Research on Landscape Renewal Design Strategies for Historic Districts Based on the CGC Model

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Abstract— In the stock era, urban renewal, especially the renewal of historical blocks, is facing great challenges: local cultural genes are being lost, while design forms are experiencing repeated homogenization. In order to solve the current design contradictions, it is necessary to study and build a CGC (collage-gene coupling) update model to avoid relying on linear design derivation by bridging the theoretical gap between the cultural genetic theory and the collage urban framework. Use the NVivo qualitative analysis method to encode the original data and analyze relevant cases to transform implicit design intuition into practical strategies. This workflow covers all aspects from deep gene identification to precise spatial operation. A comparative empirical study of the Castelvecchio Museum and Guangzhou Yongqing Fang has verified that effective urban collage is not the arbitrary accumulation of formal fragments, but the syntactic reconstruction of the deep genes of the site. The establishment of the CGC theoretical model provides a rigorous guidance for the field of urban renewal, so that it can maintain adaptability in different cultural contexts.

Keywords— Historic district renewal; collage city; cultural gene; CGC model; NVivo

I. INTRODUCTION

Urban space is a concrete projection of collective cultural grammar, and its function is far more than a physical container [1]. With the urban stock era reshaping the built environment[2], historical blocks are facing a structural crisis characterized by "genetic alienation" and "collage disorder". Theoretical research has undergone a significant change. Contemporary academic research now prioritizes the overall exploration of the social environment to obtain in-depth historical data[3]. However, there is an obvious disconnect between the practical level and these theoretical goals in development. Under the dual effect of the physical division of early modernism and the erosion of recent consumerism, the originally continuous deep context structure is often cut off and degenerated into an island that only retains symbolic appearances but loses its generative cultural ability. To make matters worse, Colin Rowe's "collage city" theory has been widely misread. In the context of post-modern "fast food" design, this theory has been alienated into a formalistic excuse, leading to arbitrary judgment. This distortion often leads to the proliferation of a large number of heterogeneous symbols that are free from geographical restrictions, further exacerbating the semantic confusion and nihilism in the historical environment. In the face of such a complex dilemma, is the empirical paradigm that traditionally relies only on the subjective intuition of designers still valid? Our analysis shows that this paradigm is not enough to cope with such a complex context deconstruction. Therefore, there is an urgent need to make a methodological revision: go beyond simple empirical judgment and establish a scientific and evidence-based identification method to explore the "genes" deep in the site. It is the necessity of constructing systematic

operation logic to realize the organic repair and weaving of the context that constitutes the basic practical basis of the CGC (collage-gene coupling) model proposed in this study.

The city is the carrier of civilization. Behind the tangible material space of the city, there is a cultural pattern that affects its formation[4]. The components of urban space, including cultural factors, like genetic material, encode the structure and logic of the city over time[5]. As early as 1996, the International Conference on Urban Planning proposed that urban development should take into account cultural and geographical factors, rather than just pursuing economic growth and modernization[6]. At present, most of the research on urban renewal starts from spatial elements, focusing on the inheritance and regeneration of urban culture. However, at the theoretical level, although the academic community has achieved fruitful results in the fields of "cultural genes" and "collage cities", these two theories face specific applicability challenges in dealing with the complex urban stock renewal background. In the theoretical system of British historical geographer Conzen, morphological genes are regarded as the basic components of urban form, which is crucial to understanding the spatial structure and historical evolution of cities[7]. In this regard, the existing research on cultural genes has made important contributions to the identification and classification of historical elements, but it tends to be static protection and inheritance, and lacks a dynamic mechanism to transform recessive genes into modern space design. This makes it a little passive in guiding innovative design.On the other hand, while the collage city theory provides a key perspective for addressing heterogeneity, in subsequent generalized practices, its profound historical dimension risks being reduced to merely formal operations. Without systematic constraints of deep cultural semantics, and when facing urban dynamics such as expansion in scale, spatial reorganization, and land use, it can easily lead to the expansion of urban form and the fragmentation of spatial meaning[8].In addition, there is a certain degree of paradigm lag at the methodological level. Existing design strategy generation still relies heavily on the designer's personal judgment and lacks a scientific deduction process, resulting in insufficient traceability of logic throughout the design process. Based on the current research issues, this study puts forward a core question: In the context of stock renewal, how can a systematic CGC (Collage-Gene Coupling) model be constructed to operationally unify the authenticity of cultural genes with the adaptability of collage techniques, thereby generating historical district landscape renewal design strategies with cross-cultural adaptability and methodological reference value?

To address the core issues raised earlier, this study aims to realize a comprehensive research pathway from theoretical model construction to the generation of operational strategies. Based on theoretical research, this study constructs a model

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of cultural genetic theory and collage city theory coupling (CGC). By introducing the perspective of systematic theory, the commonality between cultural genetic theory and collage city theory is explored from a fundamental level, aiming to provide a more reasonable design framework for the renewal of historical blocks. At the level of research methods, this study breaks through the limitations of traditional empiricism, using NVivo software for qualitative analysis, manifesting implicit design knowledge, and clarifying design logic. Finally, the Castelvecchio Museum and Yongqing Fang in Guangzhou, China were selected as typical cases for analysis. Through the combination of theory and practice, the cross-cultural adaptability of the strategic system in typical situations has been verified. The value of this research lies not only in alleviating the contradiction between conservation theory and contemporary design practice, but also in trying to provide a new cognitive perspective for stock renewal: the study proposes that historical authenticity is not only a formal visual imitation, but also a continuation of deep syntactic logic. This provides an indexable guiding theory for planners and architects, which helps to improve the scientificity of design and update project decision-making.

II. METHODOLOGY

A. Research Overview

In order to solve the actual contradiction between the rigidity of historical block heritage protection and the disorder of formal collage in urban renewal, this study adopts a multi-stage research design, and follows the logical path of evidence-based literature research to theoretical coupling, and qualitative research. The research conducts a systematic literature review based on the PRISMA 2020 guidelines, and adopts scientific and standardized methods and necessary procedures to analyze relevant literature to build the theoretical basis and empirical data of the research. In addition, in order to overcome the limitations of a single theoretical perspective, this study adopts dialectical coupling logic to combine the structural constraints of "cultural genes" with the formal adaptability of "collage cities" to build a CGC (collage-gene coupling) theoretical model that integrates cultural genes and collage city theory. Finally, use NVivo software to code the selected core literature using the grounded Theory to generate a standardized design strategy matrix. This chapter will elaborate on the operation process of data collection, model coupling logic and analysis tools.

B. Literature Selection and Screening

During the literature search stage，this study selected Web of Science, Scopus, and CNKI as the main data sources. The search time frame was set from January 2010 to January 2026, aiming to focus on the latest research findings in the era of stock-based urban planning. The retrieval logic strictly followed the tripartite structure of "Theory—Structure—Context," using topic fields in WoS and relevant fields in Scopus and CNKI. Boolean operators were applied to precisely pinpoint the intersection of "collage city/contextualism" theories and "cultural gene/urban morphology" methods within the topic of "historic district renewal." Boolean logic defined our search keywords to isolate the overlap between design methods and deep cultural structures. We identified that algorithmic indexing alone left significant gaps. The dataset was manually expanded. Using a "backward snowballing"

strategy, we traced citations within primary texts to recover relevant publications that had slipped through standard keyword filters.

Literature screening requires the establishment of inclusion and exclusion criteria and procedures. In order to ensure the reliability and validity of literature samples and focus on the core theme of "landscape renewal design", this study has formulated screening criteria covering dimensions such as timeliness, content and quality. In order to accurately grasp the latest development and paradigm innovation of collage theory in the context of contemporary technology, the research time range is set from January 2010 to January 2026. Considering the cultural context of the design, the study is specially included in the China Knowledge Network (CNKI) database to accurately identify the latest development of collage theory under the current technological background, and deeply explore the transformation and adaptive innovation of Western theories under the concept of landscape gene localization. In terms of content relevance, the included literature must meet the "theoretical dimension" and the "object dimension" at the same time, focusing on the literature applied to "collage/morphological theory" in "historical block/urban renewal". It should be noted that, in order to ensure the practical relevance of the research outcomes for design practice, this study excluded purely historical research, literature lacking spatial morphological diagrams and evolutionary analysis, and studies on landscape genes from a purely geographic semiotics perspective that do not address material spatial placement. Unrelated genetic studies in the biomedical field were also excluded, ensuring that the sample provides substantive guidance for practical design.Finally, for quality control of the literature, given the large number of theses in the Chinese CNKI database, only doctoral and master's theses from China's "Double First-Class" universities and the original "Eight Schools of Architecture" were included, in order to minimize the inclusion of low-quality studies with insufficient theoretical depth or high repetition rates (Table 1).

