TERRITORIAL SABOTAGE: FROM TRACING SEOUL'S POSSIBILITIES TO RECOMPOSITING ITS URBAN IDENTITY

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Abstract. This paper explores the evolution of architecture within an urban scale, utilizing Generative Adversarial Networks (GANs) to increase diversity and suggest various alternatives. Drawing inspiration from Henri Bergson's concepts of creative evolution, GANs' non-deterministic nature echoes Bergson's emphasis on creativity within evolutionary processes in urban design. Leveraging GANs' latent space, this study envisions a framework for AI-driven architectural generation, merging Bergson's ideas of creative intuition with AI's adaptive potential. Using Seoul as a case study, integrating Kevin Lynch's principles and symbolic representation techniques like the Nolli map, the research navigates urban spaces to create cohesive morphologies. Employing 2D GAN-based analysis and integrating 3D GAN, the study discerns urban layouts and building configurations. Additional diffusion models refine the 3D GAN outputs, expediting rendering and visualization phases, suggesting an innovative, data-driven architectural design methodology. By amalgamating diverse AI models into a cohesive workflow, it blends traditional architectural wisdom with cutting-edge computational capabilities, heralding a paradigm shift in architectural innovation.

Keywords. Generative Adversarial Networks, 3D GAN, Stable Diffusion, Cartography, Nolli map

1. Introduction

1.1. URBAN EVOLUTION

Cities are not just physical spaces but living entities, constantly evolving in response to the needs, technologies, and visions of their inhabitants. This evolution is not merely a sequence of changes but a dynamic process that embodies the unique essence and spirit of each metropolis, for example, the architectural ambition of New York's skyscrapers, the innovative utilization of Singapore's limited space, and Seoul's urban regeneration. These developments exemplify how cities are laboratories of innovation, where the constraints of space, resources, and historical legacy spur creative solutions.

This ongoing transformation of urban spaces mirrors Henri Bergson's concept of

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"Creative Evolution," which posits that true evolution is driven by a creative impulse that transcends mere survival or adaptation (Bergson, 1907). In the context of cities, this impulse can be seen in how urban environments continuously reinvent themselves, integrating new architectural styles, embracing emerging technologies, and adapting to socio-economic shifts. Bergson's philosophy suggests that the essence of a city's evolution lies in its ability to harness and embody these dynamic and inventive forces.

Thus, the evolutionary trajectory of a city is not just a tale of physical growth or expansion but a complex narrative of creative experimentation and innovation. It is through this lens of Creative Evolution that we can understand urban development as a testament to humanity's unceasing quest for progress and reinvention. Cities, in their perpetual state of transformation, become vivid illustrations of Bergson's vision, demonstrating how dynamic and inventive elements are crucial to the broader scheme of evolution, driving forward new frontiers in architecture and urban planning.

The modern evolution of a city is deeply intertwined with the advancement of digital technologies. Projects like Smart Cities focus on integrating computing powers into urban spaces, enhancing operational efficiency, and improving the quality of life. This integration reshapes the very notion of urban spaces, steering the course of urban evolution towards new horizons (Mitchell, 1996). The digital layer added to the physical cityscape showed a possibility to generate multi-dimensional urban experiences—signifying a possible use of data-driven insights to fuel the evolution of cities. This aspect highlights the importance of data in understanding and shaping the urban landscape, accelerating the pace of urban development.

1.2. CREATIVE EVOLUTION AND GAN

The integration of Henri Bergson's concept of intuition, particularly his notion of “Creative Evolution” and “élan vital”, serves as a foundational theoretical framework for our exploration of Generative Adversarial Networks (GANs) (Goodfellow et al., 2014) in urban design. This study extends Bergson's critique of mechanistic evolution, proposing that the spontaneous and creative impulse he attributes to natural processes is mirrored in the adaptive and innovative capacities of GANs. By applying Bergson's philosophy, we argue for a paradigm in architectural and urban design that embraces fluidity, adaptability, and the continuous emergence of novel forms. This approach not only challenges linear and deterministic design methodologies but also emphasizes the role of intuition in navigating the complex, often unpredictable urban landscapes.

