ABSTRACT

While parametrics and form-finding techniques focus on design as an idea of “search,” it is inevitable to wonder if the field is becoming stagnated, converging on similar “solutions” in an ever-shrinking design search space.

Initiatives like Minecraft, coming from video game design, reopen the creative desires of players by providing a rigorous algorithmic set of rules and a fully open world coupling algorithmic design and intuition. This is what J.C.R. Licklider would call “man-computer symbiosis” (Licklider 1960). This paper presents how game mechanics suggest a radically different ethos for computational design thinking. It presents the Bloom project, commissioned for the London Olympics in 2012, which combines the use of industrially produced identical components with game mechanics. This project breaks the idea of serialized outcomes and suggests that within the search space of possible formations, there are unforeseeable assemblies and creative outcomes.

The Bloom project has become a new research unit at UCL Bartlett, coupling notions of digital modular materials and crowd-farming for assembly, which positions gaming as a design heuristics to open the field of architectural design.
ARCHITECTURE AVOIDING DECISION MAKING

Decisions are singular and unrepeatable; they cannot be generalized into rules. But all this also means that we cannot say that a decision simply ‘emerges’ out of a chaotic background, or pops out thanks to the movement from one ‘basin of attraction’ to another. No self-organizing system can obviate the need for such a decision, or dictate what it will be. And a decision always implies novelty or difference—in this way it is absolutely incompatible with notions of autopoeisis, homeostasis, or Spinoza’s conatus. What we need is an aesthetics of decision, instead of our current metaphysics of emergence [my emphasis]. (Shaviro, 2009)

The role of computation and digital design practices in the past twenty years has focused on ideas of form generation and manufacturing, emphasizing the empirical performance of design and leading toward a convergent notion of optimum. The increasing use of computer simulation software grows toward a megalomania of forecasting and anticipating spatial and formal outcomes. It is precisely in this context that totalizing discourses of architecture could emerge, overarching and overriding the different approaches and design strategies still present in our design milieu.

The proliferation of computational virtuosity in the realm of design has been in the service of the few star architects who can profit and exploit these alienated models of knowledge. The continuous training of new proletarians, armed with robotic arms and laser scanners, can only reach an inevitable collapse.

While the study of complexity in different fields has led to the replacement of a reductionist model, the embracing of complexity studies in architecture has been paradoxical. For the most part, it seems to imply direct relation with form: complex system equals complex formal answer. The use of biological analogies and references to nature seem to redeem the architect from all responsibility of judgment and decision making, providing the ultimate alibi for the exploration of form.

Algorithmic simulations portray a fallacy of time-based process; while the calculations could be done in real time (with enough computational power), we seem to be fascinated by the display or “unfolding” (using Deleuzian language) of algorithms on the screen. This delay between the action of the designer and the outcome has become poetically exploited with biological and evolutionary analogies, redeeming designers from their own decision making and suggesting that there is some larger “truth” or “objectivism” in the result of such computation. There is a fear of direct manipulation and decision making, where design intent (already a convoluted way of saying “what I want”) is hidden behind layers and layers of code.

The notion of self-organization within computational design positions the creator or code builder as an extrinsic entity to the design system. By applying simple rules, like the ones from flocking (cohesion–alignment–separation), designers can detach themselves from the mathematical outcome, arguing that the results of such calculations have veracity in their own right. But where do these rules come from?

For the most part, architects in the digital age have found in structure a repository of rules that are taken for granted as true, and by combining them they can argue for almost any form imaginable. From an evolutionary perspective, it seems that the survival criteria for structures are to stand or be load-bearing. If the form can do so, it is considered performative and passes the test. More advanced practices have added economical layers to such designs; manufacturing constraints and material rationality give rise to more evolved designs that can actually endure the market.

In this culture, the ongoing addition of design constraints can only reach a convergence, or what we call a style. The rules become dogmatic and tools become mechanisms of control.

