A neo-postnatural high resolution aesthetic by Cellular Architecture

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Abstract. The level of detail in architecture is part of our legacy since our discipline has existed as a catalogue of parts, linking art and nature by using concepts of imitation, selection, neatness, and ornament. This research expands the idea of "high resolution" in architecture as a step forward in defining detail and ornament as a way of finally merging the structural and functional dimension of space with the detail and ornamental dimension of a design proposal. In that framework, this work-in-progress research emerges as an opportunity to use Cellular Automata (CA) and its principles to create coherence between different scales in the inhabitable space from a bottom-up approach. CA principles work in both computational levels (as logical machines) and a biological simulator (artificial life), enabling us to cross borders between natural and unnatural in a multi-scale design approach.

Keywords: Generative Design, Detail, High Resolution, Cellular Automata, Multi-scalar

1. Introduction

As a field that began in the Renaissance as a catalogue of components (Alberti, 1450), architecture has a long history of bridging art and nature via the application of notions like imitation, selection, neatness, and adornment. As part of the experimentation-creation-construction process, this final concept is the one that enhances the environment by adding a layer of super-nature to the architectural environment. In this way, the ornament (as a detail) enhances the bare space, assisting in creating "beauty" by mimicking imperfect aspects of nature while also forming nature as a whole.

Architecture, as a proto-discipline before Renaissance, used to be a component of collective creation, like cathedrals or temples from antiquity, where rules and negotiations among various actors governed the building process (Carpo, 2011). At the same time, it was being built and where the material served as the vehicle to reveal the true nature of a freshly imagined space. As a "little element of the total, yet it has the potential to characterize and identify the complete edifice," the craftsmen were those who were making the "detail" at that time (Weber, 1991). "The whole is to the part as the part is to the whole" in this meaning. Detail and ornament may be viewed as an architectural action on a different scale, one that acts as a constant tactile link between people and their surroundings and fosters diverse interactions with the environment, including emotional ones, because of the presence of evocative language.

Following the Industrial Revolution (Carpo, 2013), standardization procedures eliminated the minimum amount of "porosity" that enables us to produce various contrast levels, light and shadows on multiple scales. This eventually decreased the relationship between detail and occupant. Instead, architecture devolved into a monotonous series of discrete, utilitarian parts unrelated to one another or other aspects of the urban fabric at various scales.

Detail as an ornament (or lack thereof) has always served a purpose connected to aesthetic and cultural factors, representing the era in which the space was conceived (Moussavi, Kubo, 2006). It is a reinterpretation of the environment and its patterns in an exceptionally provocative and logical way, understanding rules, proportions, and connections as information to be transmitted to the inhabitants in touch with the architectural space.

Since modernism, architecture has minimized to the maximum extent possible, causing a critical disconnect between space and user and exacerbating structural and functional factors rather than maintaining them at the same level (or even subordinating them). This situation has persisted in recent architectural developments because "ornamentation" was no longer necessary due to a "more sincere" conception of space. Detail and its reconnection to the building are revisiting Alberti's original definition of architecture in his work, in which detail and its understanding of expression, construction, and materialization processes, as well as discretization, aggregation, behaviors, and growth, are now upgraded.

In a more recent definition, this research widens the notion of "high resolution" in architecture as a development of the meaning of detail and ornament that was previously mentioned and as a means of finally fusing the structural and functional dimensions of space with the detail and ornamental dimension of a design proposal. The qualities of architectural objects and the procedures used to build them have changed qualitatively and quantitatively due to the capacity to make design decisions with more accuracy and resolution. This results in a difference in how such things could be understandably beneficial in a contemporary context.

As a result, every architectural form must-have detail, which comes in a variety of depths and high resolution, works for human perception and frequently for the important organizational traits and performance of a newly constructed space. As in the study of cellular division and its application to design at various scales, high-resolution architectural fabrics are characterized by fuzzy borders, full of ruptures, similar to those defining the physiology of an organism, but bizarre and unnatural (Andrasek, 2018). Finally, a building's entire shape may be filled with details in the form of color, texture, or patterns in a 2D, 3D, or even more, including time dimension, depending on how the design assembles the specific set of issues or materials, processes, and scales (Figure 1).

