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Mereological Syntax of Space (MSS): A Relational Framework for Translating Urban Spatial Structures into Architectural Configuration

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Abstract

Contemporary urban environments exhibit increasingly complex spatial structures that challenge conventional approaches to architectural analysis and design. This paper introduces the Mereological Syntax of Space (MSS) as a relational framework for translating urban spatial structures into architectural configuration. Grounded in mereological philosophy and part-whole logic, MSS conceptualizes spatial systems as assemblies of interconnected elements whose relations can be interpreted across urban and architectural scales. The framework introduces the concepts of the urban genome and the architectural genome and uses relational matrices to examine their constituent relations. An illustrative comparative case study is presented as a preliminary application of the framework, showing its analytical usefulness as a heuristic tool for assessing spatial continuity between urban and architectural configurations. MSS is thus positioned as a conceptual and methodological bridge between urban spatial analysis and architectural design.

Keywords: Mereological Syntax of Space (MSS); Urban Genome; Architectural Configuration; Spatial Relations; Part–Whole.

1. Introduction

The escalating complexity of contemporary urban environments presents significant challenges for architects and urban designers. The intricate interplay of spatial elements, movement flows, and social dynamics often surpasses the explanatory reach of traditional analytical and design methodologies. While significant advancements have been achieved in understanding urban spatial configurations—notably through the influential framework of Space Syntax (Hillier and Hanson, 1984)—a persistent gap remains regarding the effective translation of these macro-level insights into micro-level architectural organization. This disconnect impedes the synthesis of data-informed urban analysis with the informed development of architectural form.

Relational spatial thinking has long been recognized as fundamental to both architecture and urban design, as spatial configuration profoundly influences human movement, social interaction, and the perception of place (Lynch, 1960; Hillier and Hanson, 1984). Although configurational analysis, particularly Space Syntax, offers powerful tools for quantifying spatial relationships and their impacts on urban dynamics, the precise mechanisms through which these relational structures inform and shape the internal organization of individual buildings remain largely implicit. Analytical urban research often yields data on connectivity and accessibility; however, robust methodologies for transforming this data into coherent architectural strategies remain underdeveloped.

This paper introduces the Mereological Syntax of Space (MSS) as a theoretical and methodological framework designed to address this gap. Grounded in mereology—the formal theory of part-whole relations (Simons, 1987; Varzi, 2007)—MSS conceptualizes spatial systems as hierarchical assemblies of interconnected elements. This relational logic facilitates an understanding of how spatial elements at diverse scales compose larger wholes, providing a unified approach for both analyzing spatial organization and exploring its generative potential.

MSS posits that spatial systems are governed by a "syntax," a set of rules defining the integration of their constituent parts. Viewed through a mereological lens, these rules encompass relationships such as adjacency, connectivity, and hierarchy. Applying this framework allows for the interpretation of complex urban relational patterns as an "urban genome," while the inherent organization of buildings can be understood as an "architectural

genome." This paper aims to provide a systematic method for translating patterns from the urban genome into the design of the architectural genome. The objectives are threefold: to articulate the theoretical foundations of MSS; to establish it as a framework for understanding the relationship between urban and architectural spatial systems; and to propose a methodological approach utilizing relational matrices for systematic analysis and potential generative transformation. The primary contribution of this research lies in offering a novel theoretical construct that strengthens the dialogue between urban spatial analysis and architectural design, while opening new avenues for contextually responsive generative design.

[Insert Figure 1 Here]

Figure 1. Mereological Generative Framework for Architecture and Urban Form (Source: Author). The diagram shows the progression from spatial units to mereological relations and emergent urban fields, alongside a feedback loop through which higher-order spatial conditions influence lower-order configurations.

2. Literature Review

The development of the Mereological Syntax of Space (MSS) builds upon and seeks to synthesize insights from several key bodies of research. This section reviews the most relevant literature, highlighting their contributions while identifying the methodological and theoretical gaps that MSS addresses.

2.1. Space Syntax Theory and Configurational Analysis

Space Syntax, pioneered by Hillier and Hanson (1984), remains the most influential framework for analyzing the configurational properties of space, particularly in urban environments (Hillier, 1996). By quantifying spatial relationships through measures such as depth, integration, and connectivity, Space Syntax reveals how spatial arrangements influence movement, social interaction, and urban form. Its core contribution lies in demonstrating that spatial configuration is a primary determinant of social life within the built environment. Research utilizing this framework has provided deep insights into cities as complex networks of interconnected spaces (Batty, 2013; Bafna, 2003), illuminating the "social logic of space" (Hillier and Hanson, 1984).

However, while Space Syntax excels at diagnostic analysis of existing spatial structures, its direct application to the generative development of architectural form presents challenges. Translating abstract configurational measures into concrete architectural design decisions requires significant interpretation. The framework primarily focuses on the functional consequences of spatial configuration, with less emphasis on the generative processes through which spatial organization is synthesized. Furthermore, while Space Syntax is inherently relational, it does not explicitly leverage the philosophical tradition of part–whole relationships, which offers a more granular and systematic mechanism for decomposing and recomposing spatial systems.

2.2. Relational Interpretations of Urban Morphology

Urban morphology, the study of the processes of formation and transformation of urban form, has shifted significantly toward relational interpretations. Traditional morphological studies often focused on static elements such as street grids and building typologies (Trancik, 1986). Contemporary approaches, however, emphasize the dynamic and relational aspects of urban form, viewing cities as emergent systems shaped by a web of interactions. Lynch (1960) introduced the analysis of mental maps, highlighting the importance of spatial relationships in shaping perception. More recently, Batty (2013) advanced "the new science of cities," employing computational theories to understand urban systems as emergent phenomena. Studies on urban structure (Salingaros, 2005) also emphasize the fractal and hierarchical nature of urban systems. Karimi (2012) further advocates for a "configurational approach to analytical urban design," bridging urban analysis and design practice.

These perspectives underscore the interconnectedness of urban elements; however, they often lack a unified theoretical framework for explicitly linking macro-level urban characteristics to micro-level architectural design. The "processes of formation" described in these studies often remain descriptive rather than prescriptive for design generation.

2.3. Philosophical Foundations of Part–Whole Relations in Mereology

Mereology, developed by logicians and philosophers including Leonard and Goodman (1940), Clarke (1981), and Simons (1987), provides a formal language for describing part–whole relationships. It addresses the fundamental nature of composition, defining entities as being composed of other entities. Key concepts include "part," "whole," and "mereological sum." Varzi (2007) highlights the pervasive application of mereology in spatial representation, while Casati and Varzi (1999) explored how parts constitute larger spatial

entities. The logic of mereology is directly relevant to spatial systems, where any configuration can be viewed as a whole composed of constituent parts (e.g., rooms, buildings, urban blocks). Mereology offers a rigorous framework for specifying these relationships and reasoning about their composition, providing a strong foundation for decomposing complex spatial systems and reconstructing them based on defined principles.

2.4. Bridging Spatial Analysis and Architectural Design

Attempts to bridge spatial analysis and architectural design are well-documented. Alexander's "A Pattern Language" (1977) represents a seminal effort to codify design knowledge through recurring patterns, emphasizing the creation of "living structures" through the harmonious arrangement of parts. While conceptually robust, Alexander's methodology is primarily pattern-based and descriptive. Computational approaches to design have also used spatial analysis metrics as inputs for generative algorithms (Penn, 2003). While promising, these approaches often rely on predefined algorithms and may fail to fully capture the nuanced relational logic of complex spatial systems.

Despite these efforts, a void remains for a theoretical framework that systematically integrates the relational insights of urban spatial analysis with the generative potential of architectural design, grounded in a clear philosophical understanding of part–whole relationships. MSS aims to fill this void by providing a conceptual and methodological bridge that leverages mereological principles to establish a clear translation mechanism between urban spatial structures and architectural spatial formation.

