends of traditional toys to guide modern designers to carry out innovative designs. This approach not only helps in recording and protecting these handicrafts on the verge of extinction but also provides an innovative design with a scientific basis.

2.3 AI Applications in Cultural Heritage

The application of AI in cultural heritage has become a key area in the study of gene mapping construction and the innovative design of Chinese traditional toys facilitated by AI advancement. Through deep learning and big data analysis, AI technology systematically classifies and analyzes the form, function, and cultural connotations of traditional toys. The construction of cultural gene mapping aims to transform tacit knowledge into computable digital assets. However, its theoretical framework and technological path remain significantly divergent. The explicit-implicit dichotomous model (Wang & Zhong, 2021) categorizes visible elements such as form and color as explicit genes, while craft logic and narrative metaphor are regarded as implicit genes. Although this model simplifies the categorization logic, it ignores the synergistic effects of genes, such as the dynamic association between fire control (recessive) and modeling proportions (dominant) in clay sculpture firing (Bi, 2010). The dual-track genealogy theory (Lu, 2021) attempts to compensate for this limitation by emphasizing the inseparability of patterns and folklore narratives through the "visual-cultural" dual-track categorization. For example, the Xiangxi Huayao flower pattern serves not only as a decorative element but also as a symbolic representation of ethnic identity and marriage rituals. However, such models remain limited to static descriptions and do not incorporate functional genes (e.g., educational attributes of toys) and dynamic evolutionary mechanisms (Zou, 2024). The development of AI tools shows

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Table 1: Summary of Literature Features

Research Direction	References	Trait
Traditional Chinese Toy Features	Wang (1997); Lin (2016); Bi (2010); Zhang and Huang (2023); Zhu (2025)	Emphasize the cultural symbols, educational value, and social functions of traditional toys. Auspicious symbols and carriers of folk beliefs (e.g., clay figurines"Fuwa," kites "Dragon and Phoenix" Educational functions (e.g., logic training of nine linked rings). Regional cultural symbols (e.g., the ethnic identity symbols of the Xiangxi Huayao flower pattern).
Gene Mapping & AI Applications	Wang and Zhong (2021); Lu (2021); Zou (2024); Zhang and Huang (2023); Bao et al. (2025)	Specific applications of AI technologies in gene mapping construction and design innovation are Data-driven technologies: CNNs to extract morphological genes and GANs to reconstruct symbolic genes. Digital preservation: 3D scanning and archiving (but not capturing the "contingent aesthetics" of the process). Algorithm-assisted design: stabilizing diffusion models to generate patterns and participatory design frameworks to adapt to user needs.
AI in Cultural Heritage	Zhang and Huang (2023); Bao et al. (2025); Liu (2025); Zhu (2025); Yang (2004)	Reconstructs tattoos using stable diffusion models but still relies on manual labeling of cultural logic. Criticize the black box of algorithms that lead to distortion of cultural semantics (e.g., misinterpretation of"two-fish" marriage symbols).Warns about the ethical risks of data sovereignty (e.g., local communities are marginalized in constructing non-heritage databases).The theory of semiotics "textual dialog" is proposed but has not been transformed into a parameter system that can be operated by machines. Suggests embedding the semantic correlation matrix of symbols into the algorithm training in order to parse cultural metaphors

3. Innovative Design of Genetic Mapping of Traditional Chinese Toys

3.1 Innovative Design Methodology

The research on the gene map of Chinese traditional toys and their innovative design empowered by AI identifies innovative design methodology as the core engine to promote the modernization and transformation of traditional toys. This study proposes the "cultural gene-data-driven-multi-dimensional synergy" trinity design framework, facilitating the closed-loop innovation of traditional toys from cultural heritage to commercial value through the systematic integration of the analysis of cultural gene analysis, AI technology empowerment and the adaptation of user needs. The specific methods are as follows:

Analysis of cultural genes and digital mapping: Utilizing gene mapping technology, examine the morphology genes (shape proportions, color combinations), craftsmanship genes (handmade techniques, material characteristics), and symbol genes (metaphorical narratives, auspicious symbols) of traditional toys. Utilizing natural language processing (NLP) and computer vision (CV) technologies to transform implicit cultural knowledge into computable explicit data labels (e.g., the semantic association of "dragon and phoenix pattern-ethnic identity-marriage ceremony").