TABLE I.   CRITERIA FOR LITERATURE SCREENING

Dimension	Inclusion	Exclusion
Document Type	1. Journal article: peer-reviewed journal. 2. Academic thesis (CNKI): Master's or doctoral theses from "Double First-Class" universities or the "Old Eight Schools" of architecture 3. Review article: systematic review or meta-analysis.	1. Conference abstracts, editorials, news reports. 2. Master's theses from ordinary universities (avoid studies with high repetition rates or insufficient theoretical depth). 3. Articles for which the full text cannot be obtained (non-OA).
Research Topic	1. Core theories: collage city, urban morphology, figure-ground relationship, contextualism. 2. Localization Concept: Cultural/Landscape Genes 3. Application scenarios: urban renewal, historic districts, application of suture/weaving theories.	1. Pure non-spatial research: purely historical analysis or purely sociological investigation that does not include plans, morphological analysis, or spatial diagrams. 2. Conceptual Ambiguity Exclusion: （1）Landscape gene sections in geography that discuss only "symbolic meaning" without "spatial localization."

Dimension	Inclusion	Exclusion
		(2) Fields of political science/linguistics
Methods and Techniques	Articles that use new technologies such as GIS, Space Syntax, machine learning, and eye tracking to validate or quantify traditional collage/morphological theories	1. Pure algorithm development (no background in urban planning applications) 2. Research on "regeneration/gene" from a purely biomedical/materials science perspective.
Language	Chinese, English	Other languages

Specifically, by January 2026, a total of 422 papers were collected from Web of Science (218 papers), CNKI (39 papers), and Scopus (165 papers). Further screening and deduplication of these 422 papers was conducted according to the criteria outlined in the table, based on a review of their titles, abstracts, keywords, and full content. Ultimately, 20 valid papers were collected to serve as supporting material for model output and as raw data for Nvivo coding （Figure 1）.

C. Literature Analysis and Model Construction

1)*Theoretical Review and Critical Reconstruction:* Through an in-depth review of relevant domestic and international literature, it has been found that studies focusing on the protection or revitalization of historic districts mainly employ two approaches: the pragmatic approach and the sociological approach[9].Pragmatism focuses on the method of revival, and the sociological method critically reflects on the negative consequences of revival, such as squire[10], but often ignores how to revitalize historical neighborhoods by protecting and revitalizing them and injecting new vitality. In addition, measures to protect traditional historical neighborhoods in the past often emphasized the historical value of buildings and ignored the importance of protecting the overall form and unique characteristics of these neighborhoods[11]. In the process of reconstruction, the unique urban form of the block and its interrelationship are often ignored[12], which highlights the importance of the cultural genes of historical blocks in the context of modernization. At the theoretical level, the research on the renewal of historical blocks is showing an academic trend of cross-integrating morphology and cultural genetic metaphors.However, based on a systematic literature review, it has been found that although the theories of "Collage City" and "Cultural Genes" respectively provide important perspectives for the "formal intervention" and "value cognition" of historic districts, both have significant theoretical limitations and practical alienation when applied independently in contemporary stock renewal practices. There is an urgent need for critical logical reconstruction. Moreover, existing literature has yet to establish a framework explaining how deep-seated cultural genes can be precisely transformed into modern formal design mechanisms through collage logic. Based on this insight into the theoretical gap, this study proposes that it is necessary to move beyond one-way references and construct the CGC model — this is not a mechanical

superimposition of the two theories, but rather a dynamic coupled system based on the isomorphism of cultural gene and collage methodologies, aiming to achieve a scientific translation from deep cultural semantics to modern spatial forms.
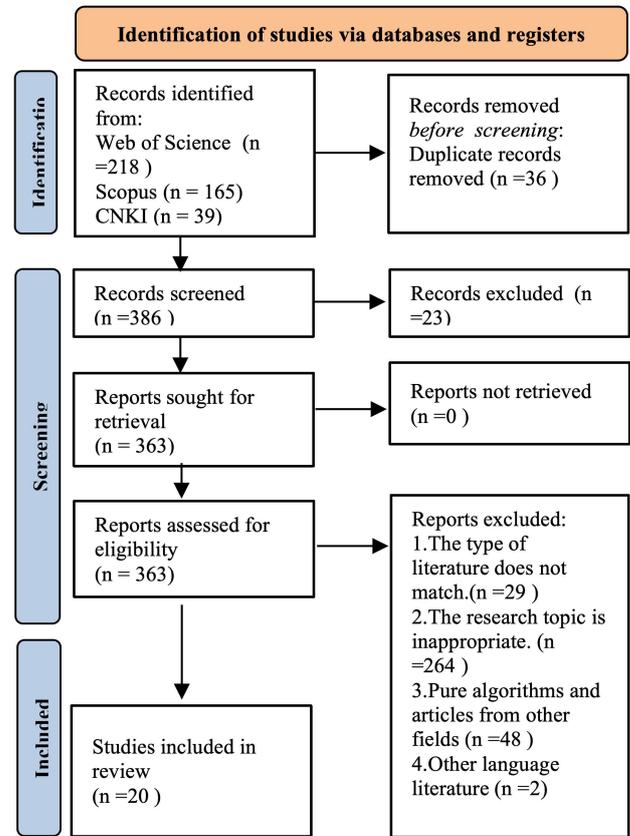

Fig. 1. PRISMA Flow Diagram.

First of all, as far as the "collage city" theory is concerned, critical analysis shows that at the micro-practical level, it often falls into the pit of formalism. Colin Rowe originally proposed that "collage" was to counter the homogenized utopia of modernism and advocate the juxtaposition of heterogeneous elements to accommodate the complexity of historical time. For those cities that have experienced cultural and spatial rupture due to passive industrialization and other special circumstances, this is of practical significance to enrich the connotation of urban culture[13]. However, in subsequent postmodern practice, this concept is often simplified into a visual game that lacks internal logic. As a technology, "collage" cannot truly realize "collage" as a way of thinking; it is revolutionary and critical in theory, but it is often reduced to formalism in practice [14]. Due to the lack of strict constraints on the deep cultural semantics of the venue, this kind of "disorderly collage" that is out of context and grammatically inconsistent often leads to the arbitrary accumulation of historical symbols, eventually forming a landscape disconnected from history. This makes the spatial context fragmented and becomes an unreal background.Thus, simply "collaging" historical fragments cannot genuinely address the functional crisis of modern cities[15].Secondly, looking at current research on the "Cultural Gene" theory, -while it has effectively

resolved issues of value identification, it commonly faces the dilemma of static preservation. Most existing studies are limited to biological-style typological classification and static extraction of historical relics, severely lacking in mechanisms for "translating" them into dynamic, modern life-adaptive forms. In the context of rapid modernization, attempts to explain traditional heritage innovation through the lens of "cultural genes" often appear "outdated" or "conservative," making it difficult to guide revitalization in urban renewal. This "recognition without evolution" preservation model is like soaking a living historic neighborhood in "formalin" for preservation: although the physical specimen is perfectly preserved, severing the mechanisms of functional metabolism results in a complete loss of social vitality.

Based on the above double criticism, this study puts forward the logical premise for building a CGC model: the renewal of historical blocks should not be just a simple implantation of modern forms, but must be based on cultural semantics. We redefined the cultural gene as the syntactic rules of the place, which provides content-level constraints for updating; at the same time, we redefined collage technology as "lexical expression" to adapt to environmental changes, which provides the possibility of form transformation and functional flexibility. Therefore, this study emphasizes that when applying collage vocabulary, the syntactic logic of genes must be followed to solve the contradiction between context protection and formal innovation, so as to realize the systematic regeneration of the historical environment.

2) *Coupling Mechanism between Cultural Genes and Collage City Theory:*Influenced by the UNESCO concept of "historical urban landscape", the academic perspective on the protection and utilization of historical urban areas has gradually shifted from the traditional concept of heritage protection to a landscape-oriented approach. This transformation pays more attention to the social and cultural connection between people and the environment, and emphasizes the historical stratification of urban landscape[16]. In order to realize the transformation from cultural semantics to modern spatial forms, the CGC model does not simply superimpose the two theories, but is based on their genetic similarity and methodological isomorphism, so as to integrate the social, cultural and economic relations between people and the environment in historical urban areas and their historical stratification into the design model.

a) *Theoretical layer mapping:* The interaction between the four elements of Colin Rowe's collage theory and the binary structure of cultural genes transcends mechanical replication, representing a theoretical expansion generated by the complexity of contemporary urban renewal. Collage city is far from just a formal strategy. It contains a three-dimensional dialectical relationship from the perspective of history, material and ideology. This characteristic has a significant intrinsic resonance with the dual opposition of dominant and recessive genes in the theory of cultural genes. In our study, we observed that the traditional analytical framework tends to be reductive, which decomposes cultural elements into isolated data points. In order to overcome this limitation, we adopt a genetic perspective to classify directly perceptible and quantifiable elements as dominant genes, and those contained in practical activities and reflect social Elements that believe in deep logic are defined as recessive

genes[17]. It is this deep structural homogeneity that inspires us to combine Colin Rowe's four classic elements of time, space, people and objects with this genetic binary structure to construct a multi-dimensional 2 × 4 analytical factor matrix.This matrix functions not as a categorical list but as a dualistic lens for deconstructing the urban fabric where the dimension of time records tangible traces of material evolution while acting as a vessel for historical memory. Similarly, the spatial dimension juxtaposes the mappable physical fabric against invisible social networks to amend the cognitive bias of single-form definitions, while the human dimension probes internalized community beliefs beyond visible flows and the material dimension elevates physical construction into cultural carriers of symbolic meaning. Through this progressive deconstruction, previously abstract cultural concepts are concretized into actionable renewal factors to fundamentally resolve the methodological challenge of what to analyze in stock renewal (Figure 2).