3. Theoretical Framework: Mereological Syntax of Space

[Insert Figure 2 Here]

Figure 2: Conceptual mapping of mereological relations to spatial-grammar configurations and their proposed urban spatial qualities (Source: Author).

The Mereological Syntax of Space (MSS) is proposed as a theoretical framework for understanding and articulating the relational organization of spatial systems across scales. Drawing on the philosophical discipline of mereology, MSS treats spatial configurations not as isolated forms, but as structured assemblies of interrelated elements whose organization can be analytically described in terms of part-whole relations. In this sense, the term "syntax"

refers to the relational principles through which spatial elements are composed, connected, and organized into coherent systems.

3.1. Mereology and Its Relevance to Spatial Theory

Mereology is fundamentally concerned with part-whole relations and the logic of composition (Simons, 1987; Varzi, 2007). It provides a formal framework for describing how entities are constituted by other entities and how wholes emerge from the arrangement of parts. In spatial terms, this logic is directly relevant to the built environment. A room may be understood as part of a floor, a floor as part of a building, and a building as part of a larger urban fabric. At each level, spatial organization depends not only on the presence of constituent elements but also on the relations through which these elements are composed.

The relevance of mereology to spatial theory lies in its capacity to formalize spatial composition. Spatial entities are defined not only by their physical boundaries and extents, but also by their relations of adjacency, inclusion, overlap, and connection. Mereology offers a precise conceptual vocabulary for specifying these relations and for reasoning about how spatial parts combine into larger wholes. This is particularly valuable for the study of complex spatial systems, where organization cannot be reduced to isolated objects but must be understood as a relational structure.

3.2. Spatial Systems as Hierarchical Assemblies

MSS conceptualizes spatial systems as hierarchical assemblies composed of nested part-whole relations. Spatial wholes are formed by constituent parts, which may themselves function as wholes at another level of analysis. A building, for example, may be composed of floors and functional zones; floors may be composed of rooms, corridors, and circulation cores; and rooms may be composed of surfaces, openings, and enclosed spatial volumes. This nested structure is not incidental but fundamental to the organization of space in both material and cognitive terms.

A hierarchical interpretation is essential because spatial relations operate differently at different levels. The relation between adjacent rooms differs from that between floors connected through vertical circulation, just as the relation between a building and its surrounding street network differs from intra-building relations. MSS therefore seeks to

capture these multi-level structures systematically. It provides a framework for decomposing complex spatial systems into constituent relational units and for examining how these units combine to produce larger spatial formations.

3.3. Spatial Relations as Syntactic Principles

Within the Mereological Syntax of Space (MSS), spatial organization is not understood as a merely aggregative arrangement of discrete entities, but as a relational order structured by a finite set of primary syntactic principles. In this framework, the coherence of spatial systems emerges through the patterned interaction of parts and wholes across architectural and urban scales, such that spatial meaning, accessibility, and functional differentiation are produced through relations rather than isolated forms.

At the foundational level, MSS identifies five primary mereological relations as the core rules of spatial composition: Adjacency, Connectivity, Containment, Overlap, and Hierarchy. These relations are not treated as passive descriptors of pre-existing spatial conditions; rather, they operate as generative principles that structure how spatial elements are configured, differentiated, and experienced within a system.

- **Adjacency** refers to the direct contact or shared boundary between spatial elements, establishing immediate relational proximity.
- **Connectivity** denotes the extent to which spatial elements are linked in a way that supports movement, interaction, or circulation.
- **Containment** describes the inclusion of one spatial element within another, producing nested or hierarchical spatial arrangements.
- **Overlap** occurs when two spatial elements partially coincide or share a common zone without full inclusion, thereby generating transitional or ambiguous spatial conditions.
- **Hierarchy** refers to the ordering of spatial elements according to rank, prominence, accessibility, or publicness, and thus structures differentiation within the overall system.

While these five relations constitute the primary syntactic base of MSS, other spatial qualities such as Sequence, Permeability, and Proximity are better understood as derived relational effects or secondary analytical indicators. These qualities emerge from the configuration and interaction of the primary relations rather than constituting independent foundational rules. For instance, sequence may arise from patterned connectivity and hierarchy; permeability

may result from the degree and arrangement of adjacency, overlap, and connectivity; and proximity may be assessed as a metric outcome of relational configuration.

Accordingly, MSS provides a conceptual and analytical basis for decomposing spatial formations into their constitutive relational components and for examining how these components combine to produce broader spatial effects. In this sense, the framework functions as a bridge between spatial analysis and architectural reasoning, enabling urban and architectural configurations to be interpreted as structured relational systems with comparable syntactic properties.

4. Urban Genome and Architectural Genome

MSS establishes a conceptual link between the macro-scale relational structures of urban environments and the micro-scale spatial organization of architectural elements through the notions of the urban genome and the architectural genome. Inspired by biological genetics, these terms refer not to literal genetic codes but to the inherent relational and structural information embedded within each domain. MSS proposes that such information can be interpreted, abstracted, and translated from the urban scale into architectural spatial organization.

[Insert Figure 3 Here]

Figure 3: Main Conceptual Diagram of the Mereological Syntax of Space (MSS) Framework (Source: Author). The diagram illustrates the translation of the urban genome, modeled through spatial relations and relational matrices, into the architectural genome and the resulting spatial configuration.

4.1. The Urban Genome

The urban genome refers to the underlying relational-spatial structure that characterizes an urban environment. It is not a physical entity in itself, but an embedded system of spatial relationships, hierarchies, and connections through which the city is organized, experienced, and used. In the author's broader research trajectory, the concept of the urban genome may also encompass patterns of flow and layers of spatial meaning. In the present article, however, the emphasis remains on its relational-structural dimension, since this aspect is the most directly translatable within the MSS framework into architectural spatial organization.

This urban genome may be understood through several interrelated components:

- **Networks of movement:** the principal systems of circulation, including streets, pathways, and public transport routes, together with their relative connectivity, integration, and depth.
- **Spatial hierarchies:** the ordering of spaces according to accessibility, visibility, centrality, and relative importance, including distinctions among public squares, main streets, residential lanes, and private access routes.
- **Accessibility structures:** the spatial patterns through which urban amenities, services, and opportunities become reachable within the underlying network.
- **Clustering patterns:** the spatial arrangement and interrelation of urban functions and building types, such as commercial centers, residential areas, and industrial zones, and the ways in which proximity or separation affects urban dynamics.
- **Topological relationships:** the fundamental connectivity and arrangement of urban spatial units, such as blocks, parcels, and public spaces, irrespective of their precise geometric form.

The urban genome thus represents the ensemble of relational properties that defines the spatial logic of the city. It provides a structured basis for understanding how movement, perception, accessibility, and social interaction are conditioned at the urban scale. Such an understanding is essential for designing interventions or new developments that are spatially responsive to their context and capable of contributing positively to the urban fabric.

4.2. The Architectural Genome

Analogous to the urban genome, the architectural genome refers to the relational-spatial organization inherent within a building or a set of buildings. It is the embedded order of spatial relations through which interior spaces are configured and through which patterns of occupation, movement, and interaction are shaped.

This architectural genome may be described through several related components:

- **Circulation systems:** the network of corridors, stairs, elevators, thresholds, and pathways that connect spaces within the building, and whose continuity, hierarchy, and integration influence usability and movement.

- **Programmatic relations:** the spatial adjacency and functional interdependence among rooms or zones, such as the relation of a kitchen to a dining area, or private offices to shared meeting spaces.
- **Spatial hierarchies**: the ordering of interior spaces according to degrees of access, visibility, privacy, and representational significance.
- **Sensory and perceptual gradients**: the distribution and relational modulation of light, views, enclosure, and acoustic conditions across different interior spaces.
- **Topological relationships:** the fundamental connectivity and arrangement of rooms and spatial units within the building plan.