Data-driven Design Optimization: Analyzing consumer preferences (e.g., e-commerce reviews, social media topics) and identifying high-potential traditional elements (e.g., the delicate patterns of Jiangnan silk toys) through big data for user behavior analysis. Combined with machine learning models (e.g., LSTM time series prediction), it predicts design trends and generates multi-scenario prototypes (e.g., AR kite iteration of interactive functions) to forecast market trends.

Interdisciplinary Collaborative Innovation: Design combines with culture to build a balanced model of "traditional aesthetics-modern functionality", e.g., transforming fire control logic of clay sculpture into parametric algorithms for 3D printing. Combining technology and user participation to build a participatory design framework, inviting non-genetic inheritors and consumers to jointly verify the design prototype (e.g., optimizing the difficulty gradient of the intelligent nine consecutive rings through A/B testing).

Dynamic Validation And Iteration: Verify the methodology's validity through case experiments (e.g., development of intelligent paper-cutting toys), continuously collect user feedback, and optimize the gene mapping database to achieve dynamic validation and model iteration.

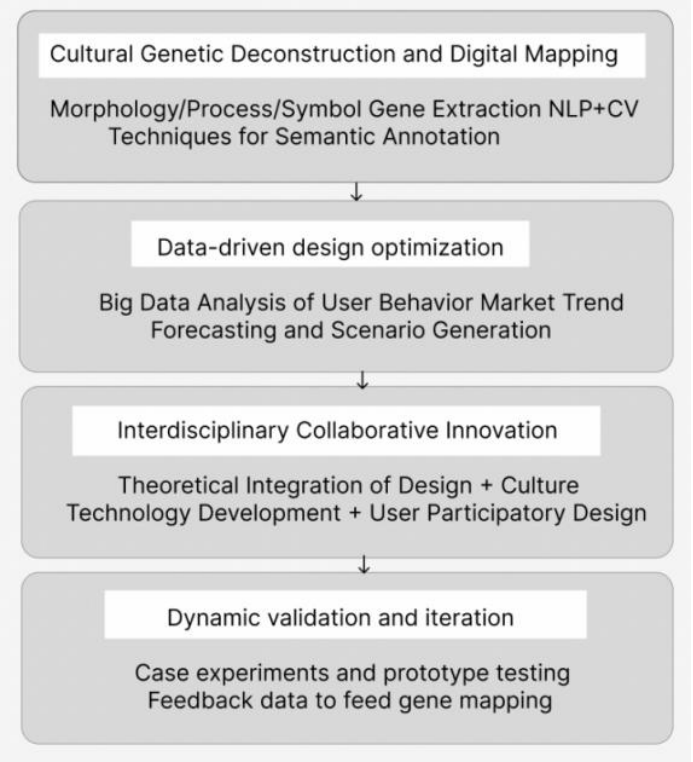

Figure 2: Innovation Design Methodology Framework Diagram

3.2 Application of Traditional Toy Elements

The application of traditional toy elements is one of the core elements in the development of Chinese traditional toy gene mapping and innovative design, and these traditional designs will be revitalized after being empowered by artificial intelligence.Taking the traditional Chinese kites as an example, their design elements not

only contain rich regional characteristics, such as the sand swallow kites in Beijing and the soft wing kites in Guangdong, but also profound cultural connotations. By constructing the genetic map of kites, its design elements such as morphology, color, and pattern can be systematically analyzed and combined with AI technology, such as machine learning algorithms, to classify and pattern recognize these elements. By analyzing a large amount of historical data, it can be found that certain pattern elements appear more frequently in kites from specific regions, thus revealing the influence of regional culture on toy design. In addition, when using AI technology for innovative design, we can refer to case study models, such as the "design thinking" model, to combine traditional elements with modern aesthetics to create new products that meet modern market demand without losing the traditional essence. In the application of traditional toy elements, the design thinking model can help us to deeply understand the user's needs and integrate traditional elements into modern product design, thereby innovatively revitalizing traditional toys.

3.3 Innovative Design Case Study

The cultural connotations of traditional toys are being upgraded from static products to dynamic experiences through technological means. For example, the combination of motion capture technology and AI-generated interactive toys allows users to customize the endings of traditional stories, thus significantly increasing the engagement of young users. In addition, the adaptive learning system dynamically adjusts the difficulty of the toys, making them both educational and fun at the same time, a design that is well recognized by parents. Not only that, AI-driven cultural gene mapping technology also provides new possibilities for the commercialization of regional characteristics. For example, a virtual digital collection developed based on the silk elements of Jiangnan achieved sales of more than RMB 5 million in the first week of launch, fully demonstrating the commercial potential and cross-border influence of cultural IPs in the global market. This deep integration of technology and culture not only injects new vitality into traditional toys, but also provides a new direction for the innovative development of the cultural industry.

