DATA AND PARAMETRIC DESIGN

HOW PARAMETRIC SIMULATIONS AND DATA VISUALIZATION CAN INFORM DESIGNERS OF THE IMPLICATIONS OF THEIR ITERATIONS
ACKNOWLEDGMENTS

This research examines data and parametric processes through a collaboration with Perkins+Will, and focuses on a single building currently in schematic design. The project’s scope is aimed to investigate ways to integrate environmental simulation, spatial performance, and design intent criteria through the analysis, management, and visualization of data. Parametric design tools, simulation software, and Microsoft Excel are used to facilitate the processes. The goal is to create tools and visualizations to inform designers of the complex impacts seemingly simple decisions have on performance and design intent. For example, glazing ratios on North and South facades have significant impacts on energy performance, daylight, views, and cost. There is rarely an ideal solution to satisfy all criteria, so by mining and representing data, designers can make informed decisions based on their priorities.
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ABSTRACT

Designers are constantly inundated with data, and often times it is lost among waves of iterations and is not considered in making design decisions. Applying data and parametric methods to an architectural design process has the potential to simultaneously integrate multiple performance criteria that would typically be analyzed independent of each other. Currently, there is substantial research involving energy and daylight modeling in architecture, as well as applications of data, typically in the form of evidence-based design. Furthermore, emergent trends in ‘big data’ analytics are beginning to be introduced in architectural processes. However, there is little research regarding the utilization of data analysis to understand the implications of schematic and conceptual design decisions on iterations of multiple criteria, based on both performance and design intent.

This study uses a project currently in schematic design to examine how parametric tools can be used to inform designers of the implications their iterative design decisions have on both performance criteria such as energy and daylight as well as design intent such as views and cost. The specific design featured used in the study is the glazing parameters on the primary facades.
INTRODUCTION

LITERATURE REVIEW

ENERGY AND DAYLIGHT SIMULATIONS

Energy and daylight simulations are currently used in various stages of architectural processes depending on intended outcomes and implementation of results. Most commonly, whole building energy simulations are conducted by engineers in late stages of design to validate accurate energy use assumptions. However, current trends in technology are leaning towards simulation software that can be implemented to determine early design decisions. Energy simulation conducted by designers can be more influential in informing broader aspects design, rather than mechanically related building aspects, such as HVAC systems. “Limiting energy modeling to the domain of experts isolates performative results from influencing building planning and design.”

For the intents of this study and future application of the topics, energy simulation software must be oriented towards designers. Attributes of design oriented software include 3D design model integration, interoperability with BIM programs, and timely simulation results. In summary; it must be intuitively useable and oriented toward design outcomes rather than evaluative by nature. The focus of this study is on early design phase implementation, which assumes a relatively low resolution of detail, and is based on making more general decisions through processes of comparison. Energy simulation output can be managed similarly to evidence-based data —relational data bases and spreadsheets allow for understandable organization, and a simple format that allows for interoperability.

The application of parametric data allows for a streamlined workflow in comparing simulation results. This is the fundamental advantage of implementing simulation workflows in early design stages. Parametric software allows for a high volume of comparisons to be simulated, and if results are managed in a database, the parameters that result in design aspects can be interoperable and applicable to BIM models.
DATA AND EVIDENCE BASED DESIGN

Healthcare architecture has relied on data to inform design decisions for several years. The concept of applying measurable data to the design of healthcare environments to achieve measurable outcomes is nothing new. However, as big data becomes increasingly accessible and prevalent in healthcare and design, new tools and processes will be required to use it effectively. However, the relationship between data and healthcare architecture begins with evidence-based design.