The architectural genome is therefore the set of relational properties that defines a building's internal spatial logic. It influences user experience, functional efficiency, spatial legibility, and the social dynamics that emerge within architectural space.

4.3. MSS as a Translation Mechanism

MSS provides the conceptual and methodological bridge for translating the urban genome into the architectural genome. This translation is achieved through a structured process that analyzes the relational properties of the urban context and uses them as generative parameters for architectural design. The framework posits that by understanding and quantifying the spatial syntax of the urban environment, designers can derive principles that guide the formation of the spatial syntax within a new architectural project. This approach moves beyond mere aesthetic or functional contextualism towards a deeper, syntactic integration between the building and its urban setting. This approach moves beyond mere aesthetic or functional contextualism towards a deeper, syntactic integration between the building and its urban setting. The overall logic of this translation process is summarized in Figure 4.

[Insert Figure 4 Here]

Figure4. Conceptual diagram of the Mereological Syntax of Space (MSS) framework (Source: Author).

The diagram illustrates the relational spatial syntax based on part–whole logic and its key relations—containment, connection, adjacency, and overlap—which operate as generative mechanisms linking urban structures to architectural spatial qualities. The part–whole dial represents the design tuning process through which relational configurations are translated into spatial qualities such as permeability, accessibility, flexibility, and publicness.

5. Methodological Framework

This research adopts the Mereological Syntax of Space (MSS) as a methodological framework for analyzing and regenerating spatial structures across the urban and architectural scales. Within this perspective, urban space is not treated as a neutral container of objects and activities, but as a relational field in which meaning, hierarchy, accessibility, and spatial coherence emerge through patterned interdependencies among elements. The central objective is therefore to identify the internal syntax of these relations and to translate them into architectural configuration, so that form is generated not as an isolated compositional gesture, but as a structured response to the logic embedded in the urban context.

The methodological procedure is organized in three interrelated stages, moving from the analytical reading of the urban field to the generative construction of an architectural system and, finally, to the evaluation of the resulting spatial configuration.

5.1. Reading the Relational Field and Extracting Spatial Elements

In the first stage, the field of analysis is defined through a combined process of direct observation, thematic mapping, and contextual interpretation. Rather than approaching the city as a continuous mass, the urban fabric is decomposed into analytically distinguishable spatial elements. These elements are identified not merely on the basis of visible form or geometric boundaries, but according to their spatial role, operational significance, and position within the broader relational structure of the site. Streets, thresholds, voids, nodes, edges, and enclosed or semi-enclosed domains are thus understood as active components of a structured field rather than as isolated physical objects.

This phase is essential because it establishes the elementary units through which the logic of the urban environment becomes legible. By reducing contextual complexity into a coherent set of coded spatial entities, the analysis prepares the ground for a more rigorous examination of how urban order is produced, sustained, and potentially transformed.

***Note**: The detailed coding logic and classification criteria are presented in the Technical Appendix.*

5.2. Encoding Mereological Relations

Once the spatial elements have been identified, the methodology proceeds by examining the relations through which these elements form an intelligible whole. In the MSS framework, the emphasis is placed not only on the presence of elements, but on the modes of relation that bind them together and give rise to spatial structure. For this purpose, five primary mereological operators are used: proximity, connectivity, containment, overlap, and precedence. Each operator captures a distinct dimension of spatial organization, ranging from physical adjacency and access relationships to enclosure, interpenetration, and hierarchical ordering.

These relations are encoded through relational matrices that register the structural condition of the urban system in a systematic and comparable form. Taken together, these matrices constitute what may be described as the urban genome: a condensed relational description of the spatial logic that underlies the observed configuration. In this sense, the genome is not a visual copy of the city, but an abstract relational script through which the city's internal organization can be read, compared, and subsequently translated.

The value of this stage lies in its capacity to move from descriptive observation to formal structural representation. It allows the urban field to be understood as a patterned network of relations whose syntax can be measured, interpreted, and transferred across scales.

***Note**: The full mathematical specification of the relational matrices and weighting procedures is provided in the Technical Appendix.*

5.3. Generative Translation

In the third stage, the relational logic extracted from the urban system is translated into an architectural one. This translation does not aim at literal imitation of urban form, nor at the direct reproduction of urban geometry within a building envelope. Instead, it seeks to preserve the deeper structural logic of the context by rearticulating it in architectural terms. Through this process, the project moves from the level of urban syntax to that of architectural configuration, while maintaining continuity in relational organization.

This stage is carried out through a set of translation operators that map urban elements and their relations onto architectural components and spatial arrangements. The result is the construction of an architectural genome: a configuration that may differ materially and formally from the original urban system, yet remains structurally aligned with its relational

order. In this respect, the design process is conceived as generative rather than imitative; it produces new form through transformation of relational principles rather than through replication of existing shapes.

To ensure that the translation remains disciplined and conceptually grounded, the generative process is guided by an objective function that minimizes the discrepancy between the relational structure of the urban source and that of the architectural outcome.

***Note**: The full formulation of the translation procedure, algorithmic sequence, and structural fidelity measures is presented in the Technical Appendix.*

5.4. Evaluation and Validation

The final configuration is evaluated through three complementary criteria: relational fidelity, functional coherence, and structural stability. Relational fidelity assesses the degree to which the architectural outcome preserves the essential syntax of the urban system from which it is derived.

[Insert Figure 5 Here]

Figure 5: generative translation and evaluation framework (Source: Author).

Functional coherence examines whether the translated configuration can accommodate programmatic requirements without undermining the relational order that organizes it. Structural stability evaluates the internal consistency of the resulting system and its capacity to operate as an integrated spatial whole rather than as a fragmented aggregation of parts.

Together, these criteria provide a basis for testing whether the proposed methodology succeeds not only as an analytical instrument but also as a design framework. The intention is to demonstrate that architectural form can emerge from a rigorous reading of contextual relations while still meeting the demands of program, legibility, and spatial integrity.

5.5. Methodological Notes on Case-Study Application

In the case-study application, MSS is implemented through plan reading, relational coding, and iterative translation. The case-specific data are first decomposed into analyzable spatial units, then encoded through the relational matrices introduced above. The derived matrices are subsequently used as the basis for generating the architectural configuration.

Because the method is case-sensitive, not every relation appears with equal intensity across all sites. Accordingly, the weighting of matrices and the selection of design parameters are adjusted according to site morphology, spatial program, and contextual constraints. This allows MSS to remain structurally consistent while remaining adaptable to the specific conditions of each project.

5.6. Methodological Notes

MSS provides a structured methodology for transforming urban spatial syntax into architectural form through relational coding, matrix-based analysis, and generative translation. Its main methodological contribution lies in the formalization of relational continuity between city and architecture, while preserving the interpretive dimension required in design research. By combining qualitative spatial reading with explicit mathematical representation, MSS offers a reproducible framework for case-based generative design.

6. Findings: Operational Demonstration of the MSS Framework at the Valiasr–Bozorgmehr Junction

This section presents an operational demonstration of the Mereological Syntax of Space (MSS) framework through its application to a spatial discontinuity located at the Valiasr–Bozorgmehr junction in Tehran. The site lies along Valiasr Street—one of the most significant urban corridors in the city—where the Iran University of Art is situated immediately behind the street frontage yet remains spatially and perceptually disconnected from the main pedestrian axis.

The analysis follows the methodological sequence introduced in Section 5 and applies the relational translation mechanism defined in the MSS framework. Through this process, the relational structure of the surrounding urban environment is examined and translated into an architectural spatial intervention capable of reconnecting the university campus to the urban system.

