Malaysia Architectural Journal

Journal homepage: https://majournal.my/index.php/maj
e-ISSN : 2716-6139

# The Construction of Cultural Gene Map and Revitalization Strategies for Industrial Heritage: A Case Study of Hanyang Ironworks in Wuhan

Qiguo Li[1], Yingfeng Hu[1*]

[1]School of Architecture and Art, Hefei University of Technology, Anhui 230601, China

**ARTICLE INFO**

***Article history:***
Received: 30 April 2024
Received in revised form
Accepted: 15 October 2024
Available online: 23 June 2025

**ABSTRACT**

Industrial heritage serves as a powerful testament to the development of urban civilization, inheriting and continuing the urban cultural context. Currently, urban construction in China has entered a phase focused on enhancing the quality of existing assets. As an important stock resource in urban development, the protection and reuse of industrial heritage have become a hot topic of research in recent years, with the focus gradually shifting from singular 'material preservation' to diverse 'cultural output.' Studies have shown that during the transformation of industrial heritage, a lack of clear understanding of its cultural system often leads to phenomena such as 'homogenization,' 'fragmentation,' and 'blind modification.' Furthermore, due to insufficient exploration of the cultural value of industrial heritage, there can be misinterpretations when conveying its cultural significance, causing people to view industrial heritage as low-quality culture. This cultural conflict hampers the protection and reuse of industrial heritage. Therefore, preserving, developing, and passing on the cultural aspects of industrial heritage is the main focus of this study. Using Hanyang Ironworks in Wuhan, Hubei Province, as a case study, this research introduces the concept of cultural genes from the perspective of biological genetics. First, it integrates grounded theory with the landscape gene extraction method to establish a process for extracting cultural genes from industrial heritage. Next, based on typology principles and the 'N-Level Coding' theory, an industrial heritage cultural gene map is created. Finally, the cultural genes in the map are organized and summarized according to three types of genes: primary genes, attached genes, and mixed genes. Through an analysis of the inheritance patterns of different cultural genes, the study proposes strategies for revitalizing the cultural genes of industrial heritage.

***Keywords:***
Industrial Heritage; Cultural Gene; Cultural Gene Map; Revitalization Strategies; Wuhan

* *Corresponding author.*
*E-mail address: hu798209@gmail.com*

# 1. Introduction

*1.1 Research background*

According to the definition in the Nizhny Tagil Charter, industrial heritage consists of the remnants of industrial culture and encompasses the entirety of buildings and structures created for industrial activities. This includes immovable artifacts such as workshops, warehouses, and docks, as well as movable artifacts like tools, machinery, and equipment. Additionally, it involves archival records such as contracts, product samples, and literary materials related to the history of enterprises [1]. As urban development in China progresses, many original factories have ceased operations or been relocated. However, due to a lack of adequate understanding of the cultural significance of industrial heritage, many valuable industrial sites have been deemed harmful to cities and are facing the threat of irreversible demolition. Therefore, it is urgent to reassess the cultural value of industrial heritage and clarify the relationship between cultural transmission and heritage protection [2].

In recent years, the protection and utilization of industrial heritage have increasingly focused on meeting people's spiritual and cultural needs and promoting sustainable urban development. As important historical evidence of China's modernization, these old factories and streets bear witness to specific historical periods and reflect a glorious chapter in China's industrial civilization [3]. Protecting and utilizing industrial heritage is not merely a matter of superficial renovation; it involves a comprehensive understanding of the site, structure, and function to effectively showcase the industrial heritage culture, with the aim of achieving cultural revival and sustainable development.

British scholar Richard Dawkins was the first to propose the concept of "cultural genes." He suggested that cultural genes, like biological genes, have hereditary attributes and later further explained them as key factors influencing the transmission and evolution of cultural systems [4]. Industrial heritage cultural genes can be understood as the unique, transmissible, and intrinsic cultural factors of industrial cultural landscapes that distinguish them from other cultural landscapes. They are the basic units through which industrial cultural characteristics are "inherited" [5]. Based on this, using cultural genes as basic units to explore and organize regional culture aims to provide new insights and guidance for the protection, development, and transmission of regional culture from a novel perspective of biological genetics.

*1.2 Literature Review*
*1.2.1 Trends in Cultural Gene Research*

The concept of cultural genes can be traced back to Darwin's theory of evolution and is an interdisciplinary research topic within fields such as cultural anthropology, sociology, and cognitive science. In 1976, Dawkins introduced the theory of "memes" in his book The Selfish Gene. He described memes as cultural replication units analogous to genes, proposing that cultural phenomena spread between individuals and groups through the replication and variation of memes. The meme theory sparked extensive discussion and became a crucial theoretical foundation for cultural gene research. Cultural genes are not static during transmission but evolve continuously with changes in the social environment and technological advancements. In 1996, Sperber's theory of "cultural epidemiology" suggested that the dissemination of cultural genes is closely related to human cognitive preferences. Certain cultural elements are more likely to become prevalent in groups because they align better with human cognitive structures, thus driving cultural evolution. This theory provides a new perspective on understanding the selective variation of cultural genes.

Chinese scholars' research and application of "cultural genes" began with the translation of The Selfish Gene into Chinese in 1981. Initially, experts in the field of philosophy focused on defining the concept of cultural genes. Zhang Daiyun *et al.* emphasized that the uniqueness of Chinese cultural genes is primarily reflected in the enduring influence of philosophical systems such as Confucianism, Daoism, and Buddhism. Subsequently, scholars expanded on the concept of cultural genes. Liu Peilin *et al.* introduced the concept of "landscape genes" and systematically elaborated on the classification and identification methods of landscape genes, applying them to the study of traditional settlements. Feng Peien *et al.* proposed the concept of "product genes" in comparison to cultural genes, revealing the bridging role of product genes between functional design and principle scheme design, and established a conceptual design framework based on the inheritance and recombination of product genes. Duan Jin *et al.* introduced the concept of "spatial genes" for complex urban systems, arguing that spatial genes carry spatial information on the "urban space-natural environment-socio-cultural" interaction evolution model, playing a crucial role in the continuity of urban spatial context.

