Politecnico di Torino

Honors Thesis

Master of Science in Sustainable Architecture

Abstract

The field of urban design and architecture is continually evolving, driven by advancements in technology and the need to address complex challenges in the built environment. As cities grow, there is an increasing demand for sustainable, efficient, and aesthetically pleasing urban spaces. To meet these demands, designers and urban planners are constantly seeking innovative approaches that can enhance the design process, optimize spatial configurations, and promote creative solutions. Evolutionary algorithms, a subset of artificial intelligence(AI) and computational design, have emerged as powerful tools with the potential to revolutionize the way we approach urban design and architecture. These algorithms, inspired by natural selection and evolutionary principles, simulate iterative processes of variation, selection, and adaptation. By harnessing the power of evolutionary algorithms, designers can generate and evaluate a vast range of design solutions, uncovering novel and optimized urban design strategies. Despite the promising potential of evolutionary algorithms in urban design and architecture, there remains a gap between their theoretical applications and their practical implementation in real-world projects. The field still lacks a comprehensive understanding of how to effectively integrate these algorithms into the design workflow and how to maximize their creative applications to tackle complex urban design challenges. Furthermore, the creative potential of evolutionary algorithms in urban design and architecture is yet to be fully explored. While these algorithms are commonly used for optimization and problem-solving tasks, their capacity to inspire and generate

innovative design solutions is often overlooked. There is a need to explore the creative capabilities of evolutionary algorithms and understand how they can push the boundaries of traditional design thinking in urban contexts. Therefore, the motivation of this thesis is to investigate the evolutionary algorithms and their creative applications in urban design and architecture. The research aims to bridge the gap between theory and practice by developing a comprehensive framework that enables designers to effectively utilize evolutionary algorithms as creative tools in the urban and architecture design process. By exploring the potential of these algorithms to generate unique and contextually responsive design solutions, this research seeks to contribute to the advancement of practice in the field.

Title

EVOLUTIONARY ALGORITHMS & THEIR CREATIVE APPLICATIONS ON URBAN DESIGN & ARCHITECTURE

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Chapter 1: Exploring the Creative Process of AI
... 1.3. Background Study
... 1.3.2. Genetic Algorithms

> Genetic algorithms are search algorithms based on the mechanics of natural selection and natural genetics. They combine survival of the fittest among string structures with a structured yet randomized information exchange to form a search algorithm with some of the innovative flair of human search(Goldberg, 1989).

The algorithm follows a series of steps to iteratively improve a population of potential design solutions. These steps include initialization, evaluation, selection, recombination, mutation, and termination. Initially, a population of design solutions is randomly generated. Each solution is evaluated based on predefined criteria or objectives. The selection process favors solutions with better fitness, which are more likely to produce desirable outcomes. Through recombination, selected solutions are combined to create new offspring with varied genetic information. Mutation introduces small random changes to the offspring, ensuring exploration of new design possibilities. The evaluation, selection, recombination, and mutation steps are repeated iteratively until a termination condition is met, such as reaching a specified number of generations or achieving a desired level of design performance.

As an example, we can consider a population of frogs living in a pond. The characteristics of each frog, such as its size, color, and jumping ability, can be represented as a set of parameters or variables in a genome. Through the processes of reproduction, mutation, and selection, the population of frogs can evolve over time to better adapt to their environment. For example, if there is a scarcity of flies in the pond, the frogs with the best jumping ability may have a higher chance of survival and reproduction, leading to an increase in the frequency of genes associated with good jumping ability in the population. This process is analogous to the way that genetic algorithms operate to find the optimal solution to a given problem.

Genetic algorithms are often used to solve optimization problems where the goal is to find the optimal solution to a given problem. They are particularly useful for problems that are too complex to be solved using traditional optimization techniques or for problems where the solution space is too large to be searched exhaustively. Some examples of problems that can be solved using genetic algorithms include finding the optimal parameters for a machine learning model, optimizing the design of a product or system, solving scheduling and resource allocation problems, and optimizing the layout of a manufacturing facility.

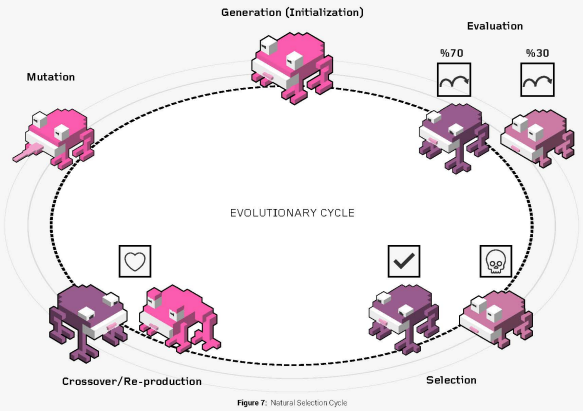
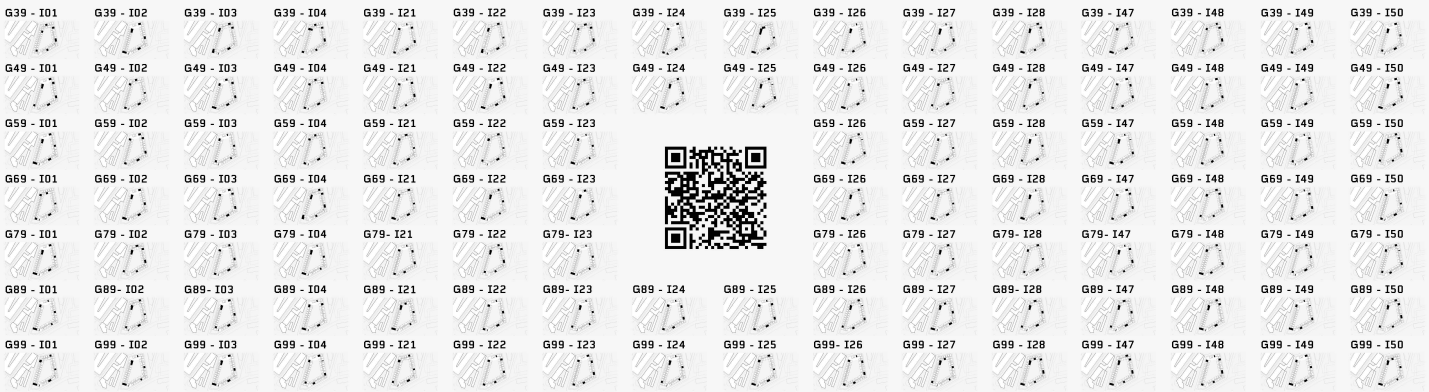


Figure 7: Natural Selection Cycle

Design Phase:1 Part:2
... 3.5. Design Simulation
... 3.5.3. Running Simulation

Design Phase:1 Part:2
... 5.5. Design Simulation
... 5.5.2. Running Simulation



For info:
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