Rather than proposing a large-scale urban redesign, the case study demonstrates how MSS can diagnose a broken relational configuration within an existing urban fabric and generate a minimal architectural intervention capable of restoring spatial continuity between urban and architectural systems.

6.1 Urban Genome Diagnosis

The selected site is located along the eastern edge of Valiasr Street near the Bozorgmehr intersection. Despite its position along one of Tehran's most active pedestrian corridors, the Iran University of Art remains largely invisible within the spatial structure of the street.

The analysis identifies three principal spatial components forming the existing configuration:

- **U – Urban Axis:** Valiasr Street, functioning as a major pedestrian and cultural corridor characterized by high spatial integration and continuous public activity.
- **B – Commercial Block:** A continuous row of small commercial units forming the street frontage. This block operates as a spatial barrier that prevents direct visual and physical access from the street to the university campus behind it.
- **A – Academic Field:** The interior courtyard system of the Iran University of Art, representing a semi-enclosed academic environment located behind the commercial frontage.

In the current configuration, the commercial frontage functions as a largely non-permeable urban edge. Although the university is located immediately behind the street frontage, the relational continuity between the urban corridor and the academic environment is effectively interrupted.

Within the MSS framework, this condition can be described as a **broken mereological chain**:

$$U \rightarrow B \rightarrow \emptyset \rightarrow A$$

where the symbol $\emptyset$ represents the absence of an intermediate spatial component capable of translating urban spatial relations into the architectural domain.

Two spatial consequences emerge from this configuration:

- The high-intensity pedestrian flows of Valiasr Street do not penetrate into the university environment.
- The academic courtyard system remains visually and spatially concealed from the urban public realm.

[Insert Figure 6 Here]

Figure 6. Existing Mereological Configuration at the Valiasr–Bozorgmehr Junction(Source: Author).

Diagram illustrating the spatial relationship between Valiasr Street (U), the commercial block acting as a spatial barrier (B), and the concealed academic courtyard of the Iran University of Art (A). The diagram demonstrates the broken relational chain ($U \rightarrow B \rightarrow \emptyset \rightarrow A$) that prevents the translation of urban spatial dynamics into the university environment.

6.2 Relational Parameters and Latent Threshold

Closer examination of the site reveals the presence of a small recessed open space located at the entrance area shared by the Iran University of Art and the neighboring Amir Kabir University. This recessed area results from a slight setback in the building line and currently functions primarily as an access zone.

Within the MSS framework, this space can be interpreted as a **latent threshold** embedded within the existing spatial configuration. Although limited in size, the space represents a potential intermediate spatial condition capable of mediating between the public urban corridor and the interior academic domain.

A further spatial observation concerns the asymmetry of visual accessibility within this recessed space. The entrance of Amir Kabir University is directly visible from the street, while the entrance of the Iran University of Art remains visually concealed even within the recessed area.

This condition produces a form of **perceptual asymmetry** in which two adjacent institutional environments exhibit unequal levels of urban visibility and spatial presence.

At the same time, the continuous commercial frontage remains a significant structural constraint. Complete removal or acquisition of the entire commercial block is not feasible within realistic urban conditions. Consequently, the MSS framework approaches the problem through a **part–whole recalibration**, shifting analytical attention from the scale of the entire commercial block to the scale of individual units within it.

At this finer scale, the block can be interpreted not as a monolithic barrier but as an assemblage of discrete spatial components, one of which can potentially function as a mediating element within the spatial system.

[Insert Figure 7 Here]

Figure7. Part–Whole Dial and Strategic Spatial Puncture (Source: Author).

Diagram illustrating the analytical shift from the scale of the entire commercial block to the scale of a single commercial unit. The highlighted unit represents a potential spatial puncture capable of functioning as a mereological connector between the urban axis and the academic courtyard.

6.3 Translation from Urban Genome to Architectural Genome

Building upon the part-whole recalibration established in the preceding analysis, the translation process operates as a formal mapping $T: G_U \rightarrow G_A$, where the high-intensity relational properties of the Valiasr urban genome are decoded and re-encoded into the architectural domain of the university. At this stage, the intervention transcends the mere creation of a physical puncture in the commercial block; instead, it is conceptualized as an **emergent spatial assembly** composed of three interconnected mereological layers that collectively function as a **thick relational threshold**.

The first layer, the **Urban Plaza (indicated in yellow)**, reclaims the wide sidewalk of Valiasr Street not as a mere transit zone, but as a "stabilizer of presence." By utilizing urban furniture, environmental graphics, and differentiated pavement, this layer enhances the *affordance* of the street for public gatherings and university branding. It translates the urban genome's property of "public visibility" into a spatial field that accommodates events and exhibitions without disrupting the continuity of the primary pedestrian flow.

The second layer, the **Art Square (indicated in orange)**, serves as a mediating domain that extends the logic of the plaza into the university's immediate periphery. This space functions as a "performative threshold" where students from the Iran University of Art externalize the architectural genome through artistic production and cultural events. This layer acts as the primary interface where the distinction between "urban public"

and “academic semi-public” is blurred, transforming a previously concealed edge into a vibrant cultural node shared by both neighboring institutions.

Finally, the **Gallery Corridor (the excavated commercial unit)** acts as the definitive “mereological link”. This carved-out space completes the translation by channeling the momentum generated within the yellow and orange layers into the university’s interior courtyard system. Within the MSS framework, this corridor is no longer a commercial unit but a **syntactic bridge** that converts the economic-cultural energy of the street into a curated academic experience.

6.4 Emergent Spatial Assembly and Restored Mereological Chain

With the synthesis of these three layers, the spatial syntax of the junction undergoes a fundamental **phase transition**. The previously fragmented configuration $U \rightarrow B \rightarrow \emptyset \rightarrow A$ is replaced by a **continuous relational field** structured as:

$$U \leftrightarrow \{P_{\text{Plaza}} + P_{\text{Square}} + P_{\dots}\} \leftrightarrow A$$

This assembly establishes a **fluid circulation loop** (as illustrated in Figure 7) that facilitates two distinct yet complementary relational dynamics. First, a *direct penetrative path* is established, allowing pedestrians to move from the urban plaza through the art square and gallery corridor into the heart of the campus. Second, a *lateral interactive field* is generated, where the visual and physical overlap of the yellow and orange zones increases the site’s overall “integration” value.

The introduction of this multi-layered assembly effectively resolves the **perceptual asymmetry** identified in Section 6.2. By expanding the intervention from a singular point to a relational sequence, the “Art Square” and “Urban Plaza” reclaim the street frontage for the university, ensuring that the Iran University of Art is no longer spatially concealed behind a rigid commercial barrier. The result is a resilient socio-spatial interface where the **Urban Genome** of cultural interaction and the **Architectural Genome** of artistic production are seamlessly integrated into a single, coherent part-whole system.

[Insert Figure 8 Here]

Figure 8. Emergent Spatial Assembly and Restored Mereological Chain (Source: Author).

Diagram illustrating the transformation of the spatial system after the insertion of the multi-layered mediating $P_{Plaza} + P_{Square} + P_{Corridor}$ The new configuration establishes a continuous and fluid relational sequence between the urban corridor and the university courtyard:

$$U \leftrightarrow \{P_{Plaza} + P_{Square} + P_{Corridor}\} \leftrightarrow A$$

This configuration generates an emergent cultural interface between the city and the campus.

6.5 MSS Evaluation of the Spatial Intervention

The proposed intervention reconfigures the Valiasr–Bozorgmehr junction from a site of spatial severance into a "thick relational threshold". By implementing the triple-layered assembly $\{P_{Plaza} + P_{Square} + P_{Corridor}\}$, the mereological syntax of the area is restored, transforming a terminal boundary into a fluid interface. The following table provides a quantified evaluation of the spatial system, comparing the existing condition with the proposed MSS-based intervention across ten key indicators.

