Collective Intelligence as Responsive Design

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Abstract

Parametric design environments (Building Information Modeling) are transforming architects into agents of their own systems, at the expense of systemic logics too complex for us to control. This agency is often defined by a system devoid of adaptive or responsive tools. The work in this paper proposes a hypothetical response to this condition by designing 'glue' for components of software to integrate new forms of information for a user.

Author Mario Carpo has recently outlined three-scenarios for these types of parametric inputs through the idea of 'split agency' (Carpo 2011). First, is an existing parametric environment such as REVIT, which has a corporate author (Autodesk). Second, is a scenario where the parametric software has a 'system' author that customizes the design environment according to a series of rules, parameters, or laws that govern how the system functions, such as *Digital Project* by Gehry Technologies. Lastly, is a scenario where the parametric software is defined by multiple users operating through collective intelligence as 'virtual authors', customizing the way that the system functions. This final scenario creates a fracture, which could redefine the significance and applicability of BIM.

By provoking the question of 'authorship', we can utilize BIM as a design and production tool that integrates ecological decision-making within parametric design environments. In many ways, Roland Barthes's assumptions about the author have become a reality that must be confronted (Barthes 1977). The loss of authorship may allow information to become more transparent, however, we must be careful to not devalue the way that multiple authors access or profit from this 'collective intelligence.'

1 Introduction

Wikipedia defines *Wikipedia* as "a free, web-based, collaborative, multilingual encyclopedia project supported by the non-profit Wikimedia Foundation... Its 18 million articles (over 3.5 million in English) have been written collaboratively by volunteers around the world, and almost all of its articles can be edited by anyone with access to the site" (Wikipedia 2011). The use of Wikipedia has allowed online collaboration to become a highly visible way to encourage information sharing in a web-based environment.

The use of wikipedia as an open source information medium points to a moment when the idea of collective intelligence could become a viable way to gather and synthesize data. *Collective Intelligence* creates awareness among various invested users that may include families, communities, or entire cultures (Goleman 2009). Currently, BIM (Building Information Modeling) is used by architects, engineers, and contractors as a way to document and analyze pragmatic construction issues such as energy simulation, construction scheduling, and product integration. However, the key to moving beyond the rudimentary features of these parametric systems may be in the implementation of more complex forms of use or authorship.

This research paper will outline four-topics of inclusion. They are: Ecological Intelligence, Collective Intelligence, Verification & Monitoring, and BIM Linkages. Each of these topics will investigate how new information sources, sustainable definitions, and Building Information Modeling can be linked through emergent computational frameworks.

2 Ecological Intelligence

Author Thomas Friedman in his book *Hot, Flat, and Crowded* discusses how 'The Energy Internet' could become a possible scenario where the forces of information technology transform Energy Technology. This scenario alters the current pattern of incremental change, in favor of a systematic overhaul of environmental thinking. The system that Friedman proposes would alter the way that utility energy use would be regulated by the Energy Internet (i.e., an online system to show the true cost of how much energy a particular person was actually using). Friedman's assertion that a network approach to energy usage is a drastic example of systematic change.

Paralleling Friedman's discussion of change, is the idea of *Collective Intelligence* (as described by Daniel Goleman). *Collective Intellligence* is defined via three-sub topics. They are: *Knowing your impacts*, *Favoring Improvements*, and *sharing what you learn.* Goleman discusses the hidden consequences of our material consumption by saying:

> "Our world of material abundance comes with a hidden price tag. We cannot see the extent to which the things we buy and use daily have other kinds of costs-their toll on the planet, on consumer health, and on the people whose labor provides us our comforts and necessities." (Goleman 2009)

The decision-making power that architects have, propagated on concepts of mass customization, have given us the illusion of choice. However, these choices mask underlying issues of material and energy flows (embodied through the mining, extraction, processing, transporting, and assembly of building components).

By leveraging 'radical transparency', information is presented to the buyer (in this case an architect/designer) in a straightforward and direct manner. Radical transparency thus becomes an accountability system to uncover the decisions we make and the ecological effects that they have on the planet.