In summary, the study of cultural genes in China has gradually diverged from the concept of memes developed abroad since its introduction through translation. Regarding the current research on industrial heritage cultural genes, it remains in its early stages, with many theories still unclear and several methodologies needing to draw on more established theories from other fields. Therefore, this paper introduces grounded theory and integrates Liu Peilin's proposed landscape gene identification methods to construct a cultural gene identification system for the Hanyang Ironworks in Wuhan. This system extracts cultural genes from both material and immaterial forms, constructs a cultural gene map, and categorizes the genes into three types: primary genes, attached genes, and mixed genes. By analyzing the different cultural transmission patterns of these gene types, the study summarizes strategies for revitalizing industrial heritage cultural genes. The aim is to provide new insights and methodological references for the cultural continuity of industrial heritage, supporting its effective protection and reasonable utilization.

#### *1.2.2 Trends in Cultural Gene Mapping Research*

The concept of a cultural gene map is an emerging idea in the field of cultural research, initially proposed by Chinese scholars. It aims to visualize cultural genes by systematically identifying and classifying them to illustrate the distribution and interaction of different cultural elements within a specific society. This concept draws from gene mapping theories in biology, viewing culture as a complex system composed of multiple identifiable and interrelated basic units. A similar concept was also proposed in the development of meme theory abroad. In 2009, Australian scholar John Paul introduced the idea of a "Meme Map.

Research on cultural gene mapping primarily focuses on traditional villages and cultural landscapes, with scholars developing cultural gene maps based on their research subjects. One of the most influential concepts in this area is the "landscape gene map," proposed by Liu Peilin and other scholars, which integrates cultural gene theory and settlement typology theory, significantly advancing the development of cultural gene mapping.

Due to the complexity and diversity of human culture, it is challenging for researchers to encompass all aspects of human cultural systems with a fixed cultural gene map. Different regions, populations, and ethnic groups have their own cultural characteristics, so the construction of cultural gene maps should be dynamic. Given the widespread distribution and large number of industrial heritage sites, textual research needs to be based on specific research subjects. This paper uses the Hanyang Ironworks in Wuhan as a case study and employs the concept of the "landscape gene map" to construct a cultural gene map for the Hanyang Ironworks.

## 2. Methodology

### *2.1 Overview of the Research Area*

#### *2.1.1 Overview of Industrial Development in Wuhan*

As one of the origins of modern industrialization in China and a major old industrial base in the interior, as well as a key concentration area for modern manufacturing, Wuhan boasts rich and diverse industrial heritage resources. The history of industrial development in Wuhan can be divided into six stages: the emergence and initial development of modern industry (1840-1911), the rapid development of modern industry (1912-1936), the stagnation of modern industry (1937-1948), the period of industrial restoration and comprehensive construction (1949-1965), the period of uneven progress in modern industry (1965-1977), and the rapid development of the reform and opening-up era (1978-present) [6].

Among these, industrial heritage from the late Qing Dynasty accounts for approximately 13.83% of the total; industrial heritage from the period of rapid development of modern industry during the Republic of China accounts for about 18.09%, while the period of stagnation in modern industrial development represents 5.32%. Industrial heritage from the People's Republic of China accounts for approximately 62.77%, with early post-liberation economic recovery and comprehensive socialist industrialization period accounting for 55.32%, the period of uneven progress in modern industry representing 4.26%, and the reform and opening-up era and the period of rapid development making up 3.19%. （Figure 1）

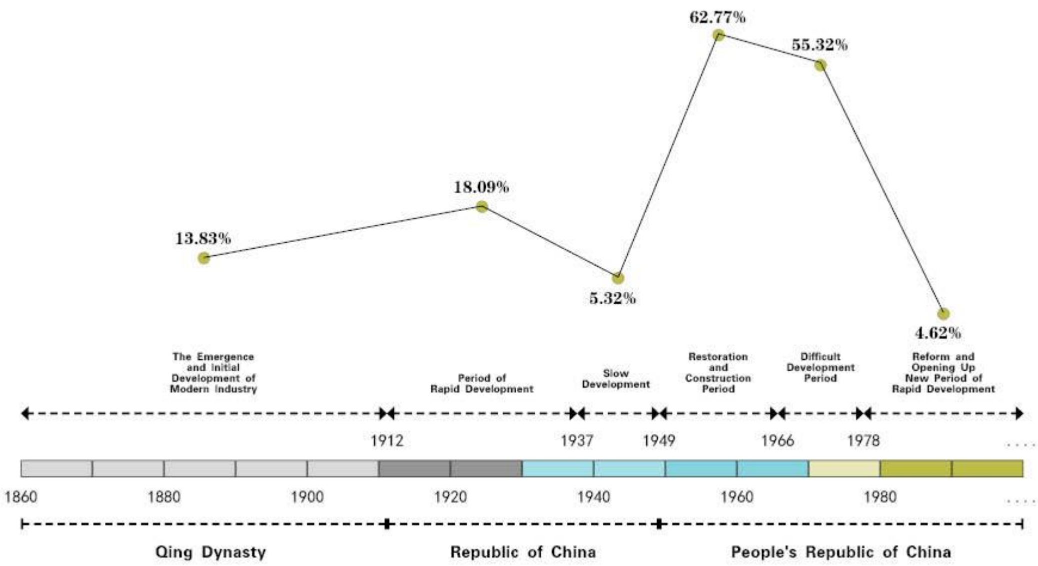



**Fig. 1.** Overview of the Development of Industrial Heritage in Wuhan

*2.1.2 Current Development and Characteristics of Hanyang Ironworks*

Hanyang Ironworks, established in 1890, was the first and largest steel conglomerate in modern Chinese history. Located to the north of the Han River and south of the Beijing-Guangzhou Railway, the ironworks was divided into two zones by Xiyue Lake (now Qintai Avenue), forming a spatial layout of one factory in two areas (see Figure 2). The northern part, known as the "North Plant," housed the rolling steel section, while the southern part, known as the "South Plant," contained the steelmaking section, with its shape resembling a battleship. Years ago, Hanyang Ironworks was planned to be converted into a residential area, and the North Plant has since been demolished and replaced by housing complexes. However, the "South Plant" was preserved after extensive efforts, primarily through negotiations between the government and Wuhan Iron and Steel Company (WISCO).