Table 1. Quantitative MSS Performance Evaluation: Before and After Intervention

[Insert Table 1 Here]

The evaluation demonstrates a significant increase in the syntactic performance of the site. The restoration of the mereological chain—moving from a state of total disconnection (0) to a highly integrated relational state (4)—proves that the multi-layered assembly effectively mediates between the city's commercial flow and the university's cultural logic. This transformation ensures that the intervention is not merely an isolated architectural object, but a vital part of the urban whole.

[Insert Figure 9 Here]

Figure 9. MSS Spatial Performance Comparison; Before vs. After Intervention (Source: Author).

Radar diagram illustrating the performance gain across all ten MSS evaluation indicators. The blue profile represents the highly restricted, broken relational state of the existing Valiasr-Bozorgmehr junction, while the orange profile shows the balanced and highly integrated relational network achieved through the proposed part-whole spatial recalibration.

The comparison demonstrates a significant improvement in relational continuity, permeability, and urban–architectural translation after the insertion of the mediating component $\{P_{Plaza} + P_{Square} + P_{Corridor}\}$. The intervention successfully transforms a previously disconnected and fragmented spatial configuration into a resilient, integrated relational system linking the urban corridor of Valiasr Street with the academic courtyard of the Iran University of Art.

7. Discussion

The MSS framework moves beyond aesthetic contextualism toward **Syntactic Contextualism**. By using relational matrices and the concepts of urban and architectural genomes, designers can ensure that a building's internal spatial organization is a logical and direct syntactic consequence of its urban context. This systematic integration of macro-scale urban relational data with micro-scale architectural design principles offers a powerful approach to creating more responsive, legible, and contextually coherent built environments.

The ability to translate complex urban spatial patterns into concrete architectural design parameters addresses a critical gap in current practice. Instead of relying on intuitive interpretations or abstract simulations, MSS offers a structured methodology grounded in formal logic and mereological principles. This allows for a more objective and reproducible approach to context-sensitive design, where the "urban genome" actively informs the creation of the "architectural genome."

The concept of the "Part-Whole Dial," illustrated in Figure 4, further emphasizes the generative potential of MSS. It suggests that designers can actively modulate the degree to which the architectural design emphasizes its connection to the "whole" (urban context) or its internal "parts" (programmatic requirements, formal explorations). This dial allows for nuanced design decisions that can range from deeply integrated insertions to more autonomous structures that still acknowledge underlying syntactic principles.

Future research should focus on the computational implementation of these matrices into generative design tools, such as parametric modeling software or advanced GIS platforms. Developing algorithms that can perform the automated translation between urban and architectural genomes would significantly enhance the practical application of MSS.

Furthermore, empirical studies validating the impact of MSS-generated designs on user experience and urban vitality are needed.

8. Conclusion

This study has introduced the *Mereological Syntax of Space* (MSS) as a theoretical step toward reformulating part–whole relations within spatial syntax. The primary innovation of this framework lies in its shift from purely topological analyses to a structural-ontological perspective, in which spatial organization is understood not merely as a network of connections but as a hierarchical semantic system of parts and wholes. In doing so, MSS opens new analytical possibilities for understanding multiscalar continuities in complex urban systems.

Regarding empirical application, the case study of Tehran's District 6 served as an initial attempt to examine and conceptually validate the proposed framework. The outcomes of this exploratory stage indicate the potential of MSS to reveal latent structural patterns; however, they also underscore that the generalizability of these observations requires broader evaluation across diverse urban contexts. Accordingly, the present study does not claim definitive empirical conclusions but instead aims to establish the conceptual groundwork for subsequent investigations. Further development and calibration of the MSS method will require additional empirical studies to systematically assess its operational capacity in complex urban development and resilient design contexts.

Conflict of Interest

I declare that I have no competing financial interests or personal relationships that could have influenced the work reported in this article.

Data Availability

This study is conceptual–analytical in nature and does not generate any shareable primary datasets. All materials used consist of publicly available maps, scholarly sources, and

analytical interpretations developed by the author. Additional clarification can be provided upon reasonable request.

Use of Artificial Intelligence

I used an AI-based language model (ChatGPT, OpenAI) to support language editing and improve clarity and structure in certain sections of the manuscript. All conceptual content, analytical reasoning, and final interpretations were developed and fully verified by me, and I take full responsibility for the accuracy and integrity of the work.

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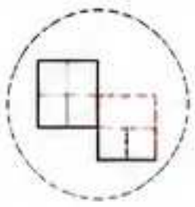
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THEORETICAL TRADITIONS



MEREOLOGY

The study of part–whole relations and the composition of entities.

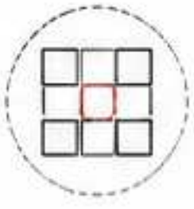
SPACE SYNTAX

Spatial configuration, relationships, and movement potential.



FIELD CONDITIONS

The influence of flows, forces, and contextual dynamics on form.

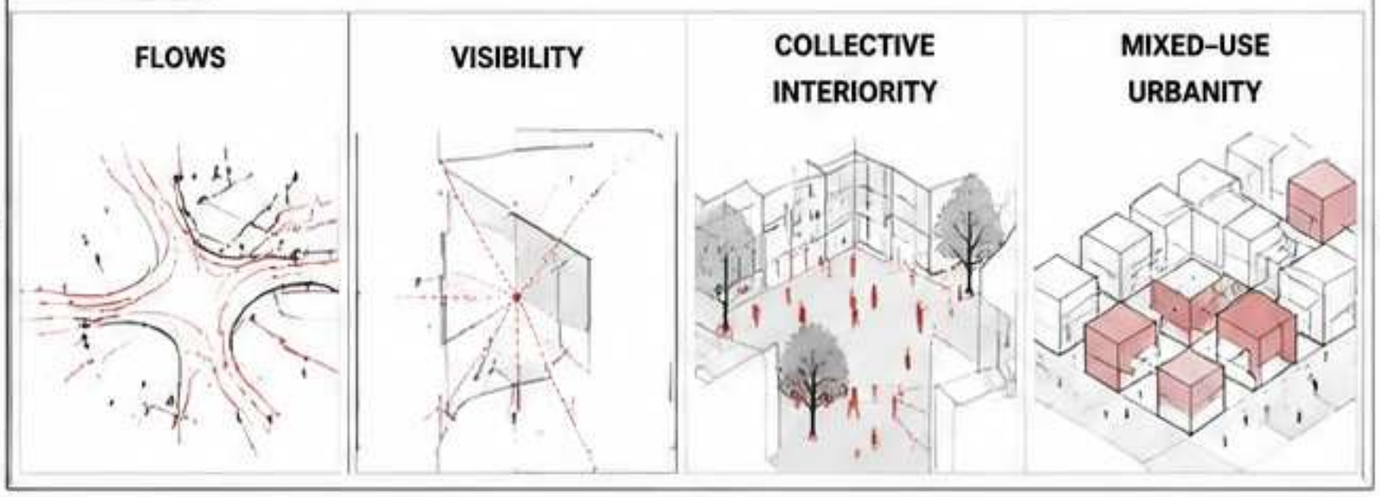


PATTERN LANGUAGE

Combinational patterns and unifying languages of built form.