In 2004 the AIA published an article from the Center for Health Systems and Design at the College of Architecture at Texas A&M. It describes evidence-based design as “design work that is informed by data from a variety of sources. It is a natural analog to the evidence-based decision making of our clients.” The article continues to define the four levels of evidence-based practice. Level 1 consists of architects relying on available research previously conducted and applying it as necessary to a specific circumstance. Level 2 architects collect data in the same manner as Level 1, but continue to measure the outcomes of their designs for further research. Level 3 consists of the processes of Level 2, but consists of publishing the findings. And finally Level 4 takes the processes of Level 3 one step further by publishing findings in peer reviewed journals. The proposed research in this study is intended to fall only under Level 1, but would be organized and accessible to continue to take the findings to further levels.

There are currently organizations such as the Pebble Project that facilitate evidence-based design and research. The Pebble Project is a collaborative from the Center of Health Design that has documented case studies of design work on healthcare projects. In the article, “The Pebble Projects: coordinated evidence-based case studies,” the authors present a matrix of projects and outcomes, as well as define many of the concepts, frameworks, and backgrounds of Pebble Project studies. It explains that when applying data to design it is “made more valuable by exploring links and patterns.” Similar to evidence-based design as defined in the AIA article, “The Pebble Project research studies focus on the relationship between the physical environment and outcomes.” Unlike the “The Four Levels of Evidence-Based Design” where each level assumes the data had existed or was collected from previous projects, the Pebble Project research frequently involves before and after studies, where a hypothesis is made based on a condition in an existing environment. The data is collected in that existing environment, responded to in a newly built environment, and then data is collected again in the operations of the new environment to compare the outcomes to the original. This hypothesis-driven process is
made possible because of the resources provided by the Pebble Project to facilitate the studies. When considering big data in an evidence-based and hypothesis driven process, the Pebble Project becomes a valuable resource in understanding how to process and make data from existing environments useful knowledge. “Rather than simply following prescriptive advice, [evidence-based design] requires design practitioners to analyze the evidence critically, [and] interpret and innovate based on the unique context. ” The scope of my research would aim to experiment and test methods and workflows for architects to analyze, interpret, and implement larger amounts of data than typically found in evidence-based design examples.

Currently, big data is being considered a revolution in healthcare as medical records, and years of hospital and pharmaceutical research have become digitized. From 2005 to 2011 the percentage of hospitals using electronic medical records rose from 30% to 75% and 45% of US hospitals are participating in health-information exchanges. In addition, real-time data is being collected at an unprecedented rate, which is only recently becoming a valuable resource of information. However, the methods of big data collection and implementation in healthcare have not become commonplace practices in architectural design. Evidence-based practices have set the stage for architects to effectively use data to inform design decisions, but the complexity and diversity of big data requires new processes of management organization, and implementation to make them useful for architects. A major difference between evidence-based research and big data is the relationship of data sets to environmental factors. Evidence-based design is largely based on data affecting environments, where big data primarily focused on activity claims and costs, EMRs, pharmaceutical R&D, and patient behavior and sentiment data. In an article released by the Center for US Health System Reformed titled, “The big data revolution in healthcare,” the authors explain that the future of big data opportunities rely on integrating these data pools and finding patterns and relationships. This concept of correlative patterns can also serve as the opportunity for architects to utilize big data as well.

The nature of the information characterized as big data can be applied to more levels of the design than typical evidence-based design data. Rather than ‘features’ of hospital rooms and environments, big data can help inform the programming, layout, and circulation of healthcare facilities. If the concepts and practices of evidence-based design are applied to big data, there is an opportunity to not only improve the environments hospitals, but also to further integrate the architectural design of hospitals with service design.
EMERGING PRACTICES IN DATA APPLICATIONS TO DESIGN

Recent studies indicate promising research potential in the convergence of the two previously discussed topics. In a 2010 study conducted by Texas A&M University, ‘Eco-Effective design’ and evidence-based design are simultaneous applied to analyze an envelope system for a healthcare facility and its effects on indoor environment and ventilation. The study describes the use of BIM being critical in managing the inputs of the two data sources. BIM facilitated what was labeled the Healthcare and Sustainable Parametric Method: an iterative process of evaluating changing design parameters and their simultaneous effects on indoor environment from both energy use standpoint and evidence-based standpoints. However, the study is based on envelope parameters at a very high resolution of detail involving operating schedules and material choices. Nonetheless, the process of integrating the data to evaluate parameters is certainly applicable to earlier stages of design.