In 2017, the Ministry of Industry and Information Technology designated Hanyang Ironworks as part of the first batch of National Industrial Heritage sites and identified the core items requiring protection (see Figure 3). In addition to the existing buildings and structures within the plant area, the Ministry emphasized the preservation of key items such as the ore dock, blast furnace cast iron, steel rails manufactured by Hanyang Ironworks, the 1894 cast iron monument, bricks and tiles produced by Hanyang Ironworks, and materials gifted by Luxembourg.

The buildings in the western section of Hanyang Ironworks have been completely demolished, with plans to develop residential housing in their place. The northern part of the site, adjacent to a major urban road, has seen many street-facing buildings rented out to different owners for commercial activities. In the western section, some of the old factory buildings have been repurposed into cultural and recreational spaces, such as museums, exhibition halls, and tea rooms. Meanwhile, a significant portion of the southern area is used for storing steel materials like rebar, with a small part still used for rolling steel (see Figure 4) [7].

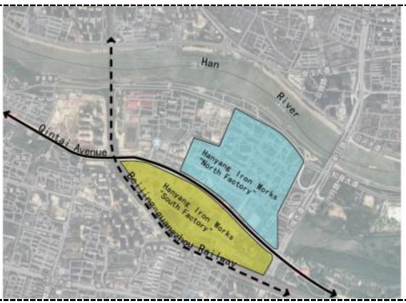



**Fig. 2.** Spatial Layout of Hanyang Ironworks


**Fig. 3.** Distribution Map of Key Protected Buildings and Structures at Hanyang Ironworks


**Fig. 4.** Land Use Map of Hanyang Ironworks

*2.2 Research Method*
*2.2.1 Field Research*

Field research is a research method that involves collecting data by directly observing and participating in the real environment where the research subjects are located. It provides firsthand information and intelligence, facilitating the effective and smooth progress of subsequent research. Additionally, field research encourages public participation, which helps in a deeper understanding of the research subjects and serves as a prerequisite for research and design. By conducting interviews, visits, investigations, and recordings of industrial heritage cultural gene artifacts and images, researchers can clarify the content of industrial heritage cultural genes. This process helps summarize the relevant content and spatial characteristics of industrial heritage cultural genes, providing comprehensive and detailed information for the extraction of these cultural genes.

*2.2.2 Extraction and Identification of Cultural Genes*

Industrial heritage can be seen as a collection of industrial landscapes, with industrial cultural landscapes serving as the carriers of industrial heritage cultural genes. Therefore, the methods for identifying landscape genes are also applicable to the identification of industrial heritage cultural genes. In his research on traditional settlement landscapes in China, scholar Liu Peilin proposed the principles for identifying landscape genes: "intrinsic uniqueness, extrinsic uniqueness, local uniqueness, and overall dominance" [8]. Scholar Shen Xiuying, based on the principles of landscape gene identification, proposed four methods for extracting landscape genes: element extraction, pattern extraction, structure extraction, and meaning extraction. These methods are currently among the mainstream extraction approaches [9].

After identifying industrial heritage cultural genes, they need to be classified. There are various methods for classifying cultural genes, with the most common being the distinction between material and immaterial cultural genes. Material cultural genes exist in the form of physical entities, which can be perceived through our senses and are also known as explicit cultural genes. Immaterial cultural genes, on the other hand, do not have a concrete form and exist in the form of mental ideologies, transmitted through actions that are based on and yet transcend sensory perception, also referred to as implicit cultural genes.

However, landscape gene identification methods are primarily used to extract the external characteristics of genes, making them highly effective for identifying material cultural genes of industrial heritage but somewhat limited in recognizing immaterial cultural genes. Therefore, this paper introduces grounded theory to identify the immaterial cultural genes of industrial heritage, while also providing secondary confirmation and supplementation of the material cultural heritage. Based on this, the extraction process for industrial heritage cultural genes is as shown in Figure 5.

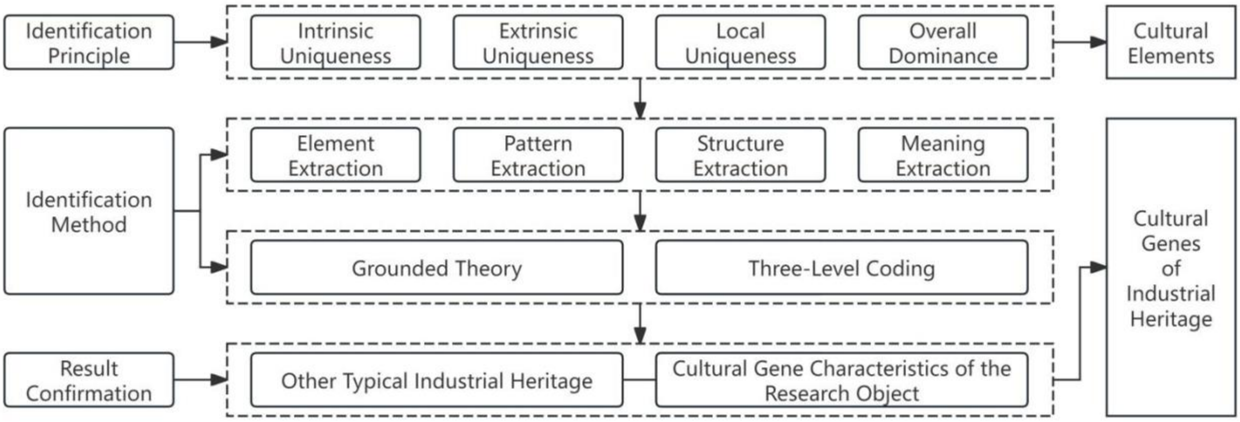



**Fig. 5.** Extraction Process of Cultural Genes of Industrial Heritage

### *2.2.3 Extraction and Identification of Cultural Genes*

The significance of constructing the map lies in simplifying complex issues. By refining and extracting the cultural genes of industrial heritage, clarifying the internal composition of these genes, and organizing the genetic information of the cultural system, it enables visual representation through imagery and logical structure. This provides cases and materials for the protection and related planning and design of industrial heritage.