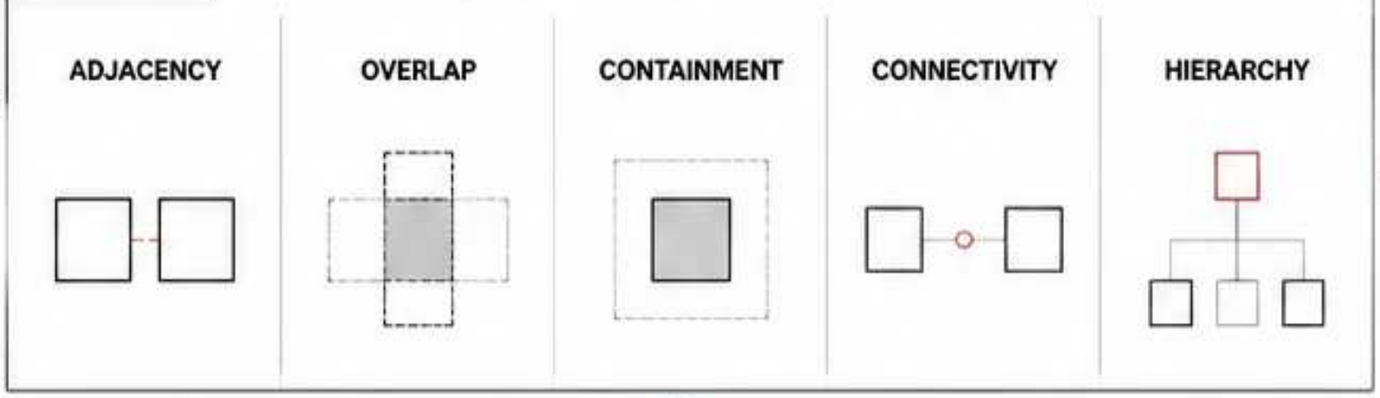
GENERATIVE PROCESS (BOTTOM–UP)

LAYER 3 EMERGENT URBAN FIELD



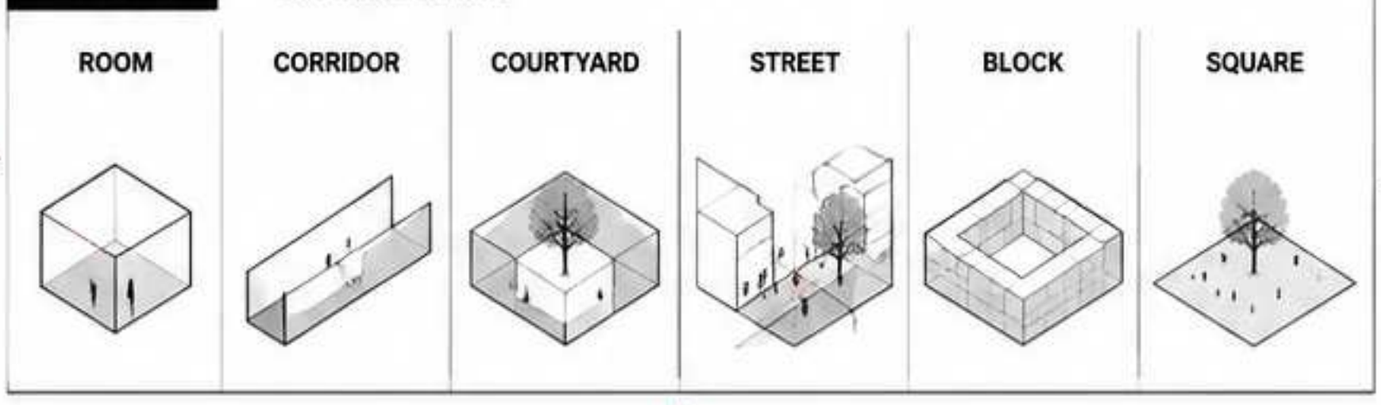
COMPOSITION & EMERGENCE

LAYER 2 MEREOLOGICAL RELATIONS



AGGREGATION & RELATION

LAYER 1 SPATIAL UNITS



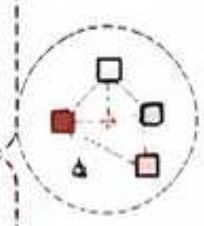
GENERATION FROM UNITS

THEORETICAL TRADITIONS



URBAN MORPHOLOGY

The study of urban form as a product of historical processes and typologies.



ASSEMBLAGE THEORY

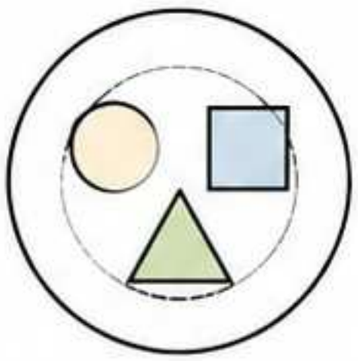
Heterogeneous elements and relations forming dynamic assemblages.

FEEDBACK LOOP (TOP–DOWN INFLUENCE)

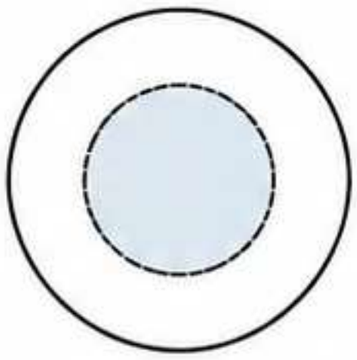
Emergent fields influence relations and units through adaptation, selection and transformation.