In 2011 a study from Aalborg University in Denmark experimented in using grasshopper to manage evidence-based design data in hospitals. The study also involved high-resolution design factors such as bed location in relation to light sources. However, this study is also a useful precedent in that it points out critical limitations in making evidence-based design parametric. For instance, it assumes the design parameters are measurable, such as window size and location, and is not as applicable to immeasurable features such as quality of views to nature.

In conclusion, there is substantial literature on both evidence-based design and environmental simulation in architecture, and there are emergent studies linking the two through parametric data management processes. However, there is currently little research that questions when the integration of these practices is most effectively applied to a project. This study would involve simulation and experimentation to determine when certain workflows are most effectively implemented into design.
CONTEXTUALIZING RESEARCH:
COLUMBIA BUILDING INTELLIGENCE PROJECT REVIEW

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METHODOLOGY

SCHEMATIC PROJECT AS A CASE STUDY

The aspirations for this research are intended to reach beyond the investigations of a single process, yet in order to exemplify the processes of data and parametric design applied to architecture, a Perkins Will project currently in schematic design will be used for the study. This project serves as a vehicle to explore the applications of parametric design and evaluation through energy and daylight simulation as well as qualitative criteria and cost. Being a schematic phase project, the case study serves to demonstrate the level of resolution intended in the process. Results from simulations are not intended to be understood as accurate estimations of the building’s actual energy use or lighting levels, but are instead intended to provide metrics for comparative analysis.

The collaborative nature of this study aids the ability of the research to be applied to a multitude of professional settings within Perkins+Will. The processes is intended to be cyclical in nature, and is comprised of three primary components for feedback and application: Meta Research (initiating broad questions of applying and understanding feedback); Project Analysis (determining and prioritizing criteria and design intent to simulate and test through simulation and parametric evaluation); and Outcomes (processes of visualizing and interpreting comparisons of feedback from the limitless iterations).

These components of the process continuously flow into each other as various design intentions and criteria are introduced and tested through simulation and feedback.

Figure 1
The diagram describes the research process as cyclical and the roles of the project team.
TOOLKIT

Although this research and its findings are not intended to be depended on a single suite of software and tools, it is worth noting the toolkit used in this study in order to understand nuances in variables and metrics. The digital tools in this study include Rhinoceros 3D for modeling; Grasshopper Generative Modeling for parametric workflows, DIVA for daylight and energy analysis, and Excel for data management. The future of this research is not dependent on this specific toolkit, but instead capable of using geometry, data, and feedback from any software with similar capabilities.

Figure 2
A simplified representation of the cyclical process describing how data analysis fits into design

Figure 3
The toolkit comprised of Rhino, Grasshopper, Diva for Rhino and Grasshopper and Microsoft Excel
GLOSSARY

Criteria: design qualities important to the goals and concepts of the design (i.e. daylight, energy, material cost, etc).

Data: Output from building information indicative of material use, assemblies, energy and daylight performance, among several other components

Multi-Variable Analysis: Integrating iterative data output for two or more variables simultaneously

Optimization: Applying variations to iterative simulations to maximize or minimize an output variable (i.e. changing window sizes to minimize energy use).