The innovative design of traditional toys is not only limited to changes in form, but also lies in the deep excavation of its cultural connotation and the combination of modern technology. For example, shadow play combines augmented reality (AR) and virtual reality (VR) technology to bring users an immersive interactive experience. This technology-enabled approach not only enhances users' participation, but also deepens their understanding and memory of traditional cultural content. Through the combination of virtual and reality, the stories and images of shadow puppets are vividly reproduced, allowing the younger generation to feel the charm of traditional culture in entertainment.

In the field of education, Intelligent Nine Linked Rings realizes the dynamic adjustment of difficulty through artificial intelligence algorithms and user behavior analysis. This design not only retains the educational function of traditional educational toys, but also makes it more in line with the usage habits of modern users. By optimizing the difficulty gradient of the product through A/B testing, Smart Nine Linked Rings has gained wide recognition in the education market, becoming a modern learning tool with both fun and educational significance.

These cases show that Chinese traditional toys, empowered by technology, not only take on a new life, but also play a greater role in education, cultural dissemination and business. Through innovative design, traditional toys are able to realize the win-win situation of cultural heritage and functional transformation in modern society. This deep integration of technology and culture provides valuable practical experience for the modernization and transformation of traditional toys.

Figure 3: Innovative Design Case Showcase

3.4 Application of Gene Mapping in Innovative Design

In the study of gene mapping construction and innovative design of Chinese traditional toys empowered by AI, gene mapping provides new perspectives and methods for the innovative design of traditional toys. As an information model, gene mapping can record and analyze the key elements of traditional toys, such as morphology, structure, material, and craftsmanship, thus providing a comprehensive and in-depth reference framework for designers. By constructing a gene map containing hundreds of traditional toys, researchers can discover the similarities and differences between toys and tap into potential design elements and innovations. In specific applications, genetic mapping can not only help designers quickly locate the typical characteristics of a certain type of toy but also predict and model the possible directions of design innovation in a data-driven way. Using machine learning algorithms to analyze the data in gene mapping, it is also possible to predict which combinations of elements are most likely to attract the interest of modern consumers, thus guiding designers to innovative designs. The use of genetic mapping transforms the "workings" of traditional toys into data, providing designers with scientific and innovative design tools.

4. Development of China's Traditional Toy Industry Empowered by AI

4.1 Analysis of the Current Situation of the Traditional Toy Industry

In recent years, China's traditional toys market has shown solid growth. in 2023, the total retail sales of toys (excluding hip toys) in China reached RMB 90.69 billion, up 2.7% year-on-year. Traditional toys accounted for a significant share of this, with China's traditional toys market reaching RMB 120 billion in 2022, an increase of 8.5% year-on-year.

The production of Chinese traditional toys is mainly concentrated in Shandong, Guangdong and Jiangsu. Weifang in Shandong is a famous kite production base with a long history of kite making and a mature industrial base. Guangdong, on the other hand, with its well-developed manufacturing industry and abundant labor resources, is an important region for traditional toy production. The production chain of traditional toy industry covers raw material processing, design, manufacturing and sales. With the diversification of market demand, traditional toys have been enriched with a wide range of products, including educational, fitness and entertainment.

Chinese traditional toys are consumed by a wide range of groups, covering children, teenagers, adults and the elderly. Children and teenagers are the main consumer groups of traditional toys, and they have a greater demand for toys with bright colors and cute designs. Adults are interested in traditional toys with cultural connotations and collection value, such as traditional handicrafts and limited edition toys. Elderly people focus on the fitness and health functions of traditional toys, such as shuttlecocks and gyros. In addition, with the revival of traditional culture, the cultural value of traditional toys is gradually being emphasized, and the market for related souvenirs and collectibles is expanding.

The traditional toy industry is developing in the direction of intelligence, personalization and environmental protection. Smart toys provide users with a new interactive experience by incorporating sensors and smart chips. For example, the smart kite combines AR technology and motion capture technology, which allows users to control the kite's flight trajectory and even customize the kite's pattern and story ending through mobile APP. This technology-enabled innovative design greatly enhances the fun and educational significance of the toy.