To make the cultural gene map of industrial heritage more organized, gene data are encoded and processed. Based on typological principles and the 'N-Level Coding' theory, cultural genes are classified into first-level, second-level, third-level, and so on, down to the level of cultural elements, as illustrated in Figure 6.

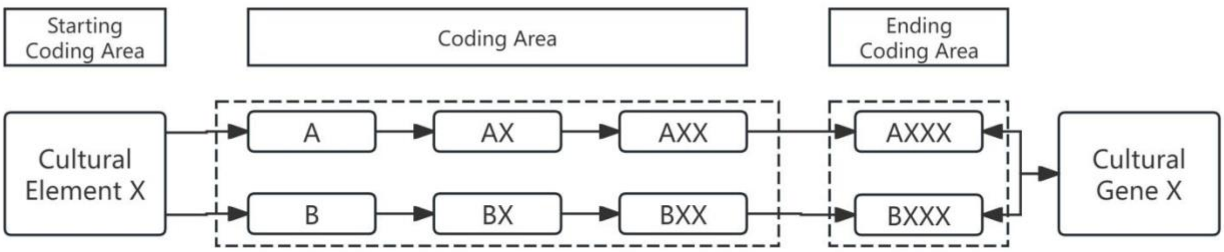



**Fig. 6.** Encoding Process of Cultural Genes of Industrial Heritage

# 3. Results

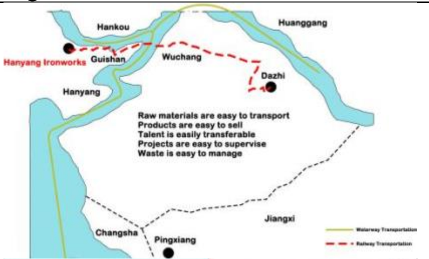
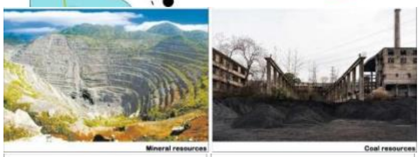
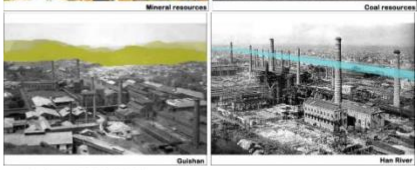
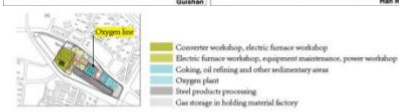
## *3.1 Identification of the Cultural Genes of Hanyang Iron Works*

This study uses Hanyang Iron Works as the research object and applies the landscape gene identification method to identify the material cultural genes of Hanyang Iron Works. Based on grounded theory, the text data are analyzed and encoded to identify the intangible cultural genes of Hanyang Iron Works, while also re-confirming the identified intangible cultural genes.

### *3.1.1 Identification of the Content of Material Cultural Genes of Hanyang Iron Works*

Based on the landscape gene identification method, the cultural genes of Hanyang Iron Works were identified and categorized into four major categories: geographical environment, layout forms, architectural relics, and industrial achievements. These categories are further subdivided into 11 subcategories. The identification results are shown in Table 1.

**Table 1**
Identification Results of the Material Cultural Genes of Hanyang Iron Works

| Broad Category | Subcategory | Description | Figure |
|---|---|---|---|
| Geographical environment | Transportation Condition | To the south of the Hanyang Iron Works lies the Beijing-Guangzhou railway line, and to the north is the Han River. Inside the factory area, there are three railways, with two docks located outside the facility. |  |
| | Geological Environment | Rich in mineral resources, with guaranteed raw materials; coal resources provide energy support for production. |  |
| | Topography and Terrain | At the foot of Guishan Mountain, adjacent to the Han River. |  |
| Layout pattern | Overall layout | Clear partition. |  |
| | Spatial Form | The overall shape of the factory area is very similar to a warship. |  |
| | Road Pattern | The buildings are all rectangular, the layout is very orderly, and the roads are straight and perpendicular. |  |

| | | | |
|---|---|---|---|
| Architectural remains | Production building | Many buildings and structures within the plant area have significant historical value. |  |
| | Living architecture | |  |
| | Structure | |  |
| Industrial achievement | Industrial product | Brushing off the dust from the rails reveals that the steel tracks still shine like new, with no rust, seemingly untouched by a century of time. On the side of the track, a row of traditional Chinese characters is clearly cast: 'Manufactured by Hanyang Iron Works in 1903. |  |
| | Literature and history archives | Luxembourg specialist at Hanyang Iron Works. |  |

*3.1.2 Identification of the Content of Intangible Cultural Genes of Hanyang Iron Works*

First, semi-structured interviews were conducted with former employees of Hanyang Iron Works, current staff, local vendors, and residents. Before the interviews, a list of guiding questions based on the research theme was prepared. During the interviews, these key points were used flexibly, and respondents were also encouraged to freely discuss their impressions, experiences, and understanding of the cultural genes of Hanyang Iron Works. A total of 25 interview samples were collected, with an average interview duration of approximately 15 minutes per respondent. Using grounded theory, the interview records of 20 respondents were analyzed and coded, with the coding process divided into open coding, axial coding, and selective coding. The remaining 5 interviews were used for saturation testing to ensure comprehensive coding of all industrial heritage cultural genes (Figure 7).