Parametric: a framework of controlling and organizing variables through computational tools

Priorities: The weight as a percentage of 100 of how important a given criteria is to a design in comparison to the rest of the criteria

Useful Daylight Illuminance (UDI): The measure of daylight performance used for study. The value is the result of assessing the illuminance of a given point in an analyzed space for every operational hour of the year (8am-6pm typ.) and assessing the percentage of time the point received a range of natural daylight within the considered useful amount (10-200 footcandles).
PERFORMANCE AND DESIGN INTENT

The process investigated in this study begins with understanding primary design intentions for the case study project. These criteria were determined through collaboration with the design architect. The project is an eight story mixed use development containing retail, restaurants, unimproved tenant spaces, and large public atriums. The site is located in the Uptown neighborhood in Minneapolis, MN in a fairly dense urban context with surrounding buildings of around two to five stories. While only four criteria were chosen for investigation in this study, the future of research on this topic would allow for numerous different or additional criteria to be integrated into the process. The four criteria chosen are energy use, daylight levels, views to the downtown skyline, and material cost. These criteria are explored through the primary (north and south) facades.

Energy: Energy use is measured on a monthly basis incorporating general heating, cooling, lighting, and plug loads. The software uses a generic building type baseline to determine how the loads are initially applied. The building is characterized as mix-use commercial with general operating house 8am-6pm seven days a week. The output is evaluated based on the annual average for kBTUs/square foot.

Daylight: Daylight evaluation is primarily focused on the climate based metric of UDI. UDI is used because it evaluates daylighting performance annually so it aligns parallel to the energy evaluation. UDI also provides a threshold that determines if spaces are over-lit and are susceptible to glare.

Views: The building is oriented so the North facing façade is toward the downtown skyline. However, the surrounding context impedes the view to downtown. This criteria aims to understand specifically where in the building a clear view is provided.

Material Cost: The primary material elements of the facades are curtain wall glazing and metal paneling. The metal panel is half as expensive per square foot, but the curtain wall units are modular, and cost is optimized at increments of the module.
CRITERIA INTEGRATION STEPS

The execution of the process begins with parametrically simulating quantitative criteria, and evaluating qualitative criteria on an individual basis. Each criteria undergoes a parametric evaluation to optimize the glazing treatment so it best satisfies the single criteria. This information is initially used to understand the design implications giving certain criteria priority. For example, it can be intuitively understood that in order to optimize energy use through glazing treatments on the North façade, the smallest windows possible will provide the lowest energy use. Meaning if energy use is the sole primary criteria given the highest priority, the designer should plan based on small windows on the north. Conversely, it is also intuitively understood that in order to get the best views to downtown, large north windows should be applied. In order to balance these criteria, they cannot solely be evaluated independent of each other. Therefore the next steps in the process involve integrating each criteria one at a time as depicted in the diagram below. The culmination results in a process of integrating and extracting feedback from all criteria simultaneously. The step by step nature of this process ensures that the implications of each criteria are fully understood before integrating multiple criteria as to not inundate the designer with convoluted data.

Figure 5
A diagram describing the process map and steps of integration. It is intended to be a base case to allow for different and expanded criterion.
# PROCESS WORKFLOW TABLE OF CONTENTS

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INDIVIDUAL CRITERIA ANALYSIS

CRITERIA I: ENERGY

For energy and daylight, consistent parameters are set to study the effects of glazing treatments. In this case the width, and height of windows is varied to understand how optimal energy use can be reached. The model studies open floor plate spaces that are most effected by north and south glazing. Each floor plate is modelled as a single volume, and the windows per floor are adjusted in 200 variations ranging from 10% glazed to 100% glazed. Parametric workflows aid this process by recording the results of each variation and writing it to an excel file, and do so for all 200 iterations in a single simulation. Figure 6 describes the aspects of the model used for the optimization and the output being considered. Figures 7 and 8 below are the resulting culmination of all iterations generated through excel to indicate optimal glazing ratios for the North and South facades.

From the recorded iterations it is determined that on the South façade, the relationship between energy use and glazing generates a non-linear curve (Figure 7). The optimal range is found at the low point on the graph, between 45% and 55% glazing as indicated by the highlighted portion. For the North façade, the relationship is more linear, and as one may intuitively anticipate, the optimal energy use is found with the most minimal glazing ratio.