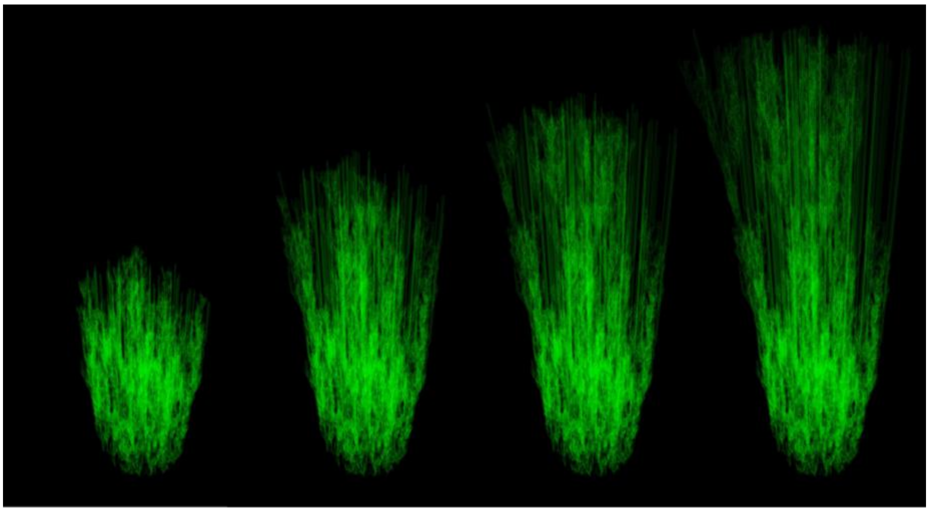

Figure 1: Incremental Cellular Automata column as time based 3d structure after 350 steps (image from the author)

2. A neo-postnatural aesthetic

Cellular Architecture uses Cellular Automata simulations to build architecture as a continuous design process, crossing scales, starting from detail (the seed) to the space (discrete system), using the environment (neighborhood) as a source of raw material to be reshaped into high-resolution spaces. This contrasts with the top-down design methodologies currently used widely in the architectural design profession. Due to this, the primary research framework is based on the transition from computational thinking to architectural design thinking, which involves several stages from the field of mathematics to automation and, ultimately, architecture as a physical manifestation of that theory in the living space.

In that context, this study offers a chance to apply Cellular Automata (CA) and its principles (Wolfram, 2002) (Hoekstra, Et al., 2010) to integrate various sizes in the inhabitable area by starting at the bottom up. In a multi-scale design approach, CA principles operate at both computational levels (as logical machines) and as biological simulators (artificial life) (Von Neumann, Burks,1966), allowing us to blur the lines between what is natural and what is artificial. These hybrid operations enable us to create artificial bodies (Oosterhuis, 2003) (Langton, 1996) that are a hybrid of nature and technology.

Based on the previous points, it is possible to understand detail as an ornament that adds an artificial pseudo-natural level to the existing space (as an original subtract). Following rules and principles from nature, the original support through the application of design principles comes from the historical pathway that led to the evolution of "the detail" till today, in a discrete way of constructing reality (due to its efficiency since ancient times), adding a higher level of detail (Figure 2).

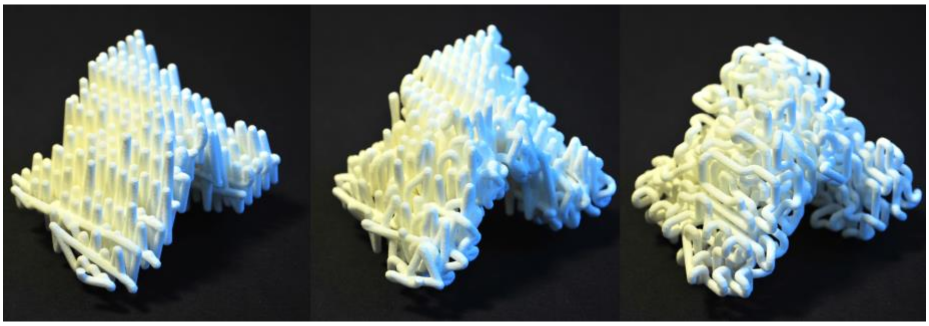

Figure 2: Same collection of Cellular Automata being translated in three different continuous processes (image from the author)

In the Post-Natural perspective, any living entity that humans have purposefully modified through domestication, selective breeding, or genetic engineering, a method of breeding organisms to satisfy a specific cultural requirement, is referred to initially in this concept. As used in cellular architecture, this concept primarily refers to the selected process by which cellular automation, which functions as artificial life and a logical machine, is digitally copied (or self-replicated) to achieve a high degree of detail in the design (as cultural material manifestation). This idea is realized by filling the area with solutions that can improve the current structures (Frazer, 1995). In this way, "the missing link" between the many layers of human-made settings may be developed by cellular architecture, which can read environmental norms and identify a set of potential outcomes to be constructed as the final step.