Collage Elements (Coupling Dimension)	Explicit genes (externalized, directly perceivable)	Implici gene (internalized, not easily perceived)
Time	**Explicit-Time: Evolutionary Outcome** The stratification and traces of transformation of material forms along the timeline.	**Implicit-Time: Historical Memory** The collective emotions, continuity of values, and logic of identity embedded within time.
Space	**Explicit Space: Morphological Texture** The measurable physical elements and combination rules that constitute the spatial form.	**Implicit-Space: Social Relationships** The invisible social networks and power structures carried and organized by space.
People	**Explicit - People: Behavior Patterns** Behavior patterns and circulation of people in space that can be directly observed.	**Implicit - People: Spiritual Core** The internalized values, beliefs, aesthetic preferences, and patterns of emotional attachment within a group.
Object	**Explicit-Object: Physical entity** A physical entity that carries information, along with its material, structural, and formal characteristics.	**Implicit-Object: Symbolic Meaning** The symbolic, metaphorical, narrative functions, and emotional projections attributed to objects.

Fig. 2. Theoretical Layer of the CGC Model

b) *Method Layer Practice:* At the practical level, dominant structural genes with physical existence, such as street patterns, determine that the design must follow the structural texture and restoration principles of the original site, because they have irreversible bottom relationships and need to be intervened through micro-renewal to maintain the continuity of spatial form. In contrast, the recessive genes that lack material carriers, such as historical memory, are invisible, forcing the design to adopt symbolic parallelism to highlight the implicit context through the expression of field elements. These genetic attributes are rooted in the internal logic of the spatial diagram, which confirms that the collage technique is not the arbitrary choice of formalism, but the inevitable response to the precise interpretation of the deep context of the site.Therefore,based on the "identification − reconstruction − recoding" lifecycle of cultural genes, the CGC model preliminarily constructs an isomorphic translation pathway from the "information layer to the operational layer," using collage techniques as the vehicle for gene evolution. Merely delineating traditional landscape areas according to existing textures does not necessarily yield a complete region[18]. Incorporating the theory of cultural genes is of great significance for the inheritance of spatial meanings, as the identification and extraction of site information correspond to the sourcing of collage materials. Through field research and oral history, information within the site is recognized, such as unique brick-and-stone masonry techniques and the spiritual genes of the site, including folk customs, neighborhood interaction rituals, etc. Genes are the basic units that control the similarity or difference of urban historical landscape features, and also

serve as carriers of public perception and experience[19]. At this stage, the goal is to achieve greater depth by uncovering both explicit and implicit genes that represent the identity of the place, which then serve as the basis for semantic reconstruction and syntactic establishment corresponding to collage logic. Fragmented raw information is abstracted and refined in this process, with cultural genes being transformed into abstract spatial syntax. For example, explicit activities like traditional festival celebrations are defined as centripetal spatial diagrams and transformed into implicit syntax. Similar to spatial syntax, different spatial syntax analyses reveal the continuity of certain significant elements[20], and different cultural genes also maintain the continuity of urban context. This step ensures that the subsequent collage operation follows the inherent logic of the cultural context, rather than arbitrary formal combinations. The last step is visual recoding and homomorphic collage, which corresponds to the "formal generation" of collage. This is the key to realizing the theoretical model - that is, the process of "visual recoding". Designers use collage techniques such as parallelization, reorganization and repair to transform abstract genetic grammar into modern design language.This aims to address, within existing research, the lack of a coordinated mechanism between authenticity preservation and productive inheritance. Under theoretical coupling, successful recoding requires that the spatial form of the collage must bear the cultural information of the genes.

Colin Rowe's dialectical collage concept provided the depth. Cultural gene theory provided the evolutionary logic. Fusing these distinct strands transformed the renewal of historical blocks from simple spatial adjustment into a systematic cultural regeneration project. In this system, the genetic structure functions as the immutable core. Collage, conversely, acts as the flexible intermediary, strictly tracking the site's lifecycle. This theoretical coupling moves beyond passive description. It constructs the methodological scaffolding essential for the subsequent operational model.

c) *CGC Model Construction:* Based on the above theoretical coupling analysis, this study constructs a visual framework for the CGC theoretical model. The model is not a simple linear process, but a hierarchical structure, in which the deep structure constraints evolve into a surface form. After reflecting and optimizing the initial concept, the study found that the research stage of "identification-reconstruction-recoding" lacked a critical perspective, so the evaluation stage was added. In general, the CGC model is not a static layered stack, but a vertical organic system. The system consists of four core layers, from the information layer to the operation layer, and is connected to each other through dynamic feedback loops. The introduction of time variables effectively avoids the disadvantage of the traditional model stalling after the update is completed, and emphasizes the ability of each component to generate its own power and continue to iterate.

The CGC theoretical model is not a simple linear arrangement, but a hierarchical structure based on dialectical relationships. The evolutionary process of the theoretical model is from deep genetic structure constraints to design form generation. The lasting pattern of urban landscape is not only the legacy of the past form, but also the active carrier of the urban genetic code[11]. In order to meet the complex renewal needs of land use and spatial form[21], it is necessary to root the research in the deep structure of genes.

But how to turn this depth into practical operation? In order to transform abstract theoretical integration into feasible tools, the model places the multi-dimensional analysis factor matrix at the core of the information layer, guides the design to go beyond the limitations of traditional morphology on physical space, coordinate the synergy between space, social and economic dimensions, and run through the whole life from genetic prototype to adaptive regeneration. The process aims to update the design through comprehensive guidance. In our research practice, we regard the matrix as the key center, connecting abstract theory and concrete design measures. By closely combining implicit social networks and explicit economic logic, we have effectively eliminated the common risks of formalism in standard practice. In addition, the matrix has dual methodological significance: on the one hand, it provides a structured coding node framework for the use of NVivo for qualitative analysis to ensure the fineness of data; on the other hand, it also provides a panoramic design strategy to meet the triple needs of morphological restoration, social cohesion and economic revitalization. Navigation chart.

The system completes the full-dimensional factor analysis and deals with the inevitable conflict between cultural genes and contemporary functional needs through the evaluation layer. Here, the pathological diagnosis mechanism can accurately locate specific "genetic mismatch" - distinguishing between physical rigid fractures and invisible cultural disconnections - so as to establish an evidence-based design path. In order to bridge the gap between the deep diagnosis background and the surface space form, the conversion layer, as a bridge to the methodology, implements the double verification process through syntactic extraction and isomorphic reconstruction, so as to prevent the project from falling into arbitrary formalistic stacking while adaptive isomorphism. All theoretical derivations eventually converge into the operation layer, that is, the intuitive spatial output terminal of the system. Here, specific genetic diagnosis is combined with adaptive recoding tools (from texture stitching to narrative recombination) to promote the reactivation of social metabolism and economic regeneration capacity of historical blocks.

What runs through the whole model is a dynamic feedback loop, which gives the system organic vitality. Unlike the linear model with one-way output as the end point, the CGC framework regards the design as a continuous process of cyclical. Returning from the operational level to the information layer shows that there is always a key time dimension in the design process, which coincides with the view that we observe that spatial intervention is the potential gene of future heritage. Successful collage operation will be precipitated into a new historical memory after verification and crystallized into future cultural genes.This mechanism continuously inputs structural order into the system, effectively resisting the decline and disorder of historic districts in the era of stock development, thus achieving truly organic renewal and the continual inheritance of cultural context （Figure 3).
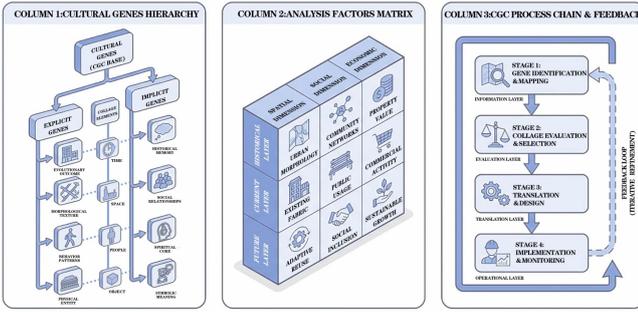
Fig. 3. Collage-gene coupling (CGC) model framework

D. NVivo Coding and Analysis

Establishing a scientific evidence base for design strategies is non-negotiable; this reality drove our adoption of the rigorous grounded theory paradigm . We utilized NVivo to process 20 high-quality core papers (Table 2) for third-level coding. The coding process follows the five-step method proposed by De Keyser[22], including familiarizing the content of the article, coding the content, classifying the code, comparing code categories and further analysis. Two researchers are coding at the same time, and any inconsistencies arising in the coding process are resolved through group discussion to avoid subjective judgment, thus ensuring the validity and reliability of the coding results.However, faced with such textual density, a critical methodological question arises: how do we prevent the analysis from splintering into incoherence? Our response plan is to connect the coding logic with the CGC framework. From micro-indicators to design logic, it finally forms a core mechanism. This method confirms that the combination of cultural genes and collage cities is not only an academic theory, but also a pragmatic strategy that can be integrated into the practice of urban renewal.