POSTHUMAN ONTOLOGIES

Computational design practitioners have adopted the vocabulary of biological studies, referencing terms like self-organization or self-assembly. But what does “self” refer to?

Is it matter? Architecture? The building? Much like in Mary Shelley’s Frankenstein or the mythology of the “golem,” self-organization in architecture implies an animistic ontology of materials, one in which a precise set of conditions would make something emerge.

In this tradition, architects like Frei Otto suggest a technique of “form finding” as a way of “discovering” the interplay of properties between materials, reaching a performative solution. The designer steps back as a spectator of what are considered advanced or smart systems. The positivism developed over complexity studies is only in the service of centralized mechanisms of control that can distribute power in the hands of a few.

Moreover, the dichotomy of the designer/matter model as two disjointed forces does not support a consistent feedback loop between intention and creation. Matter can talk and self-organize, but we designers are still in control. In order to subvert this model we have to find alternatives, ontologies that could position designers at the same level as the matter they are operating with.

Object-oriented ontology (OOO) suggests, among other things, a model of flat ontology, where all objects are considered equals and humans are also considered objects.

“As Levi Bryant puts it, a post-human ontology is one in which “humans are no longer monarchs of being, but are instead among beings, entangled in beings, and implicated in other beings.” (Bogost 2008)

Computational design could potentially allow us to operate as agents of design embedded in a design economy of transactions between intentions, affordances and possibility.

THE BLACK/BLANK SWAN

It is true that parametrics sees the outcome not as one but many, or a multiplicity. The “slider” architect is in itself a search protocol of possible architectures bound to the design space of the tools.
From all possible outcomes, only a few are unexpected virtuosos or “Black Swans”. Nassim Taleb’s *Black Swan* (Taleb, 2007) describes the unexpected event in the field of probability. A collapse in the financial market is a Black Swan because it is an improbability in the model, but its existence becomes feedback for the definition of the model itself.

The Black Swan is the perfectly unexpected event; the White Swan is the perfectly expected event. Underlying both is the category of prediction and prevision, which is the real object of my criticism. The Black Swan refers to something we cannot see or foresee (it is black) and the White Swan to something evident and clear. Although opposed, the two are predicated on the idea of content of vision, or content of mind, or content of expectation. (Ayache 2010)

Yet the unexpected does not imply impossibility. Elie Ayache tries to move ahead from the Black Swan idea by proposing the Blank Swan, one that lives outside all systems of prevision, a swan of pure difference, a swan of novelty. As a former stockbroker, Ayache suggests that everything in the stock market comes down to a moment of decision, a contingent creation.

Ayache’s framework positions decision making outside a system of predictions and data mining outside a system of search. He does not suggest that this idea would or could override a system of prevision but rather that they describe a totally parallel process, unreachable by algorithmic search.

**COMBINATORICS FOR NOVELTY, NOT SEARCH**

As computational designers look deeper and deeper into the field of artificial intelligence, the notion of the “new” becomes more distant. Artificial intelligence provides a great set of tools for problem solving. Let’s take the example of the game of chess.

Theoretically, the game of chess could be “solved” by searching through all the possible combinations. We actually do have algorithms like “depth-first search” that could solve the game of chess. The problem of chess is not a problem of having the right computation to build a machine that could always win but rather the time complexity of the problem. We can measure the complexity of the case of chess by analysing the branching factor (amount of possibilities in each move) and the number of moves. In chess these numbers are, on average, thirty and forty. This implies that chess has a complexity of thirty to the fortieth power (Thrun 2011). Even by using every single computer on the planet, it would take thousands of years to search through every possible combination of chess moves.
This has not stopped a field like AI from moving giant steps forward over the past forty years; techniques like particle filters allow quick “self-awareness” of robots or predictions of patterns behind otherwise apparently random data.

The technique of particle filtering (Thrun 2011) uses a method of elimination of samples (particles) representing hypothesis matches between the observed data and a model of the system. This technique attempts to slice the search space as quickly as possible in order to arrive at a performative solution, a model of the world that fits the perceived information.