Last but not least, this research progressively enhances Von Newman's Automata Theory as a chance to create the first logical and physical models based on generative logic with origins in a "seed" cell named "automaton".

In that sense, the concept of "neo" ("new," "recent," "revived," or "changed") has been used as "a new and different form of something that existed in the past" (Britannica, 2022) semantically: cellular architecture follows automatic steps (details) over a discrete field (space), learning from the surrounding contextual data (environment) as well as from itself and providing information about coherence inside/outside different scales, using "neo" as a strategy of revisiting data from the past inside the code.

3. A high level of detail as a research method

This work examines the application of cellular architecture to the built environment in a synthetic approach, which includes a variety of theoretical scales (from neighborhoods to livable spaces). In that sense, incrementing the detail in our cities using a high-resolution multi-scalar approximation could redefine how we view our bodies and the natural world by incorporating highly customized and interactive datascapes.

We do not need an infinite number of distinct machines performing infinitely many different tasks, as Turing noted in 1948. It only needs to be one. The office task of "programming" the universal machine to perform these tasks replaces the engineering challenge of creating different machines for different purposes (Turing, 1948). According to this theory, a cellular automaton solution of a small size must tackle diverse issues on various scales by simply increasing the number of new cells while operating, after which the procedure may be used as an available solution.

The system memory is constructed as a structure that accumulates steps that earlier generations of the same seed were creating over a solution constantly refined on each step as an incremental level of detail resolution. The high-resolution process is not just about the number of steps a CA will run as a generative process (Fernandez, 2022).

Similar to this, the incremental level of resolution can also work as an expansion of Moore machines or Von Newman automata (Koh, 2022) to add precision to the final result of the generative operation, saving steps in the process. In practice, as there is a greater range of neighbors around a seed, fewer generations are required to produce a valid result. In this view, the degree of detail and its increments, together with the incremental memory process, are searching for a more exact outcome, recognizing detail as a remedy for a multi-scalar architectural issue.

The set of experiments that are part of this research is understanding a CA firstly as a "detail generator", working in an asynchronous way in which the rules are the initial catalogue of elements to be distributed during the creation of a structure that initially is working as a digital prototype (Figure 3 - Figure 4).

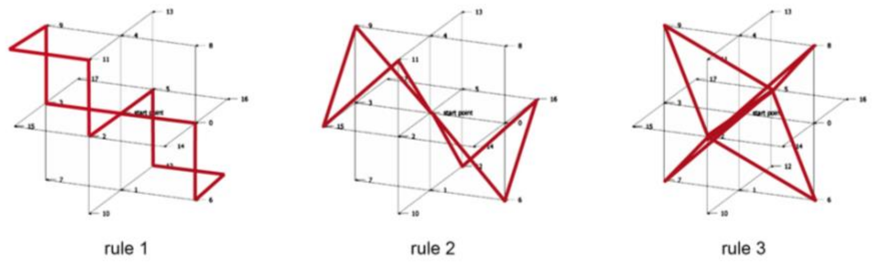

Figure 3: CA Rules as Details to be distributed in an asynchronous mode (image from the author)

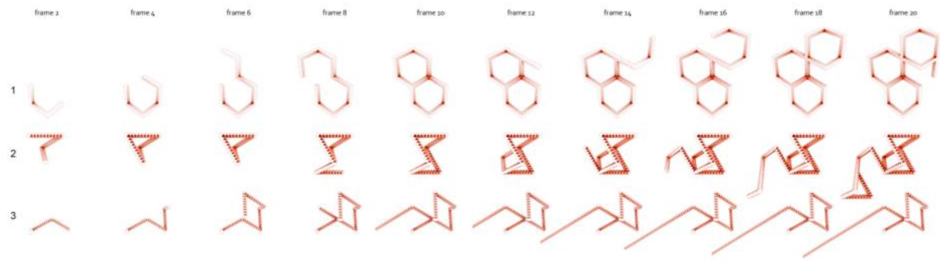

Figure 4: Asynchronous CA starting its first generation after 20 steps (image from the author)

After the first configuration of CA rules as “details”, the preliminary test on a 3d environment defined by a subdivided box of 50x50x50 units gives us the chance to appreciate different possible outcomes without any interaction with other elements than just its self-generated structure. These tests proved an exciting result about continuity and density where the same rule could create structures and forms in a high-density way without any additional help (Figure 5).