TABLE II.   RESEARCH SAMPLE INFORMATION FORM

Document Number	Title	Main research content
W01	Urban Form and Sustainable Neighborhood Regeneration—A Multiscale Study of Daegu, South Korea	Analyze the influence of different scale urban form elements on the performance of neighborhood regeneration.
W02	A Generative Urban Form Design Framework Based on Deep Convolutional GANs and Landscape Pattern Metrics for Sustainable Renewal in Highly Urbanized Cities	Propose a high-density urban form generation framework based on deep learning (DCGANs).
W03	The identification of cultural genes in historic districts and their influences on cultural perception case study in Central Street in Harbin China	Identify the latent and explicit genetic factors of historical districts and verify their quantitative impact on public perception.
W04	An analytical study of Chinese urban cemeteries based on urban morphology and spatial vitality Case studies in Nanjing	Use morphological and vitality measurement tools to diagnose the isolation problem of special spaces (such as cemeteries).
W05	Typo-morphology in the Cognition of Traditional Landscape Region-Case Study of Urban Design Project in Changting Town, China	Apply the type morphological method to analyze the traditional landscape structure and guide the design practice.
W06	Using deep learning to unravel the structural evolution of block-scale green spaces in urban renewal	Utilizing deep learning technology to analyze the structural evolution of green space forms during urban renewal processes.
W07	Unveiling the potential of space syntax approach for revitalizing historic urban areas A case study of Yushan Historic District, China	Applying spatial syntax to evaluate the influence mechanism of street network structure on the vitality of historical districts.
W08	Transition of Urban Morphology in the Mountainous Areas Since Early-Modern Times from the Perspective of Urban Historic Landscape—A GIS Tools and Historical Map Translation Approach	Reconstruct the evolution of mountainous urban forms based on the HUL perspective and the technology of historical map translation.
W09	Morphological evaluation and regeneration of informal settlements An experience-based urban design approach	Propose an experience-based morphological assessment and regeneration strategy for non-military settlements.
W10	Revitalizing historic districts Identifying built environment predictors for street vibrancy based on urban sensor data	Utilize the big data from urban sensors to identify the key built environment factors that affect the vitality of historical districts.
W11	Belgrade's urban transformation during the 19th century A space Syntax approach	A Study on the Transformation of Urban Form from Ottoman Tradition to Modern European Style from the Perspective of Spatial Syntax.
W12	When Organic Urban Forms and Grid Systems Collide Application of Space Syntax for Analyzing the Spatial Configuration of Barcelona Spain	Analyze the spatial collision and morphological integration mechanism between the historical organic structure and the modern grid system.
W13	Uncovering Urban Palimpsest through Descriptive and Analytical Approaches to Urban Morphology-Understanding the Ottoman Urban Fabric of Bursa, Türkiye	Based on the "rewritten version" theory, this paper analyzes the layered and evolving urban form under the superimposition of multiple histories.Based on the "rewritten version" theory, this paper analyzes the layered and evolving urban form under the superimposition of multiple histories.
W14	The impact of a new public transport system on neighbourhoods surrounding stations The cases of Bermondsey and West Ham with the Jubilee Line extension in London	Analyze the reshaping effect of the introduction of new transportation infrastructure on the traditional spatial form and accessibility of community areas.
W15	Exploring the Spatial Distribution Mechanisms of Restaurants Across Different Urban Morphologies A Macau Case Study Using Space Syntax and Big Data	Combining POI big data with spatial syntax, we explore the distribution logic of catering business types in different regional forms.

Document Number	Title	Main research content
W16	Identification of Landscape Characteristics of Urban Historical Districts and Optimization of Zoning Methods	Construct a refined technical system for identifying and zoning the historical district's landscape features by combining clustering algorithms.
W17	The Impact of Urban Historical Landscape Perception on the Satisfaction of Historical District Experience: A Case Study of the Zhonghua Baroque Historical District in Harbin	Empirical research was conducted to examine the influence of the public's perception of landscape elements such as environment and layout on the satisfaction of the experience.
W18	Analysis of the Protection and Renewal of Historical and Cultural Districts from the Perspective of Spatial Genes: A Case Study of Jining Juntai Temple Historical District	Extract the spatial genes of the neighborhood and propose a protection and renewal strategy based on texture restoration and architectural style continuation.
W19	Research on Morphological Control of Residential Historical Districts from the Perspective of Cultural Genes: A Case Study of Sanxue Street Historical and Cultural District in Xi'an	Establish a hierarchical and categorized control index system for the form of historical districts based on the perspective of cultural gene inheritance.
W20	Research on the Identification and Revitalization Utilization of Traditional Village Cultural Landscape Genes in Jinzhong Area - Taking Xiaozhai Village as an ExampleResearch on the Identification and Revitalization Utilization of Traditional Village Cultural Landscape Genes in Jinzhong Area - Taking Xiaozhai Village as an Example	Construct a three-dimensional genetic identification system of "space - society - culture" and propose the path for activating authenticity.

1)*Composition of original materials:*In the research, in order to improve the quality of research, we focus on the effectiveness of information and build a double-layer source of information. The 20 key documents (W01-W20) screened through the PRISMA process constitute the main basis; they ensure the high information density from basic theory to deep learning applications. However, a key methodological risk still exists: given the complexity of urban theory, how can we prevent semantic distortion in the coding process? In order to solve this problem, we have integrated the auxiliary context, especially Collage City, as a reference system for theoretical calibration. These auxiliary texts do not directly generate coding nodes; they are used to define coding nodes. By strictly clarifying the vague semantic boundaries, this auxiliary layer can prevent interpretation bias in the analysis process, thus enhancing the reliability of the entire coding architecture.

2)*Coding Operation Procedure：*

a) Open Coding: As the basic link of vocabulary extraction, the open coding stage conducts multi-label analysis of 20 selected high-quality core references. The purpose is to extract design words with practical meaning from the original text data. To avoid researchers' subjective assumptions, we have established the principle of prioritizing the extraction of physical facts and behavioral attributes.By focusing strictly on statements describing morphological characteristics and translation skills, we have successfully screened out 1,201 valid reference nodes after eliminating duplicates and ambiguous content. In the process of open coding, researchers have defined the traditional qualitative description. For example, for the original expression in the document W020 "introducing vibrant commercial functions and transforming the back street or south street section of the old village into a pedestrian street along the Shanxi merchant route", we excluded the label of "commercial development". Considering the cultural level of the scene and its upgrade characteristics, this expression is finally classified as "consumption scene iteration", emphasizing its behavioral attributes. In the coding process, any pure adjective evaluation that lacks entity carriers or specific behavior descriptions, such as "beauty", is excluded to ensure the objectivity and empirical nature of the main coding. According to the unified logic , we deliberately recode abstract concepts such as "historical characteristics" into precise genetic identification concepts, such as "graphic-background relationship analysis" and "historical hierarchical structure"; at the same time, we redefined the broad concept of renewal and transformation as specific collage concepts, such as "interface stitching strategy" and "typology Repair technology". This semantic accuracy is crucial: it ensures that the subsequent analysis does not stay at the abstract theoretical derivation level, but is firmly rooted in real, microscopic and fine morphological data.

b)Axial Coding: Open coding is the foundation of axis coding. In the axis coding stage, the analytical perspective can be broadened, going beyond the simple vocabulary level, and deeply exploring the essence of the phenomenon. By analyzing the deep logical connections between the initial concepts and conducting ongoing comparisons, causal, parallel, or hierarchical relationships among the first-level codes are examined, and reference points with similar meanings are consolidated.Under the dual guidance of cultural genes and collage urban frameworks, we systematically distilled 1,201 scattered reference points into 10 coherent subcategories. For example, in open coding, "heterogeneous texture conflict" is associated with "spatial interface incompatibility" from another source. Our analysis shows that the potential logic of these phenomena is not a simple visual contrast, but refers to the same structural disorder, that is, the new element fails to follow the morphological syntax of the original environment at the physical level. Therefore, these nodes are logically associated with the category of "scale and texture conflict", thus determining that they are the priority spatial pathology targets that must be solved first in the subsequent "collage repair" process.Specifically, the study first established a genetic type centered on the dominant morphological prototype and the connotation of recessive place in the basic stage, and clarified the deep genetic code of historical blocks as organic life forms. The research further summarizes the common collage phenomenon in the current renewal practice, such as scale and texture conflicts, spatial semantic fracture, etc., and reveals the root cause behind the failure of historical block renewal. On this basis, the adaptive transformation mechanism with texture repair and stitching, space-time parallelization and dialogue, and narrative reorganization and reconstruction as the core is studied and distilled, and the technical intermediary of morphological transformation is established using spatial syntax and generation algorithms. At the level of practical strategy, the research has established

the operation path of genetic map control, urban function reset and productive activation, which reflects the isomorphic regeneration process from material space genetic research to social value reproduction, and completes the transformation of the CGC model from theoretical hypothesis to operational path.