These ideas resonate within the current trajectory of the digital design agenda, a field with a growing interest in form finding and search rather than creation by decision making. This star system seeks Black Swan virtuosos, utilizing ever more obscure design techniques employing computation to simulate the validation of the forms they generate.

A simulation is always political. (Harman 2013)

ADDRESSING UNCERTAINTY WITH CROWD SEARCH

In May 2008, David Baker and his team at the University of Washington released Foldit, a video game based on real scientific models that allows players to engage with protein-folding solutions. Players can play with operations available to scientists, intuitively searching for ways to get rid of problematic features within the protein. The game was developed with a scientific hypothesis in mind; it would teach players how to work with protein folding, preparing the player for challenges that not even scientists with state-of-the-art algorithms were able to solve. Within days of its release, the game achieved solutions to puzzles at the edge of scientific knowledge. The crowd search approach to problem solving proved to be effective and brings back questions of how intuition and human intelligence can navigate through the landscape of such vast combinatorics (Cooper 2010).

Foldit has been recognized as a canonical example of the potential of the use of video games for research, instrumentalizing a model of human-computer symbiosis coming from J.C.R. Licklider (1960). Still, the model of “problem solving” or “problem finding” is in the realm of search, not in that of generation. However, it is crucial to understand that Foldit acknowledges a lack of knowledge and a technique to address uncertainty. This technique of crowd search implies accepting that we do not have the right solution and that we do not know the answer. The approach is one of transparency and education. Teaching non-experts to deal with scientific thinking armed with the very tools scientists use allows for collective intelligence to move forward.

A CASE FOR OPEN-ENDED WORLDS

In May 2009, Markus Persson released Minecraft, an open sand-box game. The game was built out of a three-dimensional grid where each cube could represent a different material. The actions of the player are those of mining (extracting materials from the world) and combining (building things out a set of materials). There is no real objective to the game, just to survive and create. This open-ended structure gave players an infinite array of constructions, making the game a massive success.

The unexpected response to Persson’s system of digital permutations and open game mechanics has become a paradigm shift in the world of game design. The user search space is infinitely vast and described by very simple discrete rules. The economy of relations and permutations of objects is a constant drive for invention. While Minecraft might appear more visually explicit, the work of Tarn and Zach Adams, such as their videogame Dwarf Fortress,
goes deeper into the definition of systems of transactions. The fully simulated interactions between digital properties of a vast voxel space world cannot afford more than ASCII graphics to be represented on the screen. The depth of the permutations goes beyond simulations of resistances and affordances of different tile sets and describes a complex matrix of interactions of an endless array of properties. In such a computational gamescape, the Adams brothers offer dwarfs as agents that can carry out tasks, allowing the player to multitask design decisions. These agents are bound to the rules of the digital world and the results of the interactions are not prescripted but simulated based on the properties of the tiles.

"The processing power that Dwarf Fortress uses is on the same scale as modern engineering software for designing aerospace hardware," says Ames, the engineer. "You have more complicated simulations in Dwarf Fortress than when you model the aerodynamics of a wing." (Weiner 2011)

The playscapes of Dwarf Fortress and Minecraft are vastly superior to that of chess; the combinatorics of tiles is so vast that it renders irrelevant any search algorithm or AI system of search. Moreover, the gameplay in both Dwarf Fortress and Minecraft is an act of contingent creation rather than problem solving. The gameplay is not bound to "search" but to generation and decision making.

There are many other important games such as Will Wright’s SimCity or David Jones’s Lemmings that use a similar sandbox strategy to generate a gameplay that is not narrative but procedural. The formula stays the same: rigorous computational objects and intuitive gameplay.