The novelty of our method lies in the innovative application of GANs, informed by Bergsonian intuition, to urban design and architecture. Unlike traditional approaches, our method harnesses the non-deterministic, exploratory potential of GANs to generate diverse urban morphologies that respond to complex, dynamic urban challenges. This approach not only broadens the conceptual toolkit available to designers but also introduces a new paradigm for understanding and interacting with urban spaces. The potential for generating unforeseen, adaptable urban forms represents a significant contribution to the fields of architecture and urban planning, promising to enrich the discourse with fresh perspectives and methodologies.

The application of GANs, underpinned by Bergsonian intuition, extends beyond mere form generation, offering a strategic tool for simulating and visualizing future urban scenarios. This capability is invaluable for architects and urban planners, enabling the anticipation of urban growth patterns, the exploration of sustainable urban interventions, and the enhancement of public spaces. By providing a multitude of design possibilities, our method encourages a more holistic and adaptive approach to urban design, where decisions are informed by a comprehensive understanding of potential futures. This aligns with the overarching goal of creating more resilient, inclusive, and dynamic urban environments.

1.3. CASE STUDY: SEOUL, URBAN PATTERNS

Seoul's architectural and urban landscapes have been subject to dynamic evolution and innovation, reflecting a rich tapestry of change over recent decades. This continuous transformation aligns with Aldo Rossi's concept in "The Architecture of the City" (Rossi, 1966), GAN's unique ability to generate and analyze data could also be used to elucidate unique patterns and potentials that can be translated into a design language. According to Kevin Lynch, cities can be understood through the recognition of their various constituent parts, such as paths, edges, districts, nodes, and landmarks (Lynch, 1960). Lynch's approach can be utilized to simplify urban contexts into the parameters that can be recognized by GAN models. By associating Lynch's urban elements and Rossi's architectural concepts in building the data model for GAN, a possibility of a design method emerges that could address both urban spatial configurations and cultural elements of the city.

Therefore, the following research builds upon Lynch's five elements while symbolizing the city's complex structure with the Nolli map and adapting this Nolli-type map for suitable GAN analysis.

To explore these ideas, the authors conducted a workshop in Seoul with an AI-integrated workflow. The two main objectives of the experiment were: a) to unearth Seoul's unique patterns and potential, and b) to discover possible structures and images of the city as generated in the latent space of GANs, with data parameters chosen to reflect the concepts of Rossi's architectural elements and Bergson's principles of Creative Evolution. Evolution is not simply a linear progression but a dynamic process encompassing different pathways and diversities. Hence, the authors' expectation was a series of diverse and multiform transformations that gave birth to an evolved urban fabric, catering to the multifaceted needs of the future.

2. Background

2.1. SYMBOLIZATION

Giambattista Nolli introduced the groundbreaking map, Nolli map, in 1748 in Rome, Italy. It went beyond merely documenting the city's streets and buildings; instead, it revolutionized cartography by encapsulating the essence of urban spaces and public areas with remarkable precision. This meticulous portrayal has since emerged as a powerful tool for studying and understanding urban landscapes (Ji & Ding, 2021). The selection of Nolli maps for our analysis is strategic, leveraging their unique capacity to delineate public and private urban spaces with unmatched clarity. Unlike other symbolic cartographic representations, Nolli maps provide a detailed visualization of the urban fabric, emphasizing the interplay between built environments and void spaces. This quality makes them particularly suitable for our study, where understanding the spatial dynamics of public and private realms is crucial. Furthermore, the Nolli map's historical and architectural significance offers a rich contextual layer, enhancing the interpretive depth of our GAN-generated urban designs.

2.2. APPLICATION OF AI

Crafted meticulously with consistent standards, Nolli maps offer reliable and structured data for training AI models, ensuring robust data integrity. These maps unveil the accessibility and interrelationships of public spaces, providing valuable insights into urban planning and societal dynamics. AI trained on Nolli maps show great potential to architects on developing spatial configuration and optimize the utilization of public areas, fostering inclusive and efficient urban design solutions.