One of the major questions that must be asked when considering radical transparency is: how do we as a society collect this data? LCA or life cycle analysis data for a particular building material (from extraction to disposal) is a difficult challenge. Two-major approaches to collecting LCA are Process-based LCA (process flow analysis to model life-cycle activities & stages and the EIO (Economic Input-Output) method. A process-based LCA considers major material and energy inputs & outputs and requires an analysis boundary. The EIO examines data and resource input and environmental output from public sources to influence supply chains. These methodologies, although distinctive as LCA approaches, could be used together to target a total life-cycle process; one that considers environmental effects comprehensively. However, going back to the question of HOW to collect data, there are significant hurdles that include boundary definition, data acquisition, data quality, uncertainty, and the interpretation of results (Matson, Ashok, Kammen 2004). Although data collection is not a task that should be placed upon a user (architect or designer), it is a significant obstacle to defining material life-cycle design.

There are currently a number of ‘eco’ certification systems and environmental rating scales that attempt to give clients, architects, and designers the ability to understand the ‘green’ ramifications of a particular product. Systems such as USGBC LEED, MBDC (Cradle-to-Cradle), and FSC (Forest Stewardship Council) attempt to assign ‘points’ or ‘seals’ to products or buildings.

Figure 1-USGBC LEED Logo

However, these systems have been accused of ‘green-washing’ because their valuation systems are not tied to valid environmental data. At the moment, LEED is being targeted by a class-action lawsuit. The lawsuit filed by Henry Gifford, a mechanical engineer, has accused LEED of misrepresenting the energy performance of their buildings. The lawsuit is an attempt to counter the trend of ‘seals’ being used to rate the environmental effectiveness of a building. Other criticisms have been leveled at other rating systems as well, citing their lack of clarity and relevance pertaining to effective sustainable choices.

Many of the issues raised concern how *metrics or* 'ecological data' is quantified. One of the key components for measuring this data is how it is rated against an algorithm. This algorithm would be in the form of a 'multiplier' or ratio that would take the data that is derived from these metrics and attempt to create relational ratings. For example, if material consumption were an issue with a particular project (i.e. the weight or volume of a particular construction material), then the algorithm would take the physical data and apply the algorithm to that condition. Alternatively, if fuel consumption were an issue (i.e. the amount of diesel used during truck transportation), then the algorithm would take that consumption and apply another multiplier to evaluate the relationships between types of consumption.

A consideration that applies to this algorithm concerns what we define as variables or constants. Variables define the parameters of a design project such as the geometric size of a wall panel (length, width, depth). Typically, these variables are defined by the user (architect or designer). The constants are a pre-defined algorithm. Once these variables are set, the constants can be tied to the algorithm. The algorithm then functions as a way to measure the 'eco'-effectiveness of a particular design project.

3 Collective Intelligence

The user (architect, designer, engineer, etc.) documenting or analyzing a building project with current BIM technology, can work simultaneously through real-time collaboration. This collaboration typically occurs only within the design team. However, the ability to collaborate openly, outside of one's own knowledge base, opens up unique possibilities for changing how the design process works through a much more broadly organized intelligence system.

A recent example of this trend was the *mTable* series (2002) by Gramazio and Kohler architects. According to their website, "mTABLE is the first mShape product. It enables people to create their own table using a mobile phone.

Figure 2- One instance of the *mTable*

The mTABLE is designed by sculpting a surface, choosing dimensions, materials and colors. These parameters are directly transmitted to the computer controlled production facility for the manufacturing of the custom designed mtable (mShape 2011). The mTable project allows the designer to create the parametric system but let the customer define the table according to their own desires.

The construction of a system of 'collective intelligence' as it pertains to ecological decision-making and design, could involve the usage of enabled 'advisors'. These users or advisors would communicate information to the user of the BIM program. Although the user would make all the final decisions, they would be rely on the information that is conveyed to them by these secondary users. In this case, the secondary users could be made up of three-possible advisor types. These are the 'Eco-certification systems' (LEED, MBDC, et. al), a News Feed (online news sources as advisors), and Social Networking sites (Facebook, Twitter, et. al).