Generative Process (Bottom–Up)
Feedback Loop (Top–Down)
Theoretical Influence

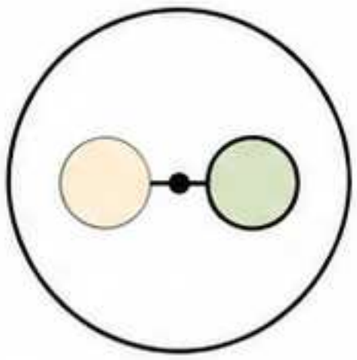
MEREOLOGICAL RELATIONS



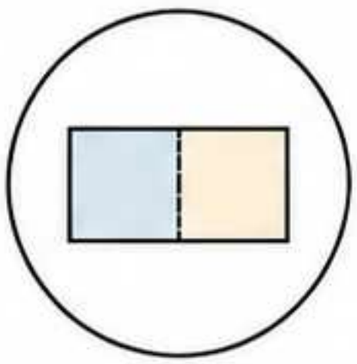
Part–Whole



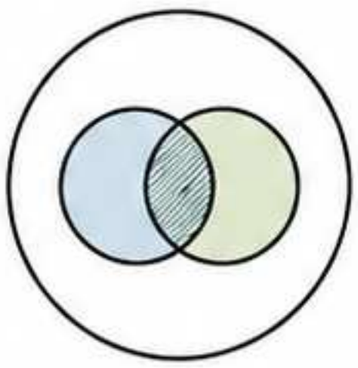
Containment



Connection

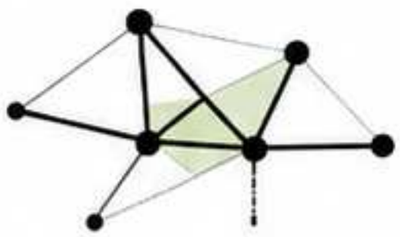


Adjacency

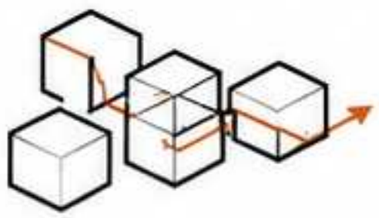


Overlap

SPATIAL GRAMMAR



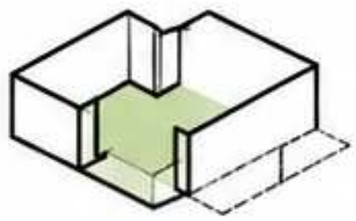
Spatial Network



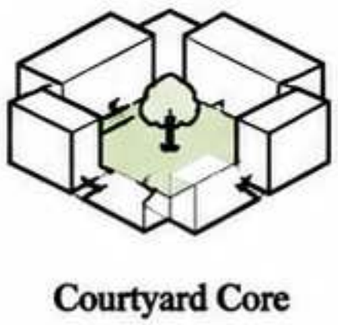
Path Sequence



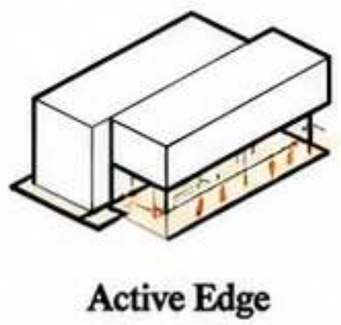
Spatial Node



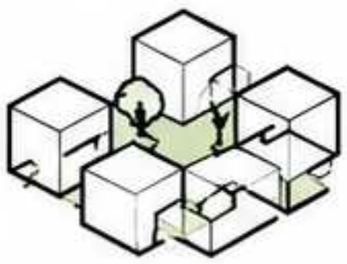
Hybrid Space



Courtyard Core



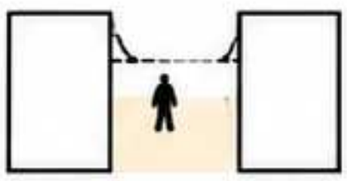
Active Edge



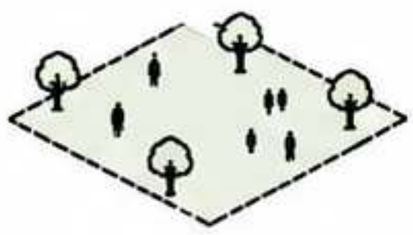
Spatial Cluster



Layered Space



Threshold Space



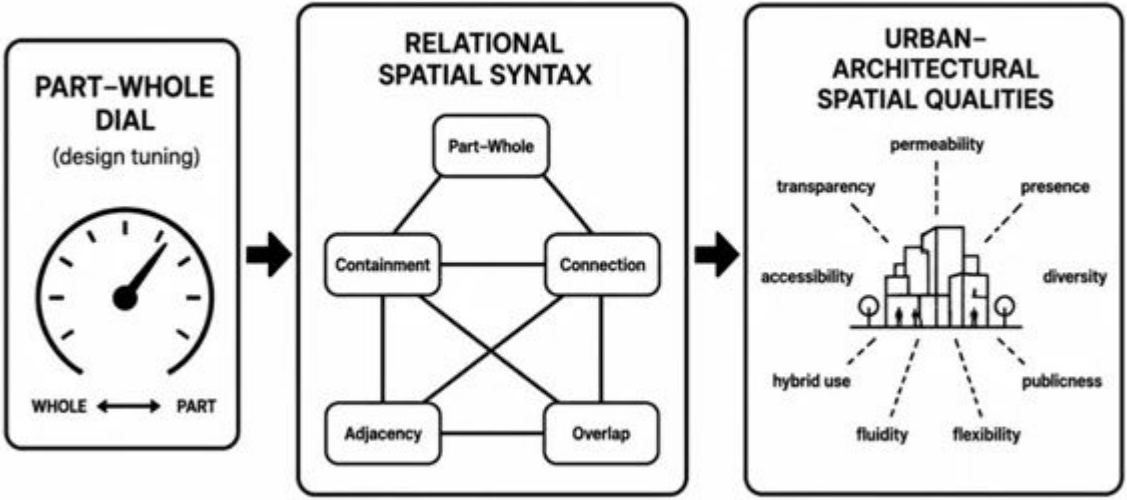
Flexible Field

URBAN SPATIAL QUALITIES

- Permeability
- Passability
- Transparency
- Sociability
- Urban Vitality
- Functional Synergy
- Mixed Use
- Public Space Generation
- Spatial Fluidity
- Diversity
- Readability
- Adaptability
- Flexibility
- Territorial Gradient
- Accessibility

MSS Main Conceptual Diagram

1	**URBAN CONTEXT:** Street Networks, Public Spaces, Blocks & Parcels, Movement Flows, Urban Nodes, Accessibility.
2	**URBAN SPATIAL ELEMENTS** $E_U = \{U_1, U_2, U_3 \dots U_n\}$ Examples: U_1 Primary Street, U_2 Secondary Street, U_3 Alley, U_4 Urban Square, U_5 Building Cluster.
3	**SPATIAL RELATIONS:** Adjacency, Connectivity, Containment, Sequence, Hierarchy, Permeability.
4	**RELATIONAL MATRICES:** A_U Adjacency Matrix, C_U Connectivity Matrix, H_U Containment Matrix, R_U Hierarchy Matrix.
5	**URBAN GENOME** $G_U = \langle E_U , R_U \rangle$ Integration, Accessibility, Spatial Hierarchy, Connectivity Degree.
6	**MSS TRANSLATION** $T : G_U \rightarrow G_A$ Urban relational patterns to architectural spatial rules.
7	**ARCHITECTURAL ELEMENTS** $E_A = \{A_1, A_2, A_3 \dots A_M\}$ A_1 Entrance Lobby, A_2 Circulation Spine, A_3 Courtyard/Atrium, A_4 Public Hall, A_5 Private Rooms.
8	**ARCHITECTURAL MATRICES:** A_A Adjacency Matrix, C_A Connectivity Matrix, H_A Containment Matrix, R_A Hierarchy Matrix.
9	**ARCHITECTURAL GENOME** $G_A = \langle E_A , R_A \rangle$.
10	**ARCHITECTURAL SPATIAL CONFIGURATION:** Urban syntax translated into architectural spatial organization.


PART–WHOLE DIAL
(design tuning)
WHOLE
PART
RELATIONAL SPATIAL SYNTAX
Part–Whole
Containment
Connection
Adjacency
Overlap
URBAN–ARCHITECTURAL SPATIAL QUALITIES
permeability
transparency
presence
accessibility
diversity
hybrid use
publicness
fluidity
flexibility

Part-Whole Logic

Primary Mereological Relations

Adjacency | Connectivity | Containment | Overlap | Hierarchy

Relational Spatial Syntax

Spatial elements | Relational matrices (A, C, H, O, P) | Configurational patterns | Syntactic measures

Generative Urban-Architectural Translation

Urban genome -> Translation operators -> Architectural genome

Evaluated Architectural Spatial Qualities

Permeability | Accessibility | Publicness | Functional coherence | Relational fidelity | Structural consistency