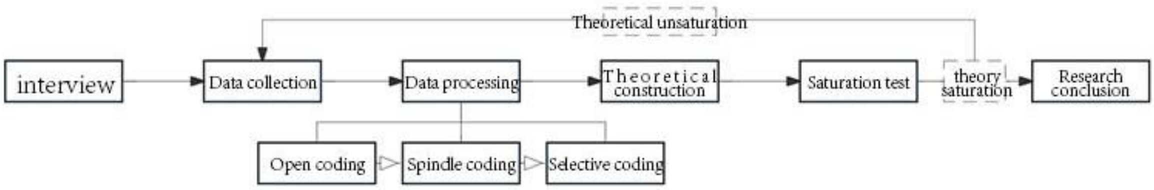



Fig. 7. Cultural Gene Coding Process

(1) Open coding

Open coding involves breaking down the collected interview data and labeling it word by word according to the interview themes (aax). By comparing the similarities and differences, concepts (ax) and categories (Ax) that accurately reflect the interview themes are summarized and abstracted [10]. Through multiple rounds of coding, analysis, and revision of the interview data, a total of 46 basic concepts were identified. Based on their semantic attributes, these basic concepts were categorized into 18 initial categories, such as historical figures, red culture, topography, transportation conditions, spatial form, and road layout. Due to space constraints, this paper will present an example of open coding of interview data from Zhang Zhidong and Hanyang Iron Works Museum staff, as shown in Table 2.

**Table 2**

Zhangzhidong and Hanyang Iron Works museum staff open coding results

| Textual data | Conceptualizing ax | Categorization Ax |
|---|---|---|
| In the late Qing Dynasty, the governor of Huguang, Zhan g Zhidong (aa1), vigorously promoted the new policies o f industry and education in Wuhan (aa3) in order to "striv e for self-improvement and prosperity" (aa2), and founde d industrial enterprises such as Hanyang Iron Factory, Ha nyang Arsenal and Hanyang Gunpowder Factory. Hanya ng iron Works next to the Beijing-Guangzhou Railway li ne in the south, the Han River (aa4) in the north, very clo se, several hundred meters. There are three railways in th e factory and two piers outside (aa5); The overall shape o f the factory resembles a warship (aa6); The buildings are square and neatly planned (aa7), and the roads are horizo ntal and vertical (aa8); Many of the buildings in the facto ry have high historical value, such as the converter works hop (aa9), which was designed by the famous architect Z hang Lianggao and was the longest span factory in China at that time; Mr. Liwege (aa10) had an important influenc e on the development of Hanyang Iron Works, he was the first to discover the problems of low production efficienc y and low production quality of iron works, and insisted on introducing new equipment and improving raw materi als (aa11). From 1902 to 1904, he went abroad twice and introduced advanced foreign production equipment into Hanyang Iron Works (aa12). In 1907, he established Han ye Ping Coal and Iron Works Company, which stabilized the raw material guarantee of Hanyang Iron Works; In 19 11, the "Technical Standard and Acceptance Code" (aa13 ) of China's first flat leg rail, which was put forward by H anyang Iron Works, was promulgated and implemented b | a1 Founder (aa1)<br>a2 Westernization Movem ent (aa2)<br>a3 Hubei New Policy (aa3)<br>a4 Location (aa4)<br>a5 Transportation Equipme nt (aa5)<br>a6 Spatial Form (aa6)<br>a7 Architectural Arrangem ent (aa7)<br>a8 Road Planning (aa8)<br>a9 Production Plant (aa9)<br>a10 Expert Scholars (aa10)<br>a11 Technology Upgrade ( aa11, aa12)<br>a12 Documentation (aa13)<br>a13 Revolutionary Leaders (aa14)<br>a14 Workers' Movement (a a15)<br>a15 War of Resistance Aga inst Japanese Aggression ( aa16)<br>a16 Public Sentiment (aa1 7) | A1 Historical Figures (a1, a10, a13)<br>A2 Red Culture (a2, a3, a1 4, a15)<br>A3 Topography (a4)<br>A4 Shipping Conditions (a 5)<br>A5 Spatial form (a6, a7)<br>A6 Road Pattern (a8)<br>A7 Production Building (a 9)<br>A8 Production Technology (a11)<br>A9 Literature and History Archives (a12)<br>A10 Local Ownership (a16 ) |

| | |
|---|---|
| y the Qing Government's postal Communication Depart ment. In June 1922, the Wuhan Branch of the Secretary Department of the Chinese Labor Union sent Xu Baihao, Lin Yunan, Lin Yuying (Zhang Hao) (aa14) to Wuhan to organize and lead the workers' movement of Hanyang Iro n Works (aa15); In 1938, when the Japanese invaded Wu han on a large scale, the Nationalist government decided to move the entire Hanyang Iron Works to Dadukou, Cho ngqing, and all the factories that could not be moved wer e blown up (aa16). Deep memories of the previous gener ation of employees and surrounding residents (aa17) | |

(2) Spindle coding

The goal of axial coding is to derive the main categories. By classifying the attributes of the 18 initial categories obtained from open coding, six main categories were identified: geographical environment, layout form, architectural relics, industrial achievements, historical culture, and spiritual culture.

(3) Selective coding

Selective coding aims to extract core categories from the main categories. Using material and immaterial as classification criteria, the core categories of material culture genes and immaterial culture genes are identified. The cultural genes of the HanYang Iron Works are divided into six aspects (with the industrial achievements category being unique, as it includes both material and immaterial culture genes). Among them, the material culture gene identification results are the same as mentioned earlier, including four aspects: geographical environment, layout form, architectural relics, and industrial achievements. The immaterial culture genes include three aspects: industrial achievements, historical culture, and spiritual culture. The cultural genes are further divided into 18 subcategories, with material culture genes comprising 11 subcategories and immaterial culture genes comprising 7 subcategories, as shown in Table 3.