By immersing themselves in Nolli maps, AI models discern architectural patterns (Kim, 2023) and urban design nuances, empowering them to generate authentic and innovative architectural concepts. Additionally, Nolli maps encapsulate historical city details, allowing AI training on rich historical datasets. This enables the creation of urban landscapes that are not only historically accurate but also offer opportunities for heritage preservation and imaginative historical reinterpretations.

3. Methodology

In the study, urban patterns are analyzed through AI models in both 2D and 3D formats, each offering a unique perspective on urban morphology.

3.1. 2D URBAN PATTERNS

The 2D patterns, focusing on the horizontal plane, capture elements like street layouts, block configurations, and aerial views of public spaces. These patterns highlight the visual intricacies and spatial relationships within the city. For instance, a 2D representation might depict the grid-like street pattern of a district, showcasing the arrangement and connectivity of urban spaces. Drawing inspiration from the concept of the Nolli Map, which provides a comprehensive view of urban form and function, these 2D datasets inform AI models by offering a structured framework for understanding the city's spatial organization and its impact on urban life.

3.2. 3D URBAN PATTERNS

On the other hand, 3D patterns provide insights into the vertical dimension of urban spaces. They encompass aspects such as building heights, spatial arrangements, and the dynamics of movement and flow within the urban fabric. A 3D pattern, for example, could reveal how buildings cluster in a particular area or align with natural topographical features. This dimension of urban analysis resonates with the architectural theories of Rossi, who emphasized the importance of understanding the built environment in three-dimensional terms. Moreover, Bergson's concept of Creative Evolution offers a philosophical lens through which to view the dynamic interplay between urban elements in three-dimensional space, highlighting the continuous process of adaptation and innovation within the cityscape.

3.3. INTEGRATIVE LEARNING APPROACH

The distinct information offered by 2D and 3D representations necessitates separate learning processes for each, followed by the integration of their findings (Figure 1). This approach allows for a comprehensive understanding of urban layouts:

- Macroscopic Citywide Patterns (2D Model): The 2D model is employed to learn and represent the broader city patterns. It serves as a tool for understanding the overall layout and structure of the city.
- Fine-scale Block Details (3D Model): The 3D model focuses on the detailed spatial structures within individual blocks. This includes building layouts, shapes, and the arrangement of open spaces, providing a closer examination of intricate spatial relationships.

3.4. COMBINING 2D AND 3D MODELS

Once the separate 2D and 3D GAN models are trained, their outcomes are integrated at a block scale. This integration process is then expanded to encompass the city scale, facilitating a holistic view of urban patterns. The resulting patterns from this combined approach are subsequently passed through a diffusion model. This final step is crucial for visualizing realistic urban scenarios and outcomes, enabling us to generate detailed and accurate representations of potential urban developments (Figure 2).

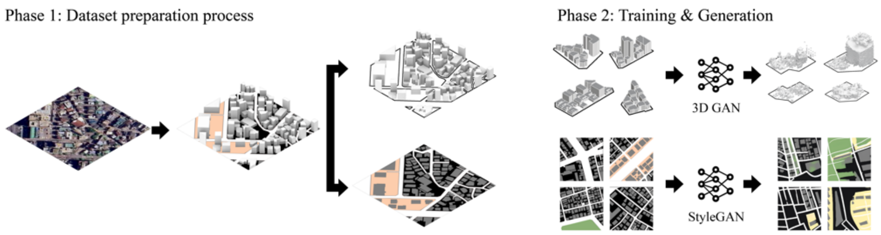

Figure 1. Overall workflow [Data preparation (Left) and Training and generation (Right)]

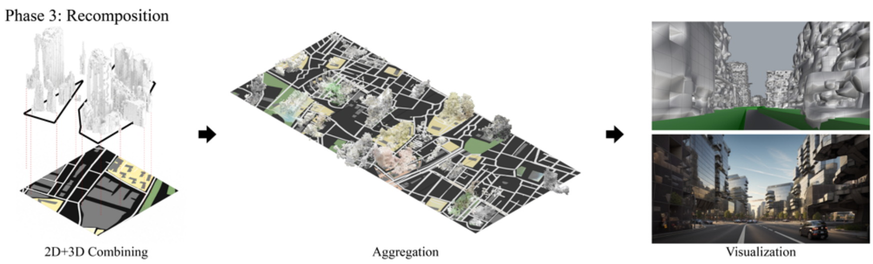

Figure 2. Overall workflow [Re-composition, Aggregation, and Visualization]