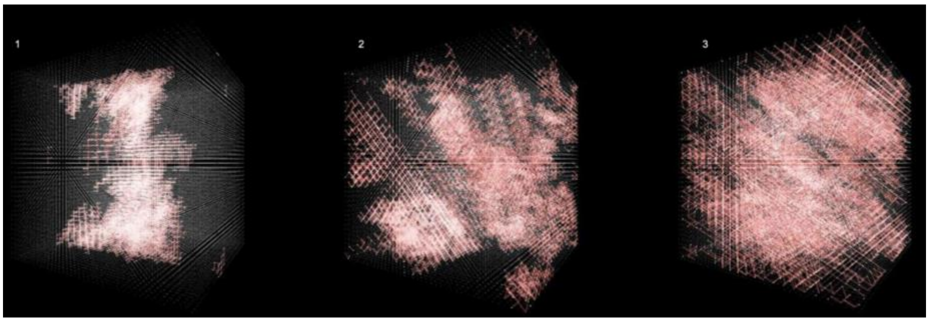

Figure 5: Asynchronous CA after 3000 steps (image from the author)

The third step in this experiment used the first set of rules in a test of interaction with an environmental constraint as a three-dimensional problem to be solved by the CA, creating a restriction that finally tests the resilience of a system like this one. After 1500 generative steps, the asynchronous CA understood the three-dimensional constraint (yellow vertical masses). From there, it created a structure that disables rules of expansion in X and Y directions and keeps the Z as an available direction to be taken (Figure 6). Finally, the result is a highly dense collection of cells represented as a white point cloud. This test is also genuinely remarkable without the interaction with a constraint in horizontal growing. The structure usually needs around 2500 - 3000 steps to consolidate a high-density point cloud to be translated as voxels for the next step in this experiment.

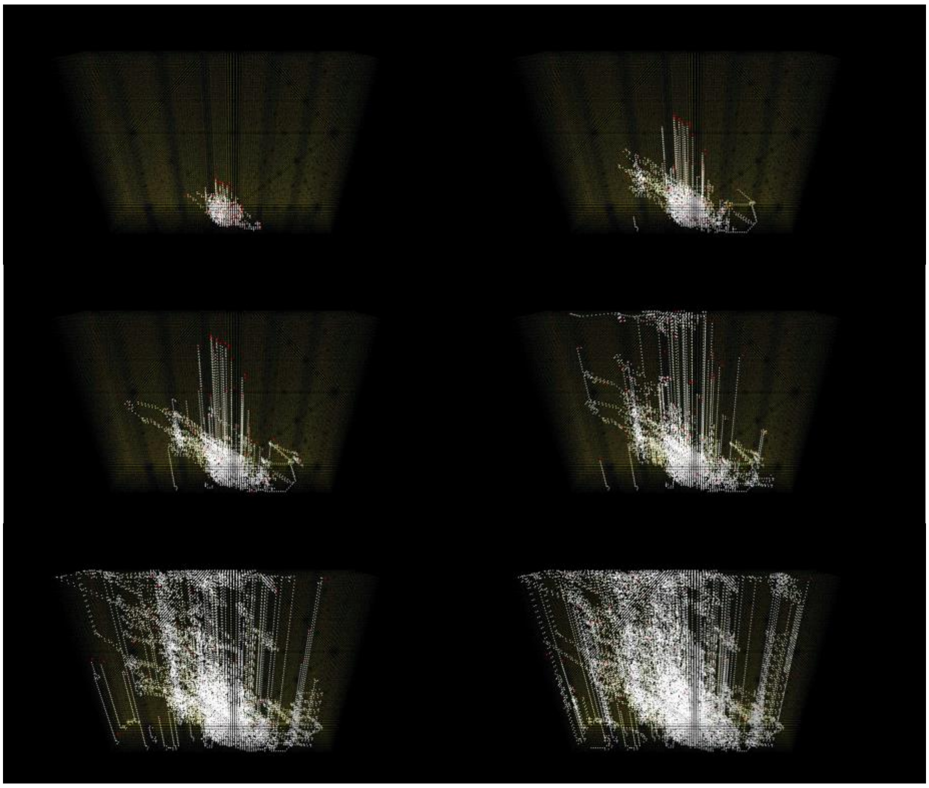

Figure 6: Asynchronous CA after 1500 steps with a three dimensional constrain as yellow mass columns (image from the author)

After all the previous steps, the collection of points is the result of the interaction between a grid as a discrete neighborhood, a seed (100 max) working asynchronously (a cellular automaton can update individual cells independently to the seed), and finally, a constrain in the 3d simulated environment (in this case a bitmap pattern). Creating a higher level of complexity in this stage relies on the problem to be addressed. According to the principles mentioned in the previous sections, a CA as artificial life and logical machine (a detail) is applying the rules loaded from the initial memory as a deterministic construction mode. Still, with external data interactions, it is possible to enrich the result with more than just one degree of data, creating more complexities and densities, creating a three-dimensional grayscale constraint, and affecting the outcome complexly (Figure 7).