c) Selective Coding: The final stage of the analysis process is selective coding, and the research goal is to shift from simple classification to establishing rigorous conceptual induction.For example, the study uniformly identifies the physical restoration of C1, the spatiotemporal dialogue of C2, and the semantic reconstruction of C3 as specific actions that convert implicit genetic codes into explicit spatial entities. Based on the complementary functions they perform during the transformation process, their logic is elevated and integrated under the core category of the "adaptive morphological translation mechanism." In this complex synthesis process, four key dimensions are gradually clarified, forming a complete logical chain: identifying the multi-dimensional deep structure as a preliminary constraint, and then pathological diagnosis of the current spatial condition to accurately locate the problem; then, the adaptive morphological conversion mechanism acts as a technical intermediary, and finally the isomorphism of the site value Regeneration is the ultimate goal of action. This result accurately reproduces the design process of the CGC model from gene decoding to collage regeneration, and is further confirmed by a significant empirical observation: the coding node directly associates "texture repair and sewing" (156 nodes) with "explicit morphological prototype" (145 nodes), and the frequency is extremely High. The empirical weight of this dense data network forces us to have a fundamental understanding of the nature of intervention. The renewal of historical blocks cannot be a canvas for arbitrary artistic imagination; it needs to be built on the structural basis of syntactic isomorphism and productive inheritance (Table 3), which is not only a theoretical preference, but also a structural inevitability. With this solid logical framework, a key issue still exists: how can we transform these fixed patterns into flexible interventions? This issue shows the need to establish a design strategy matrix and emphasizes the transformation of theoretical findings into actionable frameworks.

In order to ensure the quality of the research, we have implemented a verification scheme based on the reserved sample test. The research does not end when the analysis of the "feeling" is completed, but the saturation verification of the initially formed logic is carried out. The researchers isolate 20% of the original corpus as verification materials, and then use the remaining corpus to build a coding architecture. Judge whether it can maintain structural

integrity when introducing these reserved data. This test is very important. It transforms "saturation" from a theoretical hypothesis into a verifiable endurance test, proving that the coding system can absorb new evidence without fundamental reconstruction. After determining the framework of four main categories and ten secondary categories, we introduced the verification group data for independent coding tests. The results showed that new reference points extracted from the verification group, such as "tension between old and new" and "adaptive isomorphic design," could all be smoothly categorized under existing categories like "C2. Spatio-temporal Juxtaposition and Dialogue" or "C1. Texture Mending and Stitching." No new concepts emerged that could overturn the existing logical structure, and the attribute dimensions within the core categories were fully saturated. This indicates that, under the current theoretical framework, the model has achieved theoretical saturation—that is, the existing framework is sufficiently inclusive and explanatory to effectively cover the core features of such research topics without the need for further sampling.

III. Design Strategy System and Case Analysis

A. System of Design Strategies for the Structural Renewal of Historic Districts

Based on the theoretical assumptions of the CGC model discussed in previous sections and the empirical deconstruction using NVivo coding, this study has established a historical district renewal design strategy system characterized by "theory-data" bidirectional verification (Table 4). The logic behind the development of this system is not a simple linear listing of isolated factors, but rather strictly follows the theoretical mechanism of the CGC model: "information extraction — problem assessment — homomorphic translation — generative operation." It reorganizes discrete design vocabularies identified during the coding analysis into an action framework with spatiotemporal order. Through small-scale interventions, it connects the overall and local aspects, adapts to the existing urban fabric, and ensures that the transformation process does not undermine the traditional urban structure[23]. Specifically, the strategy system advances layer by layer along a logical chain of "deep gene identification and preservation—spatial pathology diagnosis and assessment — multidimensional narrative collage and reassembly—vital function implantation and scene creation," achieving a systematic leap from informational constraints, through evidence-based diagnosis and methodological operations, ultimately pointing toward a value-driven regeneration.

TABLE III.   Summary of Coded Data

Selective coding	Axial Coding	Open coding	Original Data Example	Source count	Number of nodes
I. Multidimensional Deep Structure Recognition	A1. Explicit Form Prototype	Spatial framework features, spatial type forms, historical stratification structure, figure-ground relationship analysis, street pattern density, traditional architectural style, infrastructure evolution, physical space remains, degree of interface openness, street height-to-width ratio, building setback from the red line	W06: To precisely capture the evolutionary characteristics of fine-grained UGSs during urban development(Historical stratification) W05: First of all, for the traditional courtyard houses, 464 well-preserved traditionalstyle courtyards were identified (Traditional Architectural Style)	8 (W03,W05 ,W06,W08 ,W13,W16 ,W18,W2)	145
	A2. Implicit	historical and cultural atmosphere, mechanisms	W03: the hard landscape richness contributes to the	7	128

Selective coding	Axial Coding	Open coding	Original Data Example	Source count	Number of nodes
	Venue Connotations	of social identification, collective memory narratives, spatial perception imagery, defensive spatial logic, commercial and cultural imprints, neighborhood interaction rituals, value belief systems, implicit social networks, emotional mapping of nostalgia, local knowledge genealogy	cultural atmosphere(Historical and cultural atmosphere) W07:In urban areas, dynamic neighborhoods often attract individuals for a variety of activities (Neighborhood Interaction Ritual)	(W03,W07 ,W09,W15 ,W17,W20 ,W13)	
II. Current Spatial Pathological Diagnosis	B1. Scale and Texture Conflict	Spatial density imbalance, collision of heterogeneous textures, social grid conflicts, edge zone effects, spatial interface incompatibility, risk of morphological homogenization, fragmentation of historical textures, scale discontinuity, blockage of visual corridors, rupture of spatial structure	W11：However, even after the application of a topological radius these areas still appear as the most segregated spaces of the system(Edge band effect) W01：The intrinsic congestion and fineness of the old low-rise city makes it the least adapted to contemporary demand(Spatial density imbalance)	8(W01,W0 5,,W07W1 1,W12,W1 4,W04,W0 8)	116
	B2.Spatial Semantic Fracture	Loss of vitality and decline, spatially isolated islands, negative externalities spillover, aging infrastructure, functional and morphological mismatch, lack of identity, disruption in perceptual experience, phenomena of social exclusion, gentrification displacement, disappearance of sense of place	W09:Informal urbanism has been generally studied within social, economic and political frameworks, yet little is known of how it performs in terms of urban vitality. (Loss of vitality and decline) W07:To address challenges including aging infrastructure, loss of vitality(Aging infrastructure)	6 (W04,W07 ,W10,W06 ,W09,W14 , W17, W18)	109
III. Adaptive Morphologica l Transduction Mechanism	C1. Texture Mending and Stitching	Spatial network optimization, generative design, continuation of street and alley patterns, restoration of architectural style, typological repair techniques, spatial syntax optimization, edge stitching strategies, adaptive isomorphic design, enhancement of texture connectivity, softening of spatial boundaries, micro-renewal interventions, nodal acupuncture-style transformation	W18： Reasonably plan the dimensions of driving lanes and pedestrian pathways to prevent vehicles from entering crowded streets and alleys, ensuring the separation of pedestrians and vehicles and optimizing the walking experience (spatial road network optimization). W16:The proposed optimization method can effectively extract the architectural features of historic districts and infer historical stratification tendencies based on the distribution of architectural genes (restoration of architectural styles).	13(W01,W 02,W04,W 05,W06,W 07,W10,W 12,W14,W 16,W17,W 18,W19,)	156
	C2. Temporal and Spatial Juxtaposition and Dialogue	Urban rewriting and reading, historical map analysis, heterogeneous spatiotemporal collage, visualization of evolutionary trajectories, multi-period morphological symbiosis, diachronic slice analysis, dialectical heterogeneous recombination, historical modernization transformation, new-old contrast and tension, utilization of ruin aesthetics, archaeological spatial presentation	W08:This study explores and organizes the historical modernization of Chongqing's parent city and using a universal approach developed by the HUL perspective(Historical modernization transformation) W13:The urban fabric transformation in Bursa can be traced through two cartographic maps, which guide the trajectory of development stages to identify similarities and differences regarding key attributes such as type(Historical Map Analysis)	5(W08,W1 1,W13,W1 2,W06)	94
	C3. Narrative restructuring and reconstruction	Experiential path design, narrative scene reconstruction, immersive spatial creation, accommodation of informal forms, revitalization of place spirit, emotional memory mapping, cultural icon translation, theatrical interpretation of space, spatial storyline linkage, semiotic decoding, participatory design	W20: By transforming daily life into stories of Shanxi merchants and developing immersive performances, the functional restructuring of faith spaces and commercial narratives is achieved. (Immersive space creation) W17: Avoid the damage caused by excessive commercialization and "gentrification" to historic districts, so as to protect the connection between commercial landscapes and historical events (emotional memory mapping).	5(W09,W1 7,W20,W0 3,W10)	88
IV. Spatial Value Isomorphic Regeneration	D1. Genetic Map Management	Hierarchical form guidance and control, characteristic zoning delineation, gene pool establishment and maintenance, protection red line control, authenticity protection indicators, landscape coordination zone management, construction intensity constraints, guideline indicator system, negative list management, three-dimensional form control, flexible adaptation range	W19: Formulate morphological guidance and control recommendations from the three levels of streets and alleys, plots and courtyard organization, and buildings, to ensure that the morphological development of the neighborhood does not deviate from its original trajectory. (Hierarchical Morphological Protection) W16: Apply the HLC approach to develop a technical system for finely identifying the historical landscape characteristics and zoning of urban historic district buildings, with divisions based on spatial clustering results from the K-means clustering algorithm. (Gene Bank Establishment and Maintenance)	6(W16,W1 9,W03,W1 8,W20,W0 5)	115
	D2. City Function Reset	Accessibility of transportation hubs, optimization of functional mix, modernization of infrastructure, integration of modern lifestyle, enhancement of walkability, provision of public services, adaptive functional updates, incorporation of smart facilities, community	W10:Second, for the adaptively used historic districts, enhanced vibrancy can provide them with what they need to survive and flourish, such as higher sense of community for residential usage(Adaptive Feature Update) W14:The implementation of transport systems would	6(W10,W1 4,W15,W0 1,W07,W0 4)	132