THE BLOOM GAME

Commissioned for the London 2012 Olympics, the Bloom game is an installation designed by Jose Sanchez and Alisa Andrasek within UCL Bartlett. The project is composed of 60,000 identical plastic units made out of injection-moulded polypropylene. Each unit (forty centimeters) has three asymmetrical connections allowing every unit to attach to others in a total of eighteen different permutations. There is no blueprint of the formations that were built; there are only local simulations of recursive aggregations that would only scratch the surface of the search space of the project. The simulations enabled the generation of ideas of how branches would inevitably coil into each other allowing for new connections. This information would allow structural engineers to have a rough idea of what could happen but without any certainty.

The project was intended as a game; the pieces would be released to the public allowing them to explore and create. Additionally, the Bloom design team would create an initial configuration that would work as an example of formations that could emerge. The rules of connections were simple and geometrical...
but in an attempt to allow for the public to explore beyond the rule set, an engineered flexibility was added to the unit allowing slight bending. This would promote the redundancy of connections and open even further the search space for design.

The challenge of the project had to do with engagement. In a way similar to that in which the forms of a flower attract insects for pollination, the Bloom unit needed to call for the attention of the public and encode its rule set of assembly in the geometry. The color (as a trademark of the London Olympics) helped with the bases of attraction, but sequences needed to quickly organize as something more than just random noise.

The structure was designed as a recursive branching loop, capable of redundancy for stability and arching for spanning. The limits of what would be possible (or necessary) were completely in the hands of the public. The public soon realized that by following certain patterns they could create stable configurations. A new set of objects emerged, from the combinations of a subset of units. The building blocks for larger structures were not defined by individual units but rather from assemblies of assemblies, many of them with different capacities.

Connections within the unit were given names (A,B,C), allowing the transmission of patterns in the form of software to create primitive formations. For example, \([A-C+A-B]\) could generate an infinite spiral. Moreover, people realized that they could not achieve a lot alone, so they quickly sought collaboration. Collective designs began to emerge as the ambition of the crowd grew for larger configurations. A constant cycle between assembly and collapse of the structures would teach some of the structural principles of the system. The rhythm and musicality of the patterns assisted the players to create intuitively.

While most of the gameplay yielded results that the design team anticipated, completely unexpected formations did occur. There were moments in which people would bend the rules of the system to fit very particular desires. These were perhaps the most exciting moments of the project, suggesting that a discrete tile set could cater to the unexpected.

**DISCRETE MATERIALITY**

Bloom’s discrete connections, very much like LEGO, suggest a primitive idea of discrete materials where the connections define a local coordinate system, and logic could be used to define sequences or “software” for material formations.

Today, most digital manufacturing focuses on numerically controlled machines that can deposit or alter materials. But materials themselves remain analog, meaning that their material definition is continuous and imprecise. The material itself is not defining its coordinates or connections, it cannot communicate with other units unless aided by external members.

In this regard, the work of Neil Gershenfeld and some of his former students, George Popescu and Jonathan Ward, brings light to the topic:

A digital material consists of a finite number of building blocks which have discrete joints and occupy discrete space. A comparison between LEGO blocks to masonry can illustrate the difference between digital and analog construction. The male/female pin joints on the top and bottom of a LEGO block are discrete connections, which either make or do not make a connection to another block. By contrast, a masonry construction is a continuous (analog) material. While the masonry brick is a discrete unit, the fluid state of the mortar allows one brick to be placed on top of another brick in an infinite number of positions. (Popescu 2007)

Because the joint is continuous and not discrete, masonry construction is analog. LEGO construction uses a finite number of blocks with discrete joints; therefore, a LEGO structure is completely digital. (Ward 2010)
Shannon’s thesis of digital communication applied to materials (Shannon 1949) suggests that we think in units that could communicate and pass information between them. The information is meaningless and its importance lies in the fact that the channel of communication exists. No material is truly digital, but an important layer of communication is achieved once we are able to send messages through them.

While digital materials offer a huge opportunity for the future of fabrication, the question of organization still remains; what kind of mechanisms of search or design do we have to operate in such a framework?