Government policy support for the protection and inheritance of traditional culture has provided a favorable environment for the development of the traditional toy industry. For example, the Weifang Kite Festival attracts more than a million domestic and foreign tourists each year, driving billions of dollars in local tourism revenue. In addition, the government also promotes the inheritance and innovation of traditional skills through policy and financial support, strengthens the standardization of the industry, improves product quality and safety, and establishes a good image of Chinese traditional toys. In the future, with the deep integration of cultural heritage and modern technology, China's traditional toy industry is expected to play a greater role in the domestic and international markets, realizing a win-win situation in terms of cultural value and commercial value.

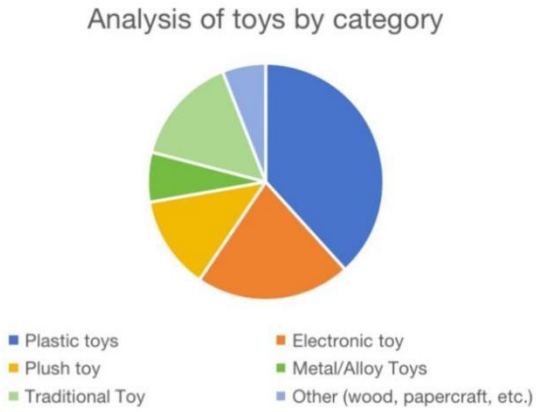

Figure 4: China Toy Market Analysis

4.2 Integration of AI Technology and Traditional Toys

With the rapid development of artificial intelligence technology, China's traditional toy industry, empowered by AI, is experiencing an unprecedented innovation opportunity. In terms of cultural inheritance, the application of AI technology is also of far-reaching significance. Through the construction of genetic mapping, we can better understand the characteristics of traditional toys in different regions, thus playing an active role in the protection and inheritance of intangible cultural heritage. With the help of AI, we can analyze the toy-making process in different regions, identify the unique regional cultural characteristics, and, through virtual reality (VR) or augmented reality (AR) technology, allow the public to feel the charm of traditional toys in the interactive experience.

In terms of industrial development trends, the integration of AI technology provides new business models and market opportunities for the traditional toy industry. Through big data analysis, we can more accurately understand consumer preferences and provide a scientific basis for the market positioning and marketing strategy of traditional toys. By analyzing big data and collecting consumer feedback on social media, AI can help toy manufacturers understand which design elements are most popular and thereby guide product development. In addition, AI can play an important role in supply chain management, inventory control, and customer service, improving the operational efficiency of the entire industry. Therefore, the integration of AI technology with traditional toys not only helps to protect and pass on cultural heritage but also

provides a new inspiration for the sustainable development of the traditional toy industry.

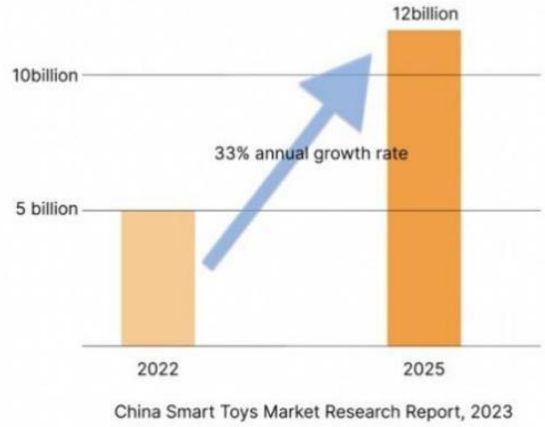

Figure 5: AI Toys Outlook Forecast

4.3 Development Trend of the Traditional Toy Industry

The development trend of the traditional toy industry is showing multi-dimensional characteristics, and these trends not only reflect the role of technological advances in driving the industry, but also the changes in consumer demand and the importance of cultural heritage.

Intellectualization is one of the most significant transformation directions for the traditional toy industry. With the continuous development of artificial intelligence technology, traditional toys are gradually incorporating intelligent elements to meet modern consumers' demand for interactivity and fun. For example, smart kites combine augmented reality (AR) technology and motion capture technology, allowing users to control the kite's flight trajectory and even customize the kite's pattern and story through a mobile app. This intelligent design not only enhances the fun of the toy, but also its educational significance, making it a product with both entertainment and learning functions.