**Table 3**
Hanyang iron works cultural gene identification system

| Core category | Principal Category | Initial Category |
|---|---|---|
| Material Cultural Gene | Geographical Environment | Transport Condition |
| | | Geological Environment |
| | | Topography and Terrain |
| | Layout Pattern | Overall Layout |
| | | Spatial Form |
| | | Road Pattern |
| | Architectural Remains | Production Building |
| | | Living Architecture |
| | | Structure |
| | Industrial Achievement | Industrial Product |
| | | Literature and History Archives |
| Immaterial Cultural Gene | Industrial Achievement | Production Technology |
| | | Business Model |
| | History and Culture | Industrial Culture |
| | | Red Culture |
| | Spiritual Culture | Historical Figure |
| | | Innovative Spirit |
| | | Local Attribution |

(4) Saturation test

To ensure the scientific validity of the theory, this study selected interview records from 5 additional respondents based on the aforementioned interview data. The coding analysis of these 5 interviews yielded results consistent with the previous research conclusions, with no new concepts or categories emerging. This indicates that the conceptual model constructed in this study is theoretically saturated.

### *3.2 Construction of the Hanyang Iron Works Cultural Gene Map*

Based on the identification results of the Hanyang Iron Works cultural genes and using typological principles and the 'N-level coding' theory, the cultural gene information is coded to construct the Hanyang Iron Works cultural gene map. The results of the construction are shown in Figure 8.


Fig. 8. Hanyang Iron Works Cultural Gene Map

*3.3 Relationship between Cultural Gene Map and Activation Strategies*

The correct classification of cultural gene types is a key factor in the effective activation of industrial heritage. Based on whether they dominate cultural attributes and whether they have heritage cultural identification functions, cultural genes are classified into principal genes, attached genes, and mixed genes [8].

*3.3.1 Main Genes*

Subject genes occupy an important position in the genealogy of cultural genes, and have a great influence on the formation and external spatial form of industrial heritage. The birth of Hanyang Iron Works is closely related to the era background of that year. In the 1890s, the Westernization movement was in full swing, which greatly promoted the development of industrial construction and accelerated the establishment of a series of new civil industries such as ships, railways, telegraphy, mining and textiles. Hanyang's geographical location is also a major factor contributing to the completion of Hanyang Iron plant, Hanyang is located in the intersection of the Yangtze River and the Han River, water and land transportation is very convenient, which makes Hanyang iron plant can easily transport products to all parts of the country, especially through the Yangtze River this golden waterway, can greatly reduce logistics costs and improve efficiency. Therefore, "geographical environment" and "historical culture" in Hanyang Iron Works cultural gene map are the main genes of Hanyang Iron Works.

*3.3.2 Adherent Genes*

Adherent genes need to exist attached to specific carriers, reflecting the heritage culture's characteristics prominently. Additionally, adherent genes enhance the core genes [11]. In the material cultural genes of the Hanyang Iron Works, industrial products and historical documents embody the memory of the factory. In the non-material cultural genes, the unique production techniques, business models, and the specific spirit derived from the people or objects within the factory are considered adherent genes of the Hanyang Iron Works. These genes are attached to the factory and also record its history, serving as crucial carriers for recalling and restoring the Hanyang Iron Works.

*3.3.3 Mixed Genes*

Mixed genes are not unique to a particular heritage, but they record important historical information about the heritage at a specific historical stage [12]. In the cultural gene map of the Hanyang Iron Works, the layout and architectural remains are not unique to the iron works. However, their distinctive scale and historical features not only reflect the history and culture of the iron works but also carry the profound memories of past workers and local residents.

## 4. Conclusions

*4.1 Activation Strategies for Industrial Heritage Cultural Genes*
*4.1.1 Modes of Cultural Gene Transmission*

The main gene dictates the dominant cultural attributes and is crucial for determining the existence of industrial heritage; both the core gene and the attached gene serve to identify the heritage culture. Although mixed genes are not unique to industrial heritage, the cultural information they embody, together with the attached genes, strengthens the core gene. The modes of cultural gene transmission can be summarized into three categories: the cultural strategy grafting model, the cultural symbol embedding model, and the cultural ecological conservation model [12]. For industrial heritage, the core gene and attached gene should prioritize activation through the cultural strategy grafting model and the cultural symbol embedding model, followed by the cultural ecological conservation model. Mixed genes are best preserved and transmitted using the cultural symbol embedding model and the cultural ecological conservation model.

*4.1.2 Hanyang Iron Works Cultural Gene Activation Strategy*

The activation strategies vary according to the different modes of cultural gene inheritance.

(1) Cultural strategy integration, promoting cultural development through multi-industry convergence.

In biology, grafting is a plant propagation technique. Applied to cultural genes, it can be understood as 'grafting' industrial heritage culture into new fields to achieve the goal of cultural revitalization [13]. With the reorganization of urban space and the commercialization and symbolization of consumption, cultural genes are grafted onto the economy, creating a 'cultural+' industry that transforms cultural resources into cultural capital and drives urban economic development. ① 'Cultural + Tourism': The Hanyang Iron Works stands as a historical witness to the magnificent rise of the Chinese nation from industrial decline to prominence, documenting the arduous revolutionary journey of the Chinese people. Its 'geographical environment' and 'historical culture' as primary cultural genes are significant tourism resources, laying a solid foundation for industrial tourism and red tourism at Hanyang Iron Works. By leveraging the development of tourism, the industrial 'rust belt' is transformed into a cultural and tourism 'showcase'. ② 'Cultural + Research and Study': 'Gaining knowledge from books is always shallow; to truly understand, one must engage in practice.' In recent years, research-based tourism aimed at in-depth experiences and practical learning has been gaining popularity, especially among parents and children. The primary cultural genes of Hanyang Iron Works make it a popular destination for cultural research and study.

Attachment genes enhance the primary genes. By 'grafting' attachment genes onto exhibitions, such as holding the Hanyang Iron Works Cultural Expo, the industrial cultural achievements of Hanyang Iron Works can be showcased. Industrial products and historical documents with physical forms can be directly 'grafted' onto the exhibition. For intangible elements like production technology, business models, and the spirit of the ironworks, indirect 'grafting' is required. This involves exploring their material carriers and presenting them through photos, films, and other media, or conveying them through explanations.

(2) Cultural Symbol Embedding, Enhancing and Highlighting Cultural Characteristics.