3.5. 2D DATA & TRAINING DETAILS

Our study involved generating 2D urban image data using Google's API with settings that emulate Nolli map visualization. We chose StyleGAN-ADA (Karras, Miika

Aittala, et al., 2020) for its ability to effectively navigate the latent space and uncover hidden patterns in training data (Kim, 2023). StyleGAN-ADA, an advancement over the original StyleGAN (Karras, Laine, et al., 2020), offers improved performance in aspects such as training time efficiency. The training dataset was created by randomly generating images within specified latitude and longitude ranges in Seoul, ensuring diverse urban pattern representations.

The amount of training data was 6557 2D nolli-type images, and the training details are as follows: GPU v100x1; Average training time 12 hours; Image size 512x512; Batch size 4; Generator & Discriminator lr = 0.0005; Dimension of latent vector 512.

3.6. 3D DATA & TRAINING DETAILS

For the 3D component, initial data was sourced from OpenStreetMap (OSM). In regions lacking 3D data, models were manually created to supplement the dataset. The 3D GAN (Wu et al., 2016) was used for training, focusing on generating a data-based probability distribution (Kim et al., 2023).

The amount of training data was 200-400 3D models, and the training details are as follows: GPU v100x1; Average training time 3 hours; Voxel size 64x64x64; Epochs 1000; Batch size 16; Generator lr = 0.0025; Discriminator lr = 0.00001; Dimension of latent vector 200.

4. Result and Discussion

There were in total of four individual teams in the study, led by the authors. Each team applied the methodology previously outlined. The paper focuses on analyzing and elucidating the work processes and outcomes of two of these teams, delving into the nuances of their approach to urban analysis and design using GAN.

During the initial phase of symbolization, each team developed unique urban codes based on their interpretations of map analysis, subsequently quantifying, and interpreting different urban areas. This process involved all four teams examining different parameters tailored to specific aspects of urban morphology. For instance, Team A analyzed the city through the lenses of “openness” and “scale”, focusing on the configurations of paths and districts. Team B, in contrast, predicted diverse urban formations by defining the “complexity” of each section using five distinct criteria.

In detail, Team A conceptualised openness in terms of accessibility. They argued that a city is more “open” when there are diverse ways to access various locations and a greater number of path choices available. This openness was quantified by counting the number of nodes, if more nodes in a block signify more path options, hence indicating a higher degree of openness. Scale was interpreted as a metric to evaluate walkability, efficiency, and potential for community formation, involving measurements and comparisons of block and building sizes to numerically represent the urban scale of each district. The team then plotted these two elements on a cross-axis, assigning scores on a four-level scale [-2, -1, 1, 2] to categorize and evaluate existing Seoul’s blocks and results from StyleGAN analysis (Figure 3). Also, they collected 3D models in a block scale to train 3D GAN, and the created 3D models from 3D GAN were placed on the corresponding block to give them three dimensionality.

In this process, changes in a single block could influence neighboring blocks over time. Under this premise, students developed a set of transformation rules for each block, seeing the continuous change of city blocks as an ongoing urban evolutionary process. They viewed a cluster of 16 blocks as one unit, theorizing a balance is achieved when the combined scores of openness and scale within the cluster approximate zero. This process involved constant transformation of each block according to the set rules, defining the overall changes as the evolution of the city (Figure 4).