Selective coding	Axial Coding	Open coding	Original Data Example	Source count	Number of nodes
		service centers, non-motorized mobility network, and composite functional replacement.	enhance capacity of transport network and accessibility around vicinity of stations.(Accessibility of transportation stations)		
	D3. Productive Activation	Stimulation of business vitality, mechanisms for productive heritage transmission, spatial self-sustaining functions, spatial economic benefits, vitality spatiotemporal forecasting, compatibility with tourism economy, revival of traditional crafts, activation of the nighttime economy, integration of creative industries, iteration of consumption scenarios	W20: Propose revitalization approaches that integrate authenticity protection with productive heritage transmission to enable traditional villages to generate their own vitality. (Spatial self-sustaining function) W15: Exploring the Spatial Distribution Mechanisms of Restaurants, investigated the spatiotemporal distribution of street vibrancy. (Spatial economic benefits)	5(W15,W20,W10,W09,W01)	118

The strategy system first sets "deep gene identification and preservation" as its logical starting point. By means of A1 explicit gene mapping, it establishes a structural syntactic foundation of "immutable zones," and, combined with A2 implicit genes, defines the cultural genes of renewal design based on multidimensional factor analysis under the CGC theoretical model, thus establishing the spatial fabric. The aim is to absorb historical information, preserve it as evidential value for traceability, and use it as a guide for future urban development[24]. On this basis, "spatial problem diagnosis and assessment" is brought in as a targeted reference. Utilizing B1 physical conflict diagnosis and B2 semantic rupture warning, it accurately identifies the rigid boundaries of "collage collision" and the risk zones of "vitality hollowing," shifting design from blind operations to evidence-based therapeutics. For the diagnosed focal points, the system constructs "multidimensional narrative collage and reassembly" as a core translation mechanism: C1 repairs physical fractures in street fabric, C2 constructs old-new dialogues through stratified exposure of time layers, and C3 utilizes cultural symbol translation to resolve the issue of semantic disembedding. Vibrant urban areas promote socio-economic performance and enrich residents' lifestyles[25]; therefore, all operations are oriented toward the value goal of "vital function implantation and scene creation." Through D1 hierarchical management to guarantee institutional baselines, and utilizing D2 medium-scale repair and D3 productive activation strategies, it replaces modern functional cores while preserving historical shells, thus transforming historic districts from static "heritage specimens" into ever-evolving "living theatres" (Figure 4).

TABLE IV.   DESIGN STRATEGIES FOR HISTORIC DISTRICT RENEWAL BASED ON THE CGC MODEL

Strategic Dimension	Core strategy	Model mechanism	Design techniques and key points	Expected value target
A. Deep-level Genetic Identification and Conservation	A1.ExplicitGene Mapping and Tiered Conservation	Identification - Extraction	Establish a material gene map using the superimposition of historical maps, architectural surveying, and typological analysis to extract high-density, fine-grained textures and topological structures. Grade according to historical value and preservation status, and designate "invariant zones" as the base for spatial collage.	Preserving historical evidence lays the groundwork for the "structural syntax" of spatial collage.
	A2. Live Records and Anchoring of Implicit Genes	Recognition - Decoding	By using methods such as oral history and activity notes to document folklore, craftsmanship, and collective memory, and combining this with social network research, the spatial needs for festival venues, craft workshops, and other requirements are translated into specific design locations and facilities.	Inheriting intangible genes, infusing material spaces with "soul" and "events."
B. Diagnosis and Evaluation of Spatial Issues	B1. Physical Conflict Diagnosis	Diagnosis - Definition	Draw the "hard boundaries" and "spatial fractures" where old and new textures collide, and mark the "urban islands" created by wide roads or large buildings cutting through the city, visually highlighting the locations of physical scars that need to be mended.	Identify breakpoints and provide targeted repairs.
	B2. Semantic Disruption Analysis	Diagnosis - Warning	Identify visually uncoordinated conflict points and functional blank areas in the block, and predict which areas may lose their traditional appearance due to excessive commercialization.	Anticipate social risks and prevent the loss of authenticity.
C. Adaptive multi-dimensional collage and recombination	C1. The "mending" and connection of urban street texture	Translate - Suture	Analyze the de-nodes of the existing street network. Based on the analysis of spatial genes, site elements with connection functions such as pocket parks, corridors and pedestrian overpasses are inserted to restore spatial continuity and promote cross-regional traffic	Improve the spatial connectivity and experience, and promote the integration of functions.

| Strategic Dimension	Core strategy	Model mechanism	Design techniques and key points	Expected value target
			activities.	
	C2. Temporal Layer "Unveiling" and Juxtaposition	Translate - Generate	Selectively display historical walls, foundations and other relics, extract historical features, put them vertically with new buildings, and use the contrast between old and new materials and transparent interfaces to present a new style.	Enhance the temporal depth and historical legibility of venues, and oppose fake antiques.
	C3. Translation and Dissemination of Cultural Symbols	Translate - Map	By extracting and encoding typical cultural symbols and transforming them into modern design elements, such as paving, lighting equipment and identification systems, so as to achieve semantic consistency between commercial functions and scene experience.	Establish implicit cultural cues to strengthen a sense of belonging and identification with the environment
	D1.Hierarchical Management and Control of Genetic Mapping	Restructuring - Management and Control	Based on the genetic characteristics of the site, establish a digital gene bank and delimit strict protected areas and flexible mutation zones.	Provide institutional safeguards to prevent constructive destruction
D. Implantation of Dynamic Functions and Scenario Creation	D2. Composite Function "Embedding" and Symbiosis	Recombination - Repair	Under the premise of retaining the appearance of historical buildings, implant medium-sized buildings, and flexibly embed small composite functions such as cultural creativity, exhibitions and community services.	Energize spatial vitality to enhance economic sustainability and social adaptability
	D3. Flexible Spaces and Event Hosting Devices	Recombination - Activation	Design multi-functional squares and mobile facilities to create a flexible and changeable space so that it can accommodate multi-form public activities and activate the space through people's activities and informal interaction..	Enhance spatial adaptability and support the spontaneous emergence and evolution of social activities.
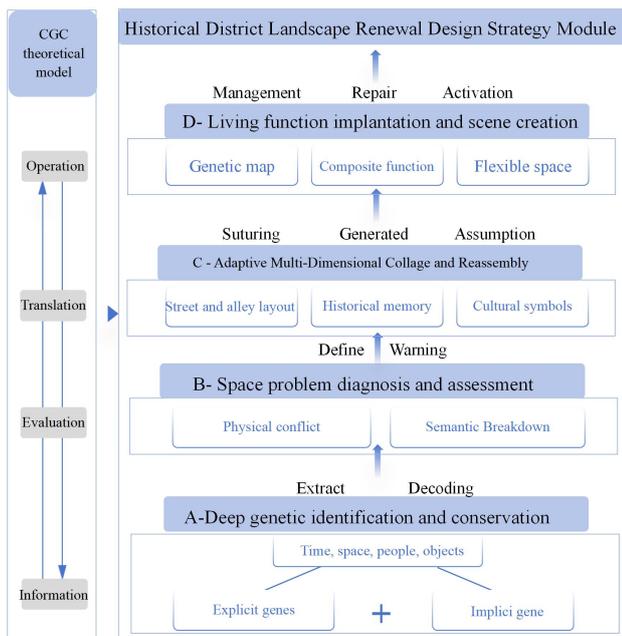
Fig. 4.   Based on the design strategy module for the landscape renewal of the CGC historical district

B.   Case Analysis

In order to test the logical consistency and method effectiveness of the CGC theoretical model in analyzing complex historical environment update projects, this study retrospectively interprets and analyzes the Castelvecchio Museum in Verona, Italy, and Yongqing Fang in Guangzhou, China. These two cases are selected not to establish a linear historical correspondence, but to use them as a prototype reference to test the universality of the model. By analyzing these built spaces, this study distils and extracts their potential "gene collage" operation syntax. This process aims to go beyond mere case appreciation and

confirm that the CGC model can extract the spatial generation mechanism from practice. Therefore, the study shows that the model is not only a theoretical framework for explaining history, but also an effective generative design tool that can guide the future site creation.