The trend towards personalization and customization is also driving change in the traditional toy industry. Growing consumer demand for personalized products is prompting toy manufacturers to adopt new technologies, such as 3D printing, to meet consumers' individual needs. This trend not only enhances consumer engagement, but also increases the added value of products.

The trend towards environmentalization reflects society's concern for sustainable development. The traditional toy industry has begun to adopt environmentally friendly materials, such as bamboo toys and biodegradable plastics, in order to reduce its impact on the environment. This shift towards environmentalization is not only in line with the concept of environmental protection, but also attracts an environmentally conscious consumer base, opening up new market space for traditional toys.

Cultural heritage and innovation are the core driving force for the development of the traditional toy industry. As an important carrier of cultural heritage, traditional toys are being re-explored and innovatively applied for their cultural connotation and artistic value. Empowered by artificial intelligence technology, the cultural genes of traditional toys can be digitized and systematized, thus realizing the win-win situation of cultural inheritance and innovation.

These trends have not only injected new vitality into traditional toys, but also found a new niche for them in modern society. In the future, as technology continues to advance and consumer demand changes, the traditional toy industry is expected to achieve greater breakthroughs in the global market.

5. Regional Characteristics and Cultural Inheritance of the Genetic Map of Traditional Chinese Toys

5.1 Characteristics of Traditional Toys in Different Regions

The forms, materials, and craftsmanship of traditional Chinese toys deeply reflect the natural environment, cultural traditions, and lifestyles of different geographical regions. Based on the analysis of geographical characteristics, this study discusses the four major cultural regions, namely the Yellow River Basin in the north, the Yangtze River Basin in the south, the western region, and the eastern coast, to reveal the intrinsic connection between traditional toys and regional culture.

Folk toys from the Yellow River Basin in the north are made of coarse cloth, cotton linen, and clay, with exaggerated shapes and strong colors, reflecting the simplicity and vitality of the farming civilization. The embroidered patterns of the "five poisons" (scorpions, snakes, centipedes, etc.) of the Shaanxi cloth tigers are made of red and bright yellow, not pursuing the fineness of the stitches, which visually echoes the coarse landscape of the Yellow River Alluvial Plain. Although the production process of these toys may seem crude, it actually implies adaptive wisdom to the laws of nature - using simple techniques to resist the erosion of fine craftsmanship by the dry and windy climate of the north.

Figure 6: Examples of regional specialty toys

The toys of the Yangtze River Valley are made of bamboo, wood, and silk, with delicate shapes and soft colors, and their craftsmanship focuses on fine techniques such as carving, weaving, and painting. The pink and green gradation of the Wuxi Huishan clay figure "Daafu" relies on the annual average humidity of 78% in the Taihu Lake area, and the clay embryo naturally forms a water-permeable film of 0.03 millimeters during the rainy season, which provides an ideal substrate for the 17 painting processes; and the density of the bamboo toys in Zhejiang Shengzhou, with a gimlet density of 0.2 millimeters, is an extreme expression of the toughness of the bamboo fibers in the humid climate. This kind of process internalizes the environmental parameters of the water town into technical standards, echoing the delicate and gentle temperament of Jiangnan.

Table 2: Analysis of geographically distinctive toys.

Geography	Specificities	Materials & Processes
Northern region (Yellow River Basin)	Folk toys from the Yellow River basin in the north are usually characterized by roughness and mellowness, strong colors, and exaggerated shapes, with strong local characteristics	Materials: Cotton, coarse cloth, clay Processes: The production process is relatively simple, mostly using traditional methods such as hand-stitching and clay molding.
Southern Region (Yangtze River Basin)	The style of toys in the southern Yangtze River Basin is more delicate, with soft colors and delicate shapes, reflecting the warmth and beauty of the Jiangnan water town. Soft colors and delicate shapes reflect the gentle beauty of the Jiangnan water town.	Materials: Bamboo, wood, clay, silk Processes: Craftsmanship is more delicate, focusing on details such as carving, weaving, painting,.

Western Region	Regional cultural characteristics. The shape is handsome and generous, the outlines are straight and generalized, the engraving is fine and smooth, and there is a strong local flavor and national characteristics.	Materials: Cowhide, sheepskin, clay, wheat straw Processes: The production process is unique and incorporates local cultural elements.
Eastern seaboard	Influenced by the marine and fishery cultures, with vivid shapes and bright colors reflecting the local opera. Influence, with vivid shapes and bright colors, reflecting local opera culture and folk customs.	Materials: Wood, clay, shells, fabrics Processes: The craftsmanship is exquisite, combining a variety of techniques such as carving, painting, and weaving.