Rasht St

Amir Kabir University

Bozorgmehr St

Vali-E-asr St

Iran Art University

Rasht St

Amir Kabir University

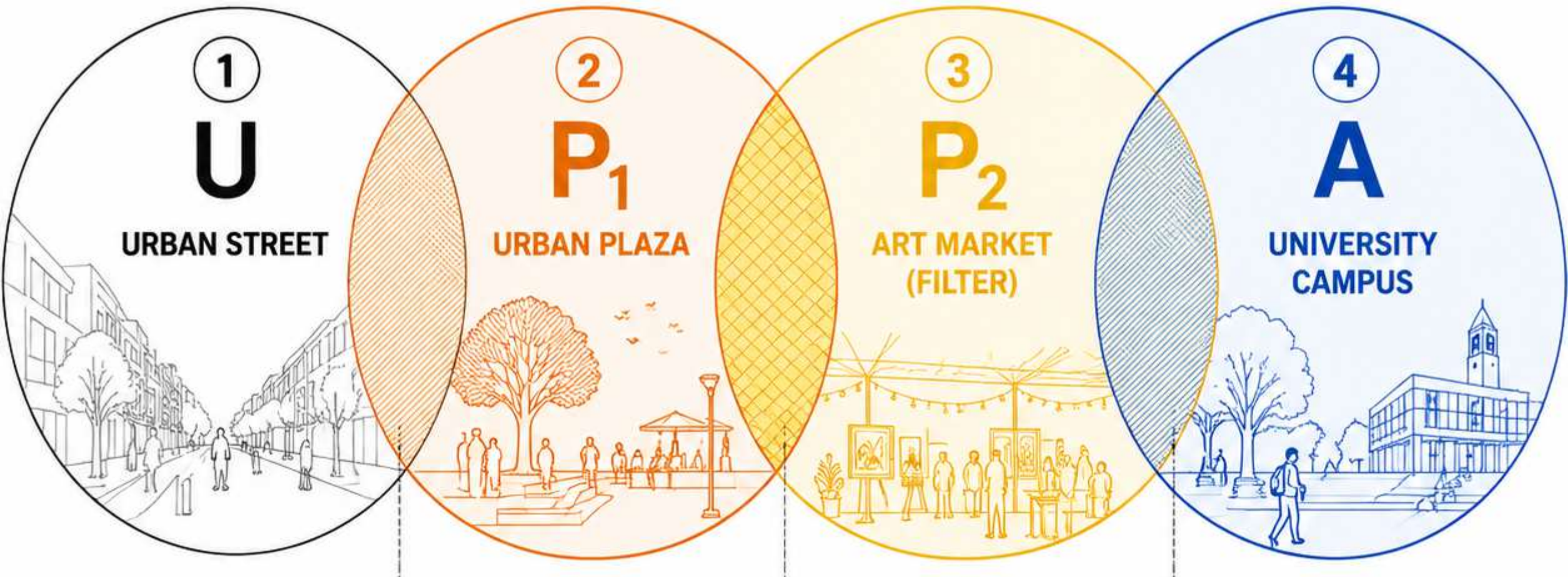
Bozorgmehr St

Vali-E-asr St

Iran Art University

A Spatial Transition Sequence: U → P1 → P2 (Filter) → A

TRANSITION 1 TRANSITION 2 TRANSITION 3



$U \cap P_1$
Edge Condition
Street meets Plaza

$P_1 \cap P_2$
Strong Overlap
Plaza flows into
Art Market (Filter)

$P_2 \cap A$
Strong Overlap
Art Market (Filter)
connects to Campus

MSS LEGEND

U — URBAN STREET
Open, linear, public movement system. First domain of encounter.

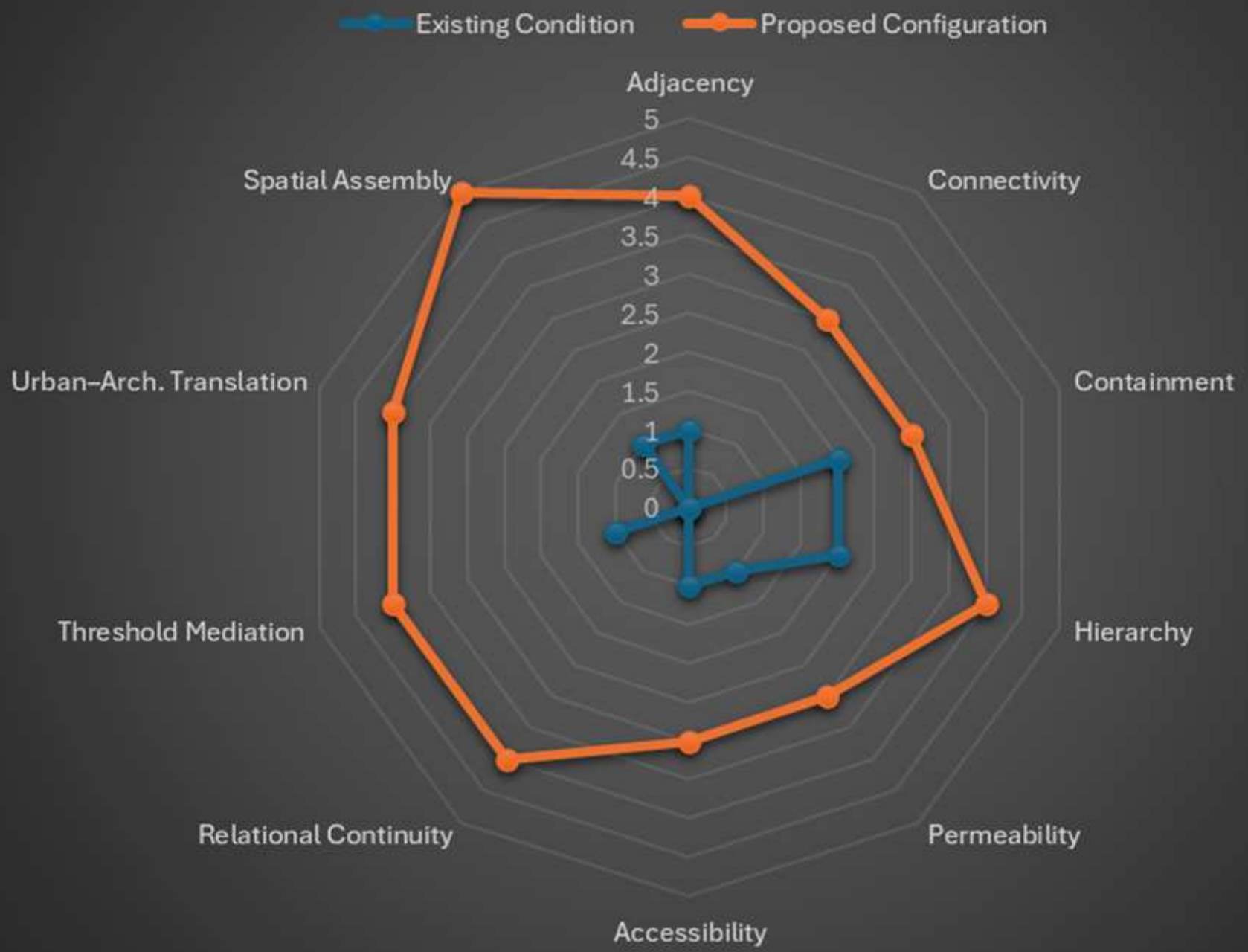
P_1 — URBAN PLAZA
Open gathering space. Social and spatial expansion from the street.

P_2 — ART MARKET (FILTER)
Porous, selective space that belongs to both systems. Acts as spatial mediator.

A — UNIVERSITY CAMPUS
Intellectual and institutional domain. Last domain of integration.

MSS SEQUENCE: U → P_1 → P_2 (FILTER) → A

MSS Spatial Performance Comparison



MSS Evaluation Indicator	Existing Condition	Proposed Configuration	Relational Description of Performance Change
Adjacency	1	4	Establishes a direct spatial interface between the urban corridor and the university courtyard system.
Connectivity	0	3	Introduces a continuous physical pedestrian path linking Valiasr Street to the academic environment.
Containment	2	3	Maintains the semi-enclosed boundary of the campus while allowing controlled functional integration.
Hierarchy	2	4	Clarifies spatial sequence by organizing transition from highly public, semi-public, to academic zones.
Permeability	1	3	Transforms a closed, impermeable storefront block into a porous, inviting spatial threshold.
Accessibility	1	3	Overcomes physical and visual barriers, improving ease of access for both students and the public.
Relational Continuity	0	4	Restores the broken chain U↮AU to a continuous sequence: $U \leftrightarrow \{P_{Plaza} + P_{Square} + P_{Corridor}\} \leftrightarrow A$
Threshold Mediation	1	4	Reclaims and activates the underutilized recessed area as an active “thick transition zone.”
Urban–Arch. Translation	0	4	Translates G_Urban (market/culture) into academic grammar through the mediating assembly.
Spatial Assembly	1	5	Unifies the Plaza, Art Square, and Gallery Corridor into a functional, emergent socio-cultural interface.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TechnicalAppendix.pdf
- SupplementaryMethodologicalNote.pdf