The 'Eco-certification systems' can be classified as a series of advisors, dependent upon where the user is in the LCA process. These parameters could be broken down into Extraction, Refinement/Processing, Social/Ethical, Transportation, Environmental Emissions, Human Health Toxins, and Waste/Disposal. Each of these elements would organize the users or advisors according to their particular focus. For example, if there was a scenario where a wood product was harvested in Malaysia to be used as plywood, then the users or advisors could be the SFI (Sustainable Forestry Initiative), FSC (Forestry Stewardship Council), or PEFC (Program for the Endorsement of Forest Certification Schemes) among others. Another example of this could be the consideration of Social/Ethical factors. The users or advisors could be the ILO (International Labor Organization), WTO (World Trade Organization), or FLC (Foreign Labor Certification).

These users or advisors would serve to provide information to the primary user making the final design decision. If these users or advisors agreed to serve in this system of ‘collective intelligence’, they would need ‘incentives’ of some kind to participate.

At this juncture in the process, the primary user could take advantage of a rating scale or measurement gauge that would show both the individual rating that a particular user granted to the product or material AND the cumulative rating that would be the mean rating value of all the users or advisors. A current example of a similar system is the *GoodGuide.*

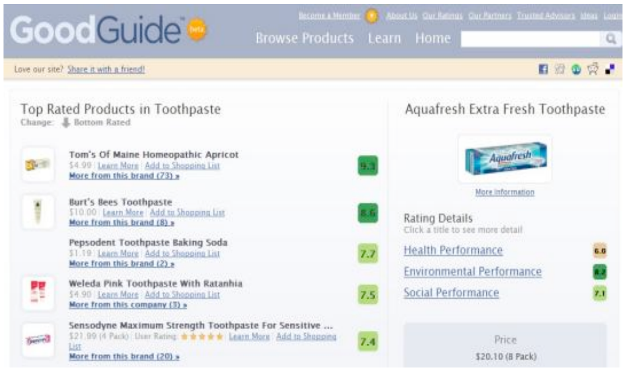

Figure 3-GOODGUIDE Website

The *GoodGuide*, founded in 2007 is an online collaborative that seeks to provide a consumer or buyer with information about the health, environmental, and social ramifications of their product choices. *GoodGuide* uses a rating scale from 1-10, with 1 being least desirable and 10 being most desirable. The *GoodGuide* serves as a mechanism that uses data compiled from a team of science and technology experts. One component of the *GoodGuide* system is the ‘Influencer Leaderboard’ that consists of various top influencers that provide an ‘influence score’, a series of ‘followers’, and product ‘recommendations’ (GOODGUIDE 2011). The effectiveness of this methodology is tied to the notion that multiple users (in this ‘influencers’) can help affect the way that others make product decisions. Essentially, this idea is linked to the idea of instant gratification and that ‘point-of-purchase’ process.

Another component to this user/advisor system is the use of a proposed News Feed. The news feed, similar to Google’s current ‘News’ tab could be used to highlight and select stories that would impact the selection or viability of a building component or material. One possible scenario could hinge upon the way that the news stories are categorized according to the phase in which a material or product is in it’s life-cycle. The stories themselves would serve to highlight issues such as labor riots, rises in gas prices, or natural disasters that could disrupt the flow of material’s used in production, assembly, or transportation.

A final aspect of the advisor system could emphasize the way that social networking impacts the idea of *collective intelligence* in a BIM environment. Social networking sites have become increasingly synonymous with an expanded awareness of interactive communication. Although there are a variety of drawbacks to a system that favors social networking over more credible scientific and technological sources of data, the use of tools such as Facebook or Twitter could begin to highlight the way that these sites report (possibly first-hand) what the environmental impacts of a material are. Similar to *GoodGuide's* use of 'influencers', social networking sites may function to bring the individual advisor into a competitive field of environmental rating.