The cultural symbol embedding model involves integrating historical information-bearing cultural symbols into heritage cultural resources, using their symbolic value to achieve cultural enrichment [14]. While preserving the cultural symbols inherent in the buildings within the factory area, the cultural symbols should be enhanced through renovation and design. Within the cultural sphere centered around the Hanyang Ironworks, the planning and design of the factory area should embed the cultural genes of the Hanyang Ironworks. First, it is important to retain the original building and site relationships, respecting the volume, structure, and material of the existing cultural symbols in the factory buildings. Second, integrate both the main and attached cultural genes of the Hanyang Ironworks into the renovation. For instance, in the renovation design of Hanyang Ironworks — 'Rongchuang 1890' — the oxygen workshop and gas station have been transformed into the Rongchuang Wuhan 1890 Shiguang Art Museum. Starting with respecting the site's relationship, the design focuses on preserving existing trees and creating external public spaces around them. In terms of building design, a sloped roof form is used; the façade combines glass and red brick walls, reflecting the historical architecture and site spirit. The red brick façade features a cross-patterned brick design, inspired by the façade patterns of the converter workshop within the factory; new functional spaces are integrated into the building's existing structural layout (Figure 9) [15].

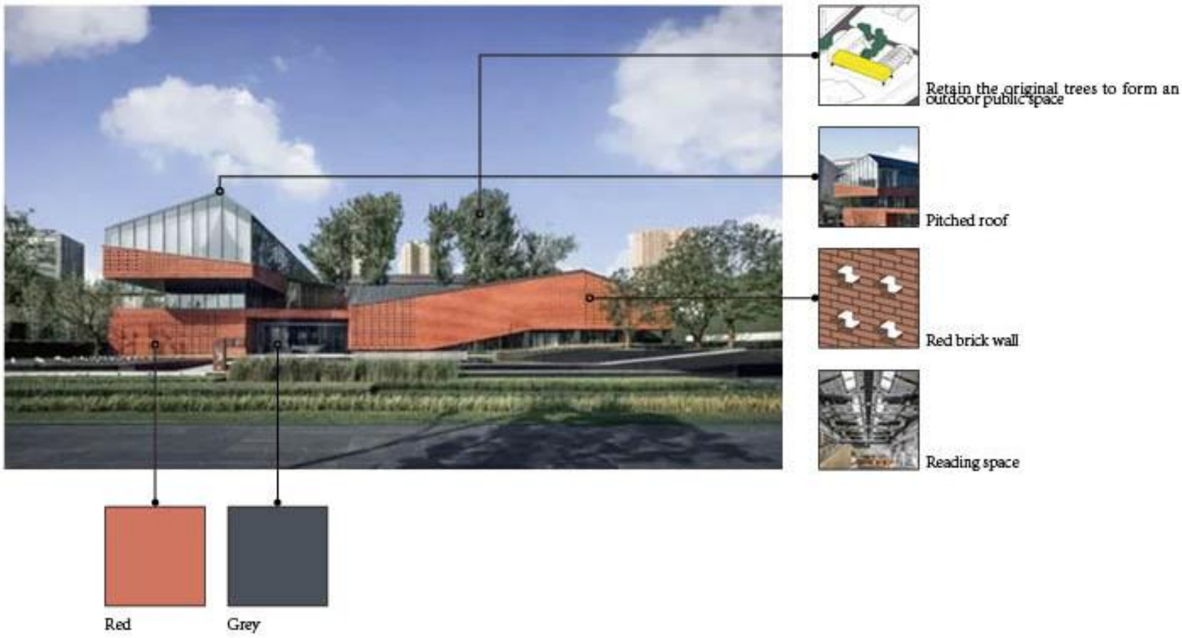



Fig. 9. Design of pilot area for transformation of Hanyang Iron works

(3) Cultural ecological preservation: integrating historical culture into modern life.

Cultural ecological preservation mode refers to the maintenance of all genes that record historical information, focusing on the protection of cultural resources. Its goal is to preserve the ecological balance of culture and the diversity of cultural genes [16]. The mixed genes of the Hanyang Ironworks exhibit significant historical and cultural value. The museum model, urban park model, and creative industry park model are specific plans within the cultural ecological preservation mode: ① Industrial Museum Model: The 'industrial framework' within the Hanyang Ironworks, a large-scale structure designed for continuous process flow, forms the basis for an open-air museum. This framework connects the buildings within the factory, allowing visitors to experience a unique industrial landscape through a guided tour along its lines. ② Urban Park Model: As urbanization accelerates, the area around Hanyang Ironworks has been increasingly surrounded by residential neighborhoods. Converting factory buildings and dormitories into community indoor spaces and transforming water towers and chimneys into parks and outdoor recreational areas helps preserve the mixed genes while improving the urban living environment and enhancing surrounding areas. ③ Creative Industry Park Model: Creative industries rely on the creativity, skills, and talents of individuals, utilizing high technology to enhance cultural resources. By offering low rents and typical industrial architecture, the site attracts modern tech creators. Old factory buildings are repurposed into art studios, galleries, fashion shops, and restaurants. The Sunac team used nearly 300 tons of steel to restore and reinforce the structure of the former bar mill, adhering to the principle of 'repairing as old' to preserve the original texture of the building. The restored bar mill has become a popular venue for major exhibitions, including the Wuhan Design Biennale in 2021, which featured nine themes: engineering design, industrial design, bridge design, animation design, digital creativity, heritage preservation, and cultural arts (Figure 10).

Fig. 10. Hold an exhibition in the bar factory

*4.2 Conclusion*

Industrial heritage is a crucial part of the world's cultural heritage. Since the Industrial Revolution, industrial heritage has progressed alongside human society, recording a wealth of industrial history and development. With the rapid advance of urbanization, industrial enterprises have been encircled by expanding urban areas, which objectively hinders the overall functionality of cities. Moreover, many of these enterprises are heavy industries that pose potential threats to the urban environment and residents' lives. Relocating old industrial enterprises and redeveloping former factory sites have become inevitable aspects of urban development. During the development and utilization of industrial heritage, there are often cases where industrial heritage culture is viewed as low-quality culture, undervaluing the significance of industrial heritage, and excessively emphasizing commercial development while neglecting its cultural and historical context. Balancing urban development with the protection of industrial heritage is a critical issue that needs urgent resolution.