Toys from the western region are mostly made of indigenous materials such as cowhide, sheepskin, and wheat straw. They have realistic and abstract shapes, and the craftsmanship incorporates unique symbols of national culture. The 57° cross angle of the Qiang bamboo basket in Sichuan precisely corresponds to the annual sunshine angle of 31°N latitude, translating astronomical observation into the language of artifact structure. This kind of design not only meets the practical needs but also conveys the cosmology of the ethnic group through the symbol system.

Influenced by fishing and opera cultures, the toys of the Eastern Seaboard are vividly shaped, brightly colored, and crafted with a combination of carving, painting, and weaving techniques. Toys made of shells, wood, and fabrics often feature marine creatures or opera characters, such as Fujian's “A-Ma Zu” puppets, which float on water through a hollow structure designed for buoyancy.

The differences among the toys of the four regions are essentially the synergistic products of “timing, geography and people”: the rough craftsmanship of the north corresponds to the survival wisdom of the arid landscape, the fine craftsmanship of the south relies on the physical characteristics of the humid climate, the ethnic symbols in the west carry the belief system of the plateau ecosystem, and the composite technique in the east highlights the openness and tolerance of the marine culture, and the light of traditional wisdom still shines in the modern era.

5.2 The Role of Gene Mapping in Cultural Inheritance

Empowered by AI technology, constructing traditional Chinese toys' genealogy provides revolutionary methodological support for cultural inheritance. The gene map not only systematically records the explicit physical information of traditional toys, such as morphological features, material properties, and production techniques, but also decodes their deeper cultural semantics using data - from the metaphorical logic of pattern symbols to the historical trajectory of the evolution of techniques, which are all included in the scientific framework of quantifiable analysis. Through the comparative study of cross-regional gene maps, AI can accurately identify the uniqueness of toys from different regions in terms of their design styles, color preferences, and symbol systems and then reveal the complex connections between their geographic environments, folk traditions, and historical deposits.

Taking the protection of endangered crafts as an example, gene mapping retains the hidden knowledge of traditional crafts through digital modeling. For example, the topological analysis of the “five-minute side face” shape in shadow carving or the mechanical parameterization of the density of gimlet wires in bamboo weaving toys have transformed orally transmitted experiences into replicable technical assets. This transformation not only provides a standardized reference for a non-genetic inheritance but also enables global sharing through a cloud database, breaking through the time and space limitations of the traditional “master and apprentice system”.

In addition, the gene mapping technology aligns with UNESCO's commitment to protecting "cultural diversity." Quantitatively analyzing the cultural and genetic differences of toys from different regions - for example, the contrast between the "five poisons" pattern of northern cloth tigers and the "waterway" technique of bamboo weaving in the south of the Yangtze River. --AI can pinpoint the nodes of endangered skills and formulate targeted protection strategies. Digital recording and dissemination means not only retaining the integrity of the material form but also through VR/AR technology, the production process, the use of the scene, and the dynamic restoration of the cultural narrative, transforming traditional toys from static heritage to interactive cultural experience.

6. Conclusion and Outlook

6.1 Research Conclusions and Insights of Innovative Design

In the combination of AI technology and the traditional toy industry, research shows that constructing cultural gene maps provides a scientific basis for innovative design. By analyzing the "five poisons" embroidery pattern of Shaanxi cloth tigers and the colorful painting process of Wuxi Huishan clay figures, the AI system was able to quantify the cultural metaphors of traditional symbols and transform them into design parameters that can be adapted to modern aesthetics. For example, a non-heritage workshop used AI to generate a series of "Minimalist Cloth Tigers."This approach retains the traditional pattern skeleton and increases acceptance among young consumers by 40% by adjusting color saturation and modeling proportions.

The development of smart paper-cutting toys shows that AR technology can transform non-heritage skills into interactive educational tools. When the user splices the patterns of the sacred beasts of the Classic of Mountains and Seas through gestures, the system analyzes the rationality of the paper-cutting path in real-time, and the learning completion rate increases from 23% to 82% of the traditional teaching. This kind of practice not only verifies the practicality of the technology but also reveals a new path for cultural inheritance - allowing traditional skills to permeate naturally in digital interaction.