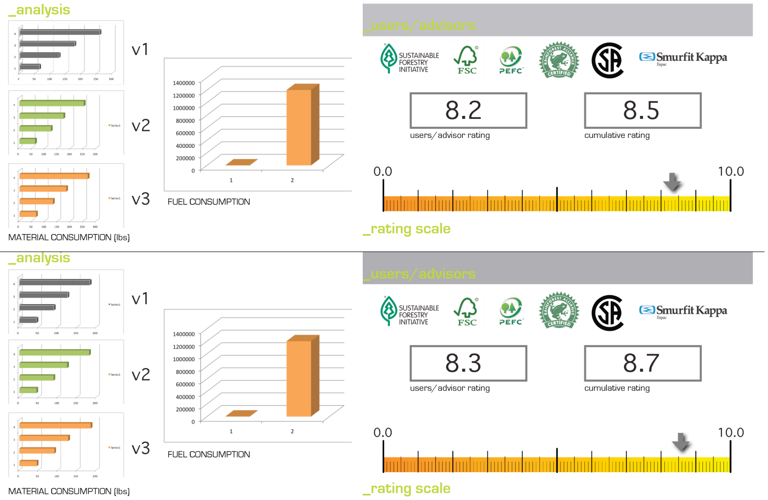

Figure 4- Proposed Analysis Sheet

This peer-to-peer networking process creates nodal connections that allow distributed thinking to permeate the BIM system. By describing a points system with responsible use, allows a user to become an advisor. If you do it well and prove your worthy, then you can earn more responsibility and therefore more influence.

4 Verification and Monitoring

One of the major questions for a system of this nature is how the ethics of the system is monitored or policed. First, we must question how we define *authority*. Many of these rating systems may have the *power* to categorize materials or products according to their environmental quality, but *authority* questions how or why a particular rating system has that power. In a parametric environment, authority is messy. A BIM system with multiple authors operating simultaneously goes against traditional hierarchy. Multiple authors (as eco-rating systems) may be able to operate in the BIM software, however, if there is a dispute amongst the parties, who would resolve these issues? Is there an intermediary, or does the creator of the system have the authority to say who has final approval? Impartiality becomes an issue of contention. Impartiality in a system such as this would require the creation of a comprehensive panel made up of various third parties to ensure fairness and equality are preserving the integrity of the system.

Another question involves how an advisor earns credibility or responsibility? Credibility must be something that is earned. If an advisor wants to participate in the BIM system as an 'eco-rater', they must first determine what level of responsibility within the overall life cycle. 'Meta'-certification systems such as LEED or MBDC could operate within the framework of the life-cycle, however, other more specialized rating or certification systems would operate provisionally until the main user of BIM (architect or designer) could verify how complete and consistent their rating or certification system is.

Existing eco-rating systems use seals, ratings, or scores for a product or material. However, how do we seal, rate, or score…the seal, rate, and score that is acquired once the users' come to some reasonable consensus on the environmental quality of a product? Are there 'allowances' that would create flexibility within the rating system? These allowances would come in the form of alternatives or tradeoff's allowing an architect or designer to see how various criteria could offset one another.

For example, if a product or material were transported trans-pacific from China to the United States aboard a cargo ship, someone would assume that a locally sourced product or material would be far superior. This local material would be shipped via truck. However, a cargo ship's emissions are nearly 1/5th the emissions of a truck.

These types of tradeoffs typify how difficult it is to determine the environmental validity of a product. A 'one-size-fits-all' approach is not appropriate. Determining the 'fitness' of a product using an LCA approach is difficult, but necessary in order to look beyond the patterns that most humans recognize with their built-in perceptual senses. We do not have sensors to interpret global warming, material depletion, or toxic chemicals that would otherwise go unnoticed. The LCA approach, linked to 'collective intelligence' could unlock an information infrastructure to counter current green washing techniques.

5 BIM Linkages

Parametric design environments use *relationships* to establish new connections between parts. The parts are defined as parameters to be pre-defined within software tools. These software tools use a *propagation*-based system that arranges objects in a directed graph such that known information is upstream of unknown information; Essentially, by propagating information through the parametric system, you can theoretically compute anything. This ability to 'compute anything' yields a larger and more complete range of models (Woodbury 2010). The emerging challenge for architects is combining dissimilar data sets and information collection techniques about material, form, and ecology into these virtual environments.

Challenges associated with this process concern the 'interoperability' of data streams. Interoperability is defined as the ability to share data between different computer systems. However, the notion of interoperability also allows parallel data sets (derived from varying sources of qualitative and quantitative data) to be combined and then used to generate emergent relationships. The challenges of 'interoperability' include how various software tools are 'glued' together. These data sources could be harnessed from material and energy inputs, thereby reinstituting the process of design as meaningful, ecological practice.