1) *Castelvecchio Museum:*As a masterpiece of Carlo Scarpa's life, the Castelvecchio Museum is not only an architectural restoration project, but also a profound interpretation of how the building reflects the relationship between the site, time and spirit. Its operating logic is highly compatible with the CGC strategic model. According to the CGC model, in the in-depth genetic identification and protection stage, Scarpa made a clear extraction of architectural forms to identify the potential defense logic of the Roman period and the surface texture of the medieval city walls. Based on a pathological diagnosis of the semantic rupture caused by 19th-century pseudo-historical decorations, he decisively implemented a stripping operation to establish genuine historical memory as the foundation of the design. Corresponding to the adaptive morphological translation phase in the CGC model, the design displays a remarkable dialectical power. The placement of the equestrian statue of Cangrande perfectly corresponds to the strategy of "juxtaposition and dialogue of time and space": the architect boldly cut through the roof and the ground, creating vertical physical fissures, and positioned the statue on a cantilevered platform high above. This method of "heterogeneous juxtaposition" forces the rough medieval masonry and the precise modern concrete to collide in the same section, generating intense spatial and temporal tension[26]. At the same time, by using "sawtooth moldings" to abstract the typology of medieval defensive crenellations, he metaphorically extended the military genes of the castle. Ultimately, from the perspective of site value isomorphic regeneration, the transformation of the Castelvecchio Museum accomplished a leap from a closed fortress to a modern public space. The originally static display of relics

was transformed into a flowing spatial narrative, successfully converting the intangible spirit of place into a perceptible modern cultural experience, and achieving the living regeneration of heritage value.

2） *Guangzhou Yongqing Fang：* Shifting to the context of urban regeneration in China, the micro-renovation practice of Yongqing Fang in Guangzhou offers an exemplary model for the "material and social" aspects of the CGC strategy when dealing with high-density social fabrics. The extraction of genes is the initial step in the spatial gene technology system[27]. When confronting the morphological rigidity of the typical Lingnan "tube-house" texture, the phase of deep gene identification demanded a strict figure-ground locking strategy. Through rigorous mapping, the vernacular "fishbone" street pattern was established not merely as a layout, but as an immutable structural syntax . Beyond physical form, we isolated non-material anchors possessing intense social cohesion — specifically Bruce Lee's ancestral home and Luan Yu Tang（Cantonese Opera Hall）. Protecting these nodes is a well-thought-out initiative to prevent the catastrophic collapse of social networks, which is usually caused by large-scale demolition. However, under the condition that the social structure is preserved, how can we stop the serious physical decline that spreads throughout the block? In response to these decay conditions, the project adopts an "acupuncture" morphological transformation strategy: for the damaged building structure, the intervention measures adopt "texture reshaping and syntactic suturing" to treat the urban texture in a surgical-like precision rather than a rough way. Here, the uneven outline of the original blue brick wall is not only preserved, but the design also embeds the transparent glass directly into the gap of the brick and stone structure. This intervention is like a physical texture stitching, emphasizing that the designer will sew up the damaged street interface and show the hierarchy of history. Traditional patterns, especially Manzhou windows, have been deconstructed into modern landscape symbols to consolidate local cultural identity.However, a key socio-economic problem still exists: can construction skills alone prevent the loss of indigenous residents? Realizing that static protection tends to accelerate the squalor, the project subverts the standard "demolition and resettlement" model. By introducing the creative industry node next to the intangible cultural heritage workshop, the design successfully broke the cycle of social extinction and ensured that the neighborhood could survive as a vibrant ecosystem rather than an empty exhibit[28].This aptly illustrates the value co-creation phase of CGC. Yongqing Fang in Guangzhou has consistently adhered to the "embroidery craftsmanship" approach, preserving the original street layout while protecting dilapidated buildings and introducing creative cultural industries, thus achieving a fusion of historical preservation and modern living[29]. Through optimizing the physical interface, the "dialectical symbiosis" of old and new communities has been gradually realized, completing the transformation from a purely residential area to a highly vibrant urban mixed-use community.

Through an analysis of the Castelvecchio Museum and Yongqing Fang in Guangzhou (Table 5), this study finds that: although the former focuses on the macro-level narrative restructuring of spiritual and temporal dimensions while the latter emphasizes the micro-level textural restoration of material and social dimensions, the CGC model successfully reveals the underlying logical consistency in their operational mechanisms. This, in turn, validates the model's cross-cultural explanatory power as an analytical and evaluative tool. This explanatory power is first manifested in the identification of "genes": whether it is Scarpa's rigorous subtractive archaeology or Yongqing Fang's strict figure-ground anchoring, both are accurately decoded by the CGC model as operations of "deep gene identification and conservation." The explanatory power of the CGC theoretical model is demonstrated in bottom-up decoding: Scarpa's subtractive archaeology and Yongqing Fang's rigorous figure-ground locking are both interpreted under the model as operating according to the same logic of deep genetic recognition and conservation. "Contextual rupture" constitutes a fatal semantic collapse. We ruthlessly dismantled the stylistic barriers that allow it. The reappearance of the conflict between historical fragments and modern space in the design is not a simple visual contrast, but the syntactic order of narrative collage. However, how these heterogeneous fragments are combined into a stable historical scene, the genetic code of the site acts as an indispensable adhesive. Interpreting this logic promotes the convergence of different technological paths and breaks the dual deadlock between protection and development.No longer a sterile specimen, cultural heritage is reactivated as a metabolic asset, fueled by its own regenerative engine.More importantly, this logical verification across time dimensions goes beyond simple retrospective interpretation and confirms the methodological validity of the model in transforming implicit experience into explicit rules. This shows that the CGC model is not only a set of design standards, but also a generative guidance and control system that can predict risks and provide direction for future design.

TABLE V.   CASE ANALYSIS TABLE

Theoretical Dimensions	Design Strategies	Castelvecchio Museum	Guangzhou Yongqing Fang
A. Deep Gene Identification and Conservation	A1. Extraction of Explicit Morphological Prototypes	Expose the original material texture of the underlying Roman foundations and medieval red brick walls to establish the syntactic base.	Strictly survey and lock in the typical Lingnan street patterns and street height-to-width ratios to serve as the spatial framework.
	A2. Anchoring the Implicit Spirit of Place	Completely preserve the original castle's defensive patrol routes and replicate the site memory through spatial circulation.	Preserve and revitalize Bruce Lee's ancestral home and Luan Yu Hall, positioning them as intangible core nodes

Theoretical Dimensions	Design Strategies	Castelvecchio Museum	Guangzhou Yongqing Fang
			that unite the indigenous community network.
B. Diagnosis and Assessment of Spatial Pathologies	B1. Diagnosis of Physical Conflicts	Diagnose that the physical closure between the main building and defensive towers caused by historical renovations actually severs historical independence.	Identify "texture voids" formed by the collapse of hazardous buildings, such as the original site of Nostalgia Plaza, and designate these areas as physical restoration targets.
	B2. Semantic Fracture Warning	Identify and remove fake decorative elements that distort and confuse historical information, clearing the semantic space for new interventions.	Establish a residential preservation red line to prevent the risk of "gentrification" caused by pure commercialization.
C. Adaptive Morphological Translation and Generation	C1. Texture Patching and Syntactic Stitching	Install modern concrete corridors to reconnect the severed tower system, restoring pathway continuity without damaging the original defensive appearance.	Utilize leftover red bricks from the site, combined with modern steel construction techniques, to restore the outline of collapsed buildings in place.
	C2. Spatiotemporal Juxtaposition and Dialogue	Incorporate a cantilevered concrete support for the statue of Cangrande on horseback, creating a vertical juxtaposition between the rough medieval masonry and the precise modern concrete.	At Nostalgia Square, retain the broken wall sections without repair, using them as "slices" of time directly juxtaposed against newly constructed transparent glass boxes, forming a symbiotic spatiotemporal dialogue between solid and void.
	C3. Narrative Reorganization and Scene Recreation	Extend the military gene of the castle through typological metaphors rather than mere formal imitation.	Extract traditional symbols such as Manzhou windows, sliding doors, and granite slabs, deconstructing and transforming them into modern elements.
D. Site Value Isomorphic Regeneration	D1. Hierarchical Control of Gene Mapping	Implement absolute protection of Roman and medieval layers, moderate retention of the Austrian layer, and strictly control the material precision and contact nodes of new modern insertions	Establish "micro-renovation" guidelines and a categorized management system, strictly dividing block buildings into three categories: protection, repair, and improvement.
	D2. Urban Texture Repair and Acupuncture	Translate the closed military fortress into an open modern public museum, breaking the original closure of military facilities by introducing cultural exhibition functions and realizing a social leap in spatial value	Apply micro-updating acupuncture strategies to turn negative residual spaces into "pocket parks" and public rest nodes.
	D3. Productive Activation and Inheritance	Stimulate visitors' exploratory behavior through multi-perspective interactive spaces, transforming static artifact displays into embodied experiences and event-based narratives.	Introduce a mix of Vanke cultural and creative offices, trendy dining, and preserved native residences to form a community economic ecosystem of "living + working + recreation."