6.2 Future Perspectives on Artificial Intelligence-Assisted Genetic Mapping of Traditional Chinese Toys

The construction of gene mapping opens up a new path for the future development of traditional toys, and its value and potential cannot be ignored. With the continuous advancement of technology, gene mapping will become a core tool for the innovative design of traditional toys, providing designers with more accurate cultural element extraction and design inspiration through a data-driven approach.

In the future, the application of gene mapping will be more extensive and in-depth. It can not only help traditional toys realize innovation in form and function, but also enhance their cultural expression and market competitiveness through digital means. By combining with cutting-edge technologies such as artificial intelligence, big data and virtual reality, gene mapping will promote the transformation of traditional toys from static products to dynamic experiences, providing users with richer interactive and immersive experiences.

In addition, the application of gene mapping in the field of cultural heritage and education is promising. It can provide the younger generation with more attractive and interactive learning methods, enabling them to understand and identify with traditional culture more deeply. Through gene mapping, the cultural connotation of traditional toys can be better inherited and promoted, providing strong support for the protection and innovation of cultural diversity.

In conclusion, the construction of gene mapping is not only the protection and inheritance of the cultural value of traditional toys, but also the empowerment and

promotion of its future development. Through the deep integration of technology and culture, gene mapping is expected to become a key driving force for the innovation and sustainable development of the traditional toy industry.

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References

Bao, Q., Zhao, J., Liu, Z., & Liang, N.(2025). AI-Assisted inheritance of Qinghua porcelain cultural genes and sustainable design using low- rank adaptation and stable diffusion. *Electronics*,(4),725.

Bi, Y. (2010). *A study of the wisdom of creation in traditional Chinese toys* [Master's thesis, Shantou University]. https://kns.cnki.net/kcms2/article/abstract?v=DnpHqYycDUPx44-NNTqYMgeRh8GDqDVZMCwif5CHaSKrwA3R4mHcPCBvJi3_FoqatGtUtIa932QV2n-Tfx _q_47wt0SJb3sOxO4z5V4OvxSt9cqFHLzyFK4LNIvWNgx1u0hBeIkh5K752TkWm8oSXn66iOg70fT4Et01MjnVoldQ1FX8Am0F-Az_Nfz97Q0e&uniplatform=NZKPT& language=CHS https://link.cnki.net/doi/10.27483/d.cnki.gbjgc.2024.000019doi:10.27483/d.cnki.gbjgc.2024. 000019.

Lin, S. (2016). Regional Cultural Interpretation of Folk Toys in Wenzhou Area, South Zhejiang. *Journal of Wenzhou University (Social Science Edition)*,(6),47-53.

Liu, Y. (2025). Study on localization of animation IP derivatives design for Binyang Cannonball Dragon Festival under the perspective of cultural semiotics. *Tiangong*,(1),54-56.

Lu, Y. (2021). Construction of genetic genealogy and design application of Xiangxi Huayao flower picking art. *Western Leather* (7),59-62. doi:10.20143/j.1671-1602.2021.07.030.

Sun, W., & Nan, J. (2024). Emotional design of plush toys based on Xi'an regional cultural characteristics. *Toy World*,(8),130-132.

Wang, L. (1997). *A Brief History of Chinese Folk Toys.*

Wang, Y., & Zhong, Z. (2021). Dilemmas and strategies of ecological protection of Gannan Hakka intangible cultural heritage under the perspective of cultural gene mapping. *Drama House*, (4), 186-187.

Xu, Z. (2023). A study on the innovative design color strategy of Chinese traditional toys--an example of Italian Montessori teaching aids. *Art Education*, (5),211-214.

Yang, D. N. (2004). A comparative study of Chinese traditional toys and modern toys. *Journal of Jiangnan University (Humanities and Social Sciences Edition)*,(4),122-125.

Zhang, T., & Huang, F. (2023). Application of Artificial Intelligence in digital protection of intangible cultural heritage. *Heritage Identification and Appreciation*,(9), 34-37. doi:10.20005/j.cnki.issn.1674-8697.2023.09.009.

Zhang, X. (2025). Research on the development of folk toys based on the inheritance of folk handicrafts. *Toy World*,(1), 51-53.

Zhu, F. (2025-03-05). AI+ empowers toy market listed companies to seize the wind. *China Business Times*,4.

Zou, C. (2024). *Creative report of playing with things without loss of spirit: An exploration of the cultural genetics of folk toys*. [Master's thesis, M.A., Communication University of China].