In summary, effective urban renewal and the cultural revival of industrial heritage both require an in-depth exploration of the heritage's cultural genes. Only by extracting the unique cultural gene elements of industrial heritage and clarifying the value of the heritage culture can we sustain its development, avoid homogenized and crude transformations, and reverse the decline of heritage culture. This paper, based on the perspective of cultural genes, has established a system for identifying industrial heritage cultural genes. Using the Hanyang Ironworks as a case study, it has identified and extracted the cultural genes of the Hanyang Ironworks and constructed a cultural gene map for it. On this basis, the relationship between cultural genes and activation strategies is clarified, and activation strategies for industrial heritage cultural genes are proposed. The conclusions are as follows:

First, a methodological system for identifying industrial heritage cultural genes has been developed. Existing landscape gene identification methods were used to identify the cultural genes of industrial heritage. However, there may be information omissions or gaps when identifying intangible cultural genes. This paper introduces Grounded Theory to address the shortcomings of landscape gene identification in recognizing intangible cultural genes, thereby constructing a more comprehensive system for identifying industrial heritage cultural genes.

Second, taking the Hanyang Ironworks as a case study, an industrial heritage cultural gene map has been constructed. This paper clarifies the connotations and concepts of industrial heritage cultural genes, identifies and extracts the material cultural genes of the Hanyang Ironworks, including geographical environment, layout morphology, architectural relics, and industrial achievements (industrial products, historical and documentary archives), as well as the intangible cultural genes of industrial achievements (production technology, business models), historical culture, and spiritual culture. A cultural gene map of the Hanyang Ironworks has been developed.

Finally, strategies for activating industrial heritage cultural genes are proposed. Industrial heritage cultural genes can be categorized into core genes, attached genes, and mixed genes, with different methods of inheritance for each. Based on this, the following activation strategies are proposed: ① Cultural strategic grafting, promoting cultural development through multi-industry integration; ② Cultural symbol embedding, enhancing and highlighting cultural characteristics; ③ Cultural ecological conservation, integrating historical culture into modern life.

**Acknowledgement**
This research was not funded by any grant.

## References

For each work shown in the list of references must be a reference in the text. All citations in the text and all references must meet APA styles (American Psychological Association 7th edition – more information http://www.apastyle.org/)

**Book**

[1] Cichocki, A. and Unbehaven, R., (1993). *Neural Networks for Optimization and Signal Processing*, 1st ed. Chichester, U.K.: Wiley.

[2] Chen, W. K. (1993). *Linear Networks and Systems*, Belmont, CA: Wadsworth, pp. 123-135.

**Journal**

[1] Liu B Y. and Li K. (2006). “The composition and value evaluation method of industrial heritage,” *Architectural Creation*, vol. vol. 9, pp.24-30.

[2] Liu, C., Lu, X. and Li, G Y. (2016). “Research on modern industrial heritage Network in Liaoning Province -- A case study of petrochemical industry,” *Journal of Shenyang Jianzhu University (Social Science Edition)*, vol. 4, pp. 325-330.

[3] Zhao, Y L. and Yang, A J. (2022). “rotection and utilization of industrial heritage in Wuhan from the perspective of industrial culture inheritance,” *Journal of Hubei Second Normal University*, vol. 6, pp. 28-32.

[4] Wang, C., Ren, S b., He, Y., Chen, L. and Xu, G T. (2019). Research on the conservation and development of inner and outer ancient cities based on historical genes: A case study of the integrated conservation and development planning of Jingzhou Ancient City. *China Urban Planning Annual Conference*. Chongqing, China, pp. 969-978.

[5] Wang, Q J., Ma, Y Y., Wang, Y., Gao, Y. and Zhang, B. (2023). “Identification of industrial cultural genes and the path of recreation utilization in Beijing West Mining area,” *Journal of Beijing union university (humanities and social science edition)* , vol. 1, pp. 42-50.

[6] Dong, F F. (2012). “Master of Architectural Heritage Reuse and Environmental Regeneration Research of Hanyang Steel Mill,” *Wuhan University of Technology*.

[7] Han, J. (2019). “Master of Implementation Path of Integrated Protection and Reuse of Industrial Heritage,” *Huazhong University of Science and Technology*.

[8] Liu, P L. (2011). “Ph.D., Construction and Application of Gene Map of Chinese traditional settlement landscape,” *Peking University*.

[9] Shen, X Y., Liu, P L., Deng, Y Y and Zheng, W W. (2006). “Landscape gene map: a new perspective for the study of settlement cultural landscape flora,” *Journal of Liaoning University (Philosophy and Social Sciences Edition)*, vol. 3, pp. 143-148.

[10] Li, N. (2019). “Master of Architectural Heritage Value Research of Dazhao Temple, Inner Mongolia,” *Inner Mongolia University of Technology*.

[11] Bi, Mi Y. (2011). “Master of Rural Cultural Gene Inheritance Path Research,” *Suzhou University of Science and Technology*.

[12] Zhao, H L., Wang, J., Yuan, Z J and Ma, T. (2014). “Genealogies construction and inheritance path of cultural genes: A case study of cultural genes in ancient Yunnan,” *Modern Urban Research*, vol. 5, pp. 90-97.

[13] Zhang, M., Liu X. and Wang, F. (2007). “Nanjing Urban cultural Strategy and its spatial effect,” *Urban Development Research*, vol. 5, pp. 13-18.

[14] Chen, Y M. (2009). "Cultural industry brand building strategy in the era of symbol economy," *Comparison of Economic and Social Systems*, vol. 4, pp. 188-191.

[15] Lacime Architects. (2022). "Renovation design of pilot area of Wuhan Hanyang Steel Plant," *Architectural Practice*, vol. 9, pp. 44-53.

[16] Zhang, S. (2009). "Discussion on regional protection strategies of cultural ecology -- A case study of Huizhou cultural ecology protection Experimental Area," *ournal of Tongji University (Social Science Edition)*, vol. 3, pp. 27-35+48.