IV. DISCUSSION

This study constructs the CGC (Collage-Gene Coupling) theoretical model, aiming to provide a systematic methodology—from gene decoding to collage translation—for the renewal of historical districts in the stock era. This section will deeply explore the explanatory power of the CGC model in design through the case analysis of Castelvecchio Museum and Guangzhou Yongqing Fang.

A. Strategic Effectiveness: From Formal Imitation to Syntactic Isomorphism

The study provides case analysis. We can clearly see that the effectiveness of the CGC model lies not only in optimizing design tools; more importantly, it fundamentally corrects the deep-rooted methodological errors in traditional urban renewal, that is, paying excessive attention to the surface form and ignoring the structural essence. The previous interventions eventually became the "blind accumulation" of formal elements, which is a direct consequence of the lack of structure. In order to curb this chaotic eclecticism, we are facing a technical problem. We need to combine the intangible deep structure of cultural genetic theory with the tangible framework of collaged cities. This is no longer a static theoretical amalgam; it

functions as a kinetic apparatus . We installed genetic identification as a hard-stop protocol before any spatial action. This constraint forces the design trajectory off the path of subjective drift, bolting renewal practices to the rails of evidence-based rationality.

1) The constraining role of gene identification: In the intervention at Verona Castle , Scarpa transcended the passive role of preservationist by meticulously stripping away the counterfeit plaster added in the 1920s. This deliberate act of subtraction did more than clean the surface; by exposing the raw material texture of the underlying Roman foundation and the medieval red brick, an approach classified here as the A1 strategy , he established an immutable "syntactic baseplate" that serves as the honest foundation for all subsequent design moves. Similarly, in Yongqing Fang, Guangzhou, the design strategy did not pursue the replication of a particular historical architectural style. Instead, it focused strictly on preserving the typical fishbone-shaped street pattern of Lingnan (A1 strategy) and the intangible core nodes such as the ancestral home of Bruce Lee (A2 strategy). These two cases demonstrate that, whether in the Western context that emphasizes material authenticity or the Eastern context that values the continuity of social networks, the CGC model effectively identifies the

"explicit and implicit genes" that determine the identity of a place, thus providing a solid foundation of local information for subsequent interventions.

2) *The restorative logic of collage translation:* Guided by this logic, collage is no longer the arbitrary piling up of heterogeneous elements, but rather a pathology-based reconstruction and regeneration. In Verona Castle, in response to the physical closure between the main building and the defensive towers caused by historical renovations (B1 diagnosis), the designer inserted a separated modern concrete corridor. This topologically restored (C1 strategy) the continuity of the pathways. Confronting the jagged "texture voids" left by structural collapse in Yongqing Fang, The design rejected passive restoration and fused salvaged red brick with modern steel skeletons, physically stitching the fractured street interfaces (Strategy C1) . Research proves that effective renewal is by no means superficial imitation or nostalgic patchwork. The real vitality of historical blocks only appears when contemporary vocabulary is used under the constraints of the deep genes of the site. The resulting intervention is in line with the evolution of the spirit of the place and continues the vitality of the venue to the present.

B. Model Universality: Mechanisms of Adaptation Across Scales and Cultures

Through case tracing and analysis, it can be clearly seen that the reason why the CGC model can successfully interpret phenomena of different scales from single buildings to complex urban blocks stems from its fundamental ability to transcend the limitations of single-dimensional morphological reduction theory. This adaptability shows that the model is not only a descriptive framework, but also an advanced methodological tool; it prioritizes deep structural logic over superficial appearance, showing the universality and dynamic flexibility needed to meet the multifaceted challenges inherent in contemporary urban renewal.

1) *Cross-scale adaptability*：The universality of the model is first reflected in its ability to cross different scales. In our research, we observed that the logical framework of the CGC model showed excellent flexibility: when applied to the microenvironment of the Castelvecchio Museum, the intersection of rough concrete and medieval masonry structures and the fine roof cutting to the exquisite architectural seams all reflect the reliance on precise reduction. The method operation creates a strong spatial tension. However, when the scope of analysis extends to the macro scale of the Yongqing Fang urban block, the same genetic decoding logic is cleverly transformed into a broader regional functional replacement strategy, in which traditional symbolic elements such as "Manchurian Window" are deconstructed into modern landscape wall elements (this practice is classified as C3 strategy). This remarkable scale comparison reveals a key insight: the CGC model is not a rigid dogma, but a dynamic system that can transcend the physical hierarchy, thus effectively solving the challenge of coexistence of the old and the new at a completely different particle size level.

2) *Cross-cultural compatibility:* Given that the effectiveness of the model has been confirmed on different physical scales, a deeper question arises: can the model cope with the subtle and often elusive differences between different cultural values? Our comparative case analysis

provides a clear verification, indicating that the CGC model has a high degree of inclusiveness and cross-cultural compatibility. We observe that in the context of Western protection, its philosophy strictly follows the principles of "authenticity" and "identification", and the model has successfully transformed these principles into hierarchical intervention rules (classified as D1 strategy). This mechanism helps to establish a clear, almost dogmatic distinction between contemporary new parts and historical sites to ensure the clarity of the timeline. In stark contrast to this, when applied to the oriental context that prioritizes "image" and "life continuation" rather than material static, the framework shows the necessary flexibility; in this case, it can accommodate "micro-transformation" and "acupuncture" interventions, so as to achieve a softer integration with the community. The development of the mechanism is compatible, rather than rigid museumization. This ability to operate effectively within the distinct cultural frameworks of the East and the West strongly proves that the CGC model has the potential to transcend the limitations of specific regional styles and become a universally applicable method of heritage renewal.

C. Methodological Extension: From Value Identification to Design Generation

Based on the case review above, this study positions the CGC model as a key practical extension of the current historic urban landscape theoretical system. While existing theories have addressed the macro-level question of "what to preserve" in terms of value recognition, they often fall into formalism when it comes to the specific morphological generation at the meso- and micro-scales of "how to design," due to a lack of transformative tools. However, the effectiveness of things depends not only on themselves but also on contextual factors such as spatial and cultural adaptation, supporting community resources, and policy frameworks[30]. Therefore, the CGC model effectively overcomes the dilemma of formalism by building a link between value assessment and the current spatial context of a site: it takes the identification of abstract cultural genes as an information constraint, and at the same time introduces collage strategies as a means for form generation, accurately translating ambiguous contextual conservation requirements into actionable spatial syntactic instructions such as "texture weaving (C1)" and "spatiotemporal juxtaposition (C2)." In response to the inevitable heterogeneity and fragmentation in the process of contemporary urban renewal, the CGC model has gone beyond the disadvantages of pursuing superficial and static unity in traditional design and established a stable and dynamic order. This method avoids false style unification, but gives modern functional entities the ability to dialogue in parallel and strictly respects the structure of historical space, creating a fruitful example for urban renewal and effectively bridging the gap between value protection and actual design implementation in the process of existing environmental renewal.

V. CONCLUSION

Facing the dilemma of rigid protection and chaotic collage coexisting in the renewal of historical blocks, this study abandons the traditional empirical induction method, adopts the rooted theoretical paradigm, and uses NVivo software to code to construct a CGC (collage-gene coupling) model. These data-driven insights subvert the traditional perception of formalism and reveal that collage is a multi-

dimensional integration of spatial, social and ecological genes. Specifically, research confirms that organic symbiosis depends on an "isomorphic system theory", that is, modern forms strictly follow the constraints of deep genotypes. Based on 1,201 precise explicit coding nodes, this dialectical framework transforms implicit knowledge into explicit knowledge, corrects the arbitrariness of traditional collage theory, and marks the fundamental transformation of the discipline from pure empiricism to data-assisted scientific logic. However, this scientific progress is not without limitations; a critical assessment points out that qualitative coding has inherent subjective limitations, insufficient coverage of political and economic dimensions, and possible survivor biases in case selection, all of which delimit the necessary scope for future research. In view of this, future research will strive to transcend the limitations of qualitative analysis and introduce parametric design and generative artificial intelligence technology to quantify the mathematical indicators of "isomorphic mapping". In addition, the research aims to build a closed-loop evaluation system through the dynamic monitoring of urban big data, so as to promote the development of historical block renewal theory from logical deduction to algorithmic generation and dynamic governance.

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