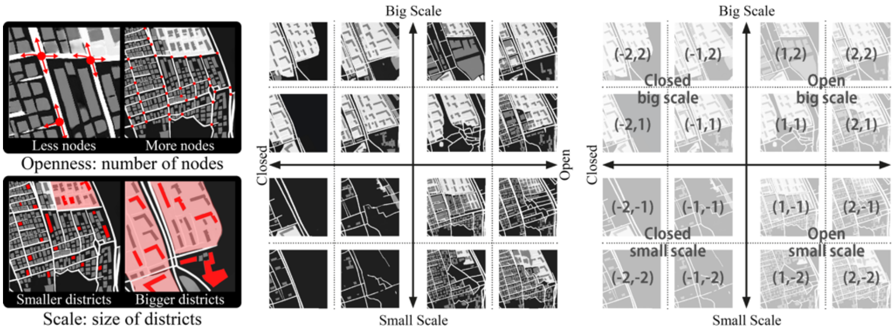

Figure 3. Team A, quantification of openness (Left) and scale (Middle), then categorising (Right)

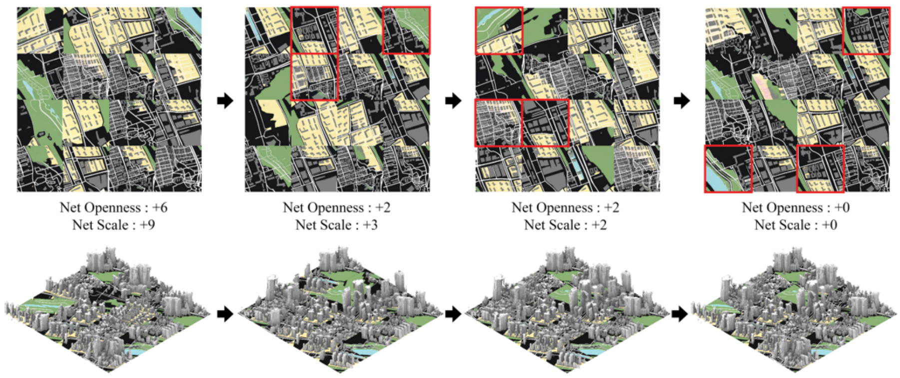

Figure 4. Team A, the sample of the urban evolutionary process based on the rule sets

Team B, on the other hand, quantified urban elements revealed in the Nolli map by measuring specific aspects such as the offset distance between roads and buildings, the number of intersections indicated by nodes, the variety of functions in each district, the width of paths, and the number of axes each path contained. They defined the complexity of each block using a five-digit binary code system, with measurements above the average marked as [1] and those below as [0] (Figure 5 and 6).

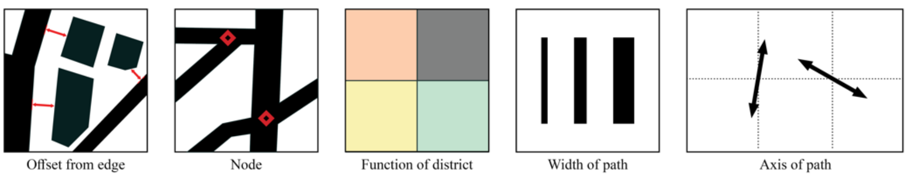

Figure 5. Team B, Quantification criteria to codify urban blocks

Figure 6. Team B, example of codification by five factors

The students employed this coding method to categorize various locations within the city, ensuring that the code of each block remained consistent despite any changes in its detailed structure. This methodology led to an understanding that the array of potential outcomes within a block's latent space symbolized its possible forms (Figure 7). For the 3D data, data sets from blocks sharing the same code were gathered and applied to 3D GAN. Subsequently, the team synchronized the city's composition by aligning the results from the 2D latent space with those from the 3D latent space, corresponding to the same district size (Figure 8). This strategy unveiled an urban evolutionary process in which the city's complexity is preserved, while its form is subject to continual evolution.