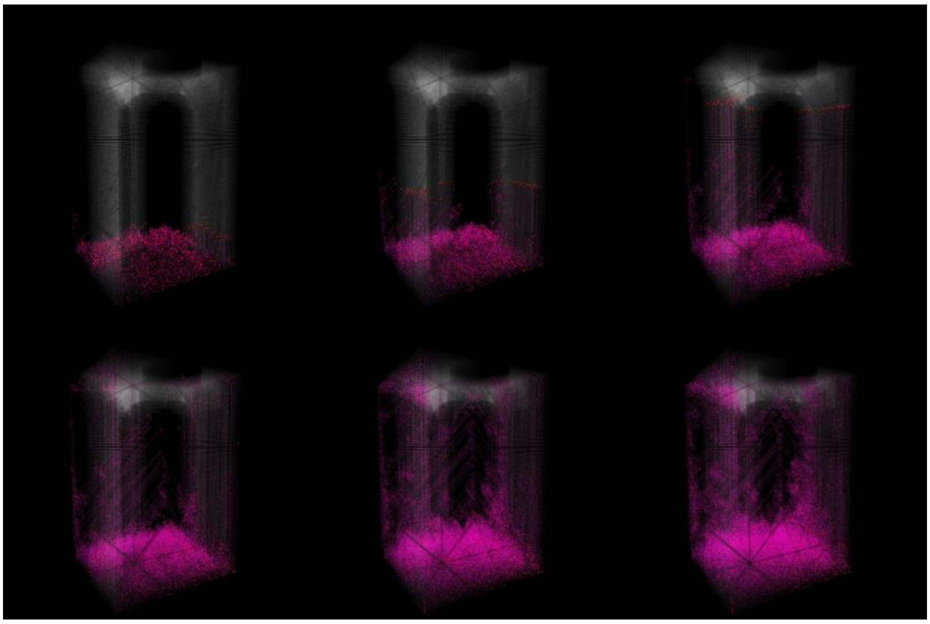

Figure 7: Asynchronous CA after 2000 steps with a three dimensional grayscale constrain on a 100x100x150 subdivided space (image from the author)

4. Conclusions and further steps

From the standpoint of Cellular Architecture, detail has more than just one unique quality; it also offers a different perspective on how an improvement in the generative design process as a degree of resolution may successfully revive earlier notions of detail and their connection to architecture. From that perspective, it is essential to emphasize the development that detail has gone through during its existence in architectural history and its relevance in developing contemporary design strategies.

Cellular Architecture acts as both a qualitative and a quantitative intermediary between the space and its inhabitants, as an additional layer of the spatial notion (working between data and nature). In that sense, the inextricable connection between nature and architecture (as an abstraction process) can now be re-understood as a component of the digital simulation agenda, following the pathway of artificial life and logical machine simulations.

Understanding the process that nowadays science and architecture are sharing (more closely related than ever before in the methods of digital simulation, material experimentation, and spatial expression), we must keep in mind the haptic dimension of the designed space without neglecting its aesthetic dimension and the data before and after that process.

The generative process behind CA as detail to be gradually improved is a concept that emerges as an opportunity in which digital creates new chances to develop the idea of detail, not just as an accessory for architectural space.

As a fundamental part of the space we are building, detail can operate as a building block with rules that find different positions according to the data we use as an environment to be colonized. From there, the concept of high resolution in architecture within a neo-post natural vision of how we are dealing with an aesthetical outcome emerges as an intentionally altered life simulation system that seeks high resolution under the frame of the incremental level of detail.

The previous perspective looks into a more precise generative result for the problems that a CA can face on different scales are two ways that Cellular Architecture is finally expanding the idea of detail. Finally, the keys in the system are: bigger neighborhood + more steps + more seeds = more detail = more accuracy. This research, which is still in progress, explores the increase in the result definition by adding frames to project development and a more comprehensive range of neighborhood interactions.

The following steps for this work will be the process of importing precise data from the environment as images that are breaking the deterministic way of growing a CA, pushing the system's limits into a direct link between detail, gradients, accurate information, and AI, generated based databases, accelerating the generation of various potential solutions to be generated by the same CA simulated seed.

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