Zach Barth began his work by developing video games for engineering problems. This early work, far from commercial, encapsulates the designer’s mind at the moment of designing systems of interactions. In his game KOHCTPYKTOP: Engineer of the People, he developed a puzzle circuit solver that relies on the creativity of the player to lay down materials in a discrete grid and an understanding of how conductivity operates throughout the circuit. The game presents the objective as a challenge but otherwise is an open-ended sandbox for chip design.

Initiatives like this take game mechanics away from the focus of cultural and commercial artifacts of fun. Within a new territory of design, game mechanics can become a powerful tool for human-computer symbiosis. In this context, Gamescapes’s research and the hypothesis that games could become a computational design heuristics emerge.

**GAMESCAPES RESEARCH CLUSTER**

Since the 1990s, architecture has inherited significant inspiration from the process of embryogenesis and understands morphogenesis as a time-based process. This understanding has been supported by the work of philosophers such as Henri Bergson and Gilles Deleuze, who have expanded the vocabulary of process-
driven architectures. Bergson’s “duration” (2002) and Deleuze’s “becoming” (1987) are at the center of generative design agendas.

From an algorithmic point of view, games could be classified more as systems of transactions, “trade-based systems” rather than time-based systems. Their taxonomy is not determined by absolute entropy but rather by a discrete interaction between units. This is easily understood in simple board games like tic-tac-toe, where the moves or actions of different agents are not sequential in time but relative to each other.

In fact, board games today offer a simple intuitive introduction to computational thinking and systems of rules. You do not need to know how to program in order to define them, and their complexity can be overwhelming. These ideas have been explored in the research cluster at UCL Bartlett; slow computation and turn-by-turn systems allow students to evaluate, step-by-step, the playing out of motivations and resource management.

While nonlinear systems are chaotic based on their sensitivity to initial conditions, games are nonlinear in the set of decisions taken in every step by the agents playing them. The rule set becomes the software that allows us to understand competition in the city and speculate with possible cooperation. The cluster envisions parallel economies and systems of motivation. These ideas, explored at various scales, can choreograph urban systems or agencies of the built fabric. All of these systems are far from equilibrium.

**DESIGN AS PLAY**

Working with a brief of open-ended tectonics, the Gamescapes agenda has coupled notions of digital materiality with human-computer symbiosis to suggest design as “play” rather than
The research presents the challenge of the sandbox as a discrete kit of parts that could be assembled and dis-assembled for local contingencies. Looking at traditional games, students have derived generative systems of construction. Within the studio, we develop new architectural games from scratch, focusing on mechanics of generative design guiding the player to produce outcomes with different performances. Central to the design of these tools is the design of the interface and the presentation of the information, as the player is central to the game algorithm.

In this format, designers (players) are not decoupled from the simulation but rather entangled in it. Their own decisions are the process in which the system unfolds. Often, the presentation of information is not to arrive at one solution. Open-ended structures allow the presentation of several different scores that might be opposite each other, allowing the player to make the decision of what kind of performance to achieve or perhaps design for an average.
Iterative gameplay of such systems does not live only within the designer’s hands. Today games possess a much larger infrastructure for distribution; the ideas are experienced by the player rather than being described on a board.

The “procedural rhetoric” (Bogost 2010) of games could open channels for new design outputs: those of computation, intuition and participation, which constitute collective intelligence as the means for design innovation.

CONCLUSION

The Bloom project has constituted a departing point for larger research in the consideration of game mechanics as a design heuristic. Many of the features of the Bloom project, such as social engagement and geometry as a system of communication and notation, can be further explored in deeper architectural research. The Gamescapes agenda is addressing this challenge by developing architectural algorithms in the form of video games which couple simulation and decision making, attempting to develop a notion of design as man-computer symbiosis.

The video game output has the potential to be a new architectural medium that can be educational and crowdsource design decisions, aiming for a much larger distribution of architectural design thinking into everyday life.

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