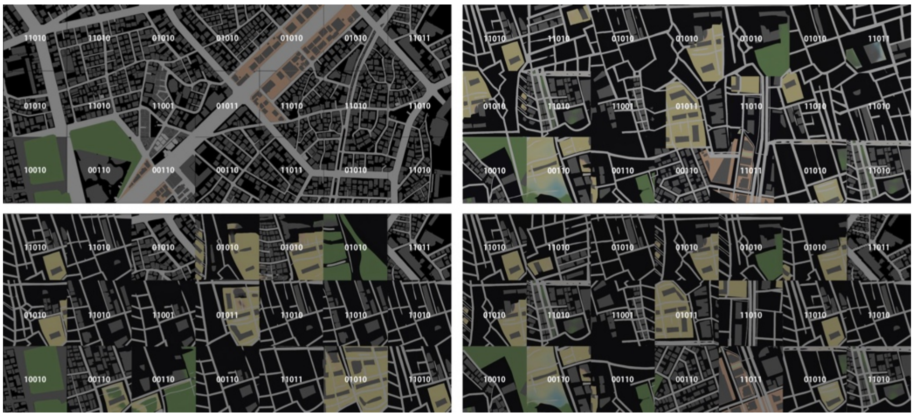

Figure 7. Team B, possible evolutionary urban patterns
(Left top: existing condition, Others: variation of the existing condition)

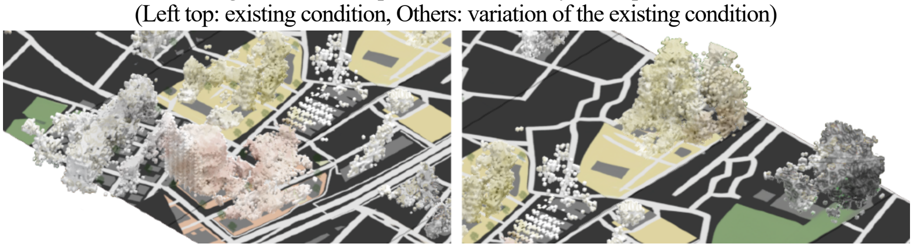

Figure 8. Team B, 2D & 3D combined output

All four teams, including Teams A and B, reconstructed the city using GAN results in their respective ways, leading to preliminary, low-resolution models. To translate these results into design imagery, the authors opted to use the sampling procedure from a diffusion model such as Stable Diffusion (Rombach et al., 2021). The students formulated their prompts based on the analysis criteria they had initially set for understanding the city, thereby generating evolved images of the city (Figure 9).

Figure 9. Visualization using a diffusion model

Their results proposed alternatives to the current model of urban transformation, demonstrating a fundamental aspect shared between creative evolution and GAN: the generation of novelty and the perpetual creation of new forms, embodying the concept of "élan vital". Through the processes and outcomes of these works, they have illustrated the potential for innovative methods in urban image design creation with urban and architectural data. This approach displays a valuable design methodology, leveraging two distinct GANs to infinitely generate architectural and urban forms, opening new avenues for exploration in urban design and architectural creativity.

However, the process encountered a notable limitation in accessing 3D data due to security concerns in Seoul, contrasting the 2D data. This constraint led to a research bias towards 2D analysis, causing outcomes predominantly influenced by planar data.

5. Conclusion

Considering the city as a dynamic, evolving entity, our exploration aimed to forecast temporal patterns using machine learning techniques applied to urban data. This endeavor not only proposes a pioneering predictive methodology but also redefines design paradigms. With this study, we tried to showcase the transformative power of processing, categorizing, refining, and reimagining complex data, shaping it into a viable design technique via an integrated workflow.

Throughout this study, artificial intelligence emerged as a crucial ally, enabling the processing of extensive, previously untapped data within urban and architectural design realms. Our established workflow systematically addresses each phase, paving the way for data-driven pattern creation. This innovative approach holds the potential to birth designs that elude conventional methodologies or urban design, ultimately amplifying human creativity in architectural and urban design realms.

The paper also underscores the pivotal role of data curation and the evolving role of designers, transiting from traditional drafters to novel data curators. The way data is organized significantly impacts the outcomes yielded by the design process. Different combinations of data can produce starkly contrasting results or innovative design possibilities. Moreover, the accuracy and integrity of the dataset play a critical role, given that the data serves as the foundation for training various artificial intelligence models. Hence, the meticulous construction of an accurate dataset devoid of noise or discrepancies emerges as a paramount necessity in the architecture domain.

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Territorial Sabotage: From tracing Seoul's possibilities to recompositing its urban identity, Unit 4

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