Linked to these very same ideas are concepts of ecological responsibility. Anna Dyson, in her article “Recombinant Assemblies” examines how informatics and mechanical paradigms can revive the architectural design process. Dyson identifies this shift through ‘collective subjectivities’.

> “This shift requires the emergence of a locally catalytic socioeconomic meshwork, one that is galvanized by a tipping point in the perception of valued opportunities from extensive material economies to intensive parametric loops.” (Dyson 2002)

By integrating material and information through parametric design environments, it is possible to reconstitute ecological design based upon a closed loop material cycle. The concept of a closed loop material cycle discussed by Dyson emerged from ‘industrial ecology’ that seeks to integrate issues of physical, chemical, and biological processes with the rigors of industrial and ecological systems (Garner and Keoleian 1995). The overlap of parametric information and material ecologies thus becomes a way to mediate wasteful construction practices, as well as a way to address the idea of ‘collective intelligence’.

For the purposes of testing out these ideas we have two unique processes for linking adaptive data (in this instance insolation measurements from *Autodesk Ecotect*) with specific geometric outputs. *Gehry Technologies, Digital Project* has been identified as the specific tool for creating our first parametric system. *Digital Project* uses *parameters* to create specific, applied information about a particular piece of geometry. We are using the software backwards in this case, inverting the relationships that Gehry or many architects might use, to pre-rationalize a set of relationships that define a piece of geometry.

In this example we created a surface constructed out of plywood sheets; the sheet thickness could be restricted to *parameters.* Therefore, the architect would create a new parameter, specify multiple values (i.e. ¼”, ½”, ¾”, 1”), and then change the values according to the desired function.

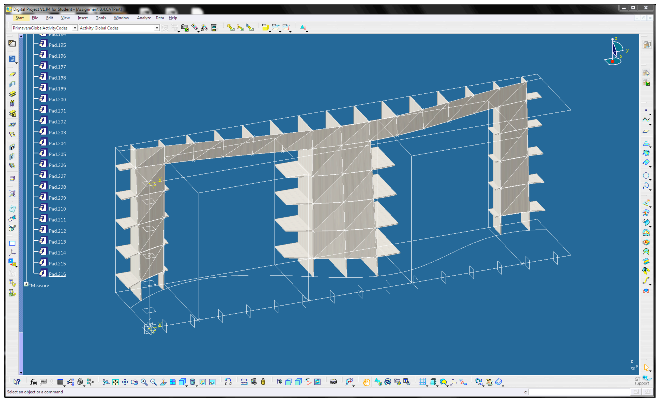

Figure 5- Wall Prototype in Digital Project

Once defined, these parameters can be inserted into a spreadsheet format via Microsoft Excel. Changes made by the architect or designer in the spreadsheet can be exported to the BIM model, and updated accordingly. Finally, the *Knowledge Advisor* tool in Digital Project allows the information to be analyzed via the 'Check' feature. The 'Check' functions as a way to tell the user how to improve or resolve issues with their geometry. The Check editor tells a user what type of check they are applying and the resultant message.

A proposed BIM system such as this that utilizes the idea of 'collective intelligence' would function via constraints organized according to the type of material, the life-cycle phase(s), and the formal/spatial designations of a design. Material constraints would consist of geometric properties (dimensional values such as length, width, or height) and physical properties (intrinsic values such as weight, volume, or density). These constraints could be managed via existing parametric features that can be used to measure an item's geometry and properties.

Life-cycle constraints would be categorized as mentioned earlier: Extraction/Harvest, Processing/Refining, Social/Ethical Labor Issues, Transportation, Environmental Emissions, Human Health Hazards, and Waste/Disposal. These life-cycle issues would have be input as constraints via the users or advisors. This step in the process would be essential in determining how the overall design of an architectural project is shaped. This information would link the *material* and *spatial* qualities of a particular project. Spatial constraints would be categorized through: Site, Surface, and Environmental parameters.

The ramifications of material, life cycle, and spatial decisions would be linked to the *Knowledge Advisor* to determine the validity of a project and 'suggest' alternatives or resolutions to particular problems inherent within the overall system. By leveraging the advanced capabilities of the software, we can allow the environmental users/advisors to input information but at the same time, allow the architect or designer to have the power to make changes according their particular criteria.

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