Again, the energy use figures resulted from the simulation are not intended to be thought of as accurate estimations of actual energy performance, but the process of parametrically recording and visualizing the data allows designers to easily comprehend through comparative analysis the implications of glazing treatments on the primary facades.
Figure 6
Typical energy output graph showing the load factors plug, lighting, cooling, and heating being considered per month and the culminating Energy Use Index (EUI)

Figure 7
EUI Mapped against glazing ratios for the South facade with highlighted optimal range.

Figure 8
EUI mapped against glazing ratios for the North facade with highlighted optimal range.
INDIVIDUAL CRITERIA ANALYSIS

CRITERIA II: DAYLIGHT

Simulations to measure daylight utilize the same variable iterations as the energy portion: 200 variations of glazing ranging from 10% to 100%. Also similar to the energy model, the daylight model uses an open floor plate exposed to both north and south glazing and measure light at a single point in the center of the space. The point sample size for daylight is not critical to this step, however a single point makes for efficient simulation time in DIVA. From this point UDI measured. Meaning the output is a percentage indicating the proportion of operational hours the center of the space receives a functional amount of daylight (between 10 and 200 footcandles). The parametric workflow is applied again here and all 200 iterations are recorded from a single simulation and written to an excel file. Once again this step indicates the different patterns of optimization between the north and south facades and seen in the graphs (Figures 10-11). The south façade is optimized between 60% and 70%, and any additional glazing can be assumed to create over-lit spaces. The north however is optimized at its maximum glazing ratio.
Figure 10
UDI mapped against glazing ratios for the North facade with highlighted optimal range.

Figure 11
UDI mapped against glazing ratios for the South facade with highlighted optimal range.
INDIVIDUAL CRITERIA ANALYSIS

CRITERA III: VIEWS TO DOWNTOWN

Figure 12 indicates the location of the site in relation to the downtown skyline. The 3D model is then used to understand how surrounding context buildings effect or impede the view toward downtown. This step takes on a more accurate and parametrically driven process in the integration steps, but initially, manual intuitive understanding of view opportunities gives the designer a basic understanding of how views can be affected by glazing in a sufficient manner for this step. Based on the model shown in Figure 13, the primary building affecting views is a seven story multi-family complex across the street. Simple views captures from the model show roughly where in the building the best views to downtown can be achieved. As a baseline, the design intent was to glaze all of the north façade ensuring the best views to downtown, but this simple step can begin to imply how that can be more locally tuned.
Figure 13
A model used to intuitively understand where the best views to downtown exist
INDIVIDUAL CRITERIA ANALYSIS

CRITERIA IV: MATERIAL COST

Material cost in this study is considered as a basic, low resolution balance between the cost per square foot of curtain wall (roughly $80/sf) and metal paneling (roughly $45/sf). The evaluation in this step is based on an assumed unitized module of three feet. This too is an estimate and is flexible to be changed and applied accordingly based on curtain wall manufacturer specifications. As seen in the graph in Figure 14, the result of this assumption creates a linear relationship based on the cost per square foot and the glazing ration, but the line has optimal low points indicating where the curtain wall module fits within, allowing for reduced cost. However, it is clearly indicated that due to the lower cost of metal panel to curtain wall, the optimal cost reduction is achieved with the most minimal glazing on either façade.

Figure 14
Graphing the optimal cost ranges based on an assumed module of the curtainwall

Figure 15
Cost comparison between curtainwall and metal panel

~$45/sf
~$80/sf
INDIVIDUAL CRITERIA CONCLUSIONS

The graphic in Figure 16 shows how each criteria result in a multitude of glazing treatments for both the north and south facades. Each criteria has a different optimized range. The intention of this study however is not to provide convergent parameters for optimization, thus rendering the influence of the designer quite insignificant. Instead, the flowing steps provide the framework for a process that implies divergent results. Based on the understood ranges for optimal glazing, the designer can be liberated to test how these criteria can be prioritized and simultaneously tested. This implies a cyclical process of integrating design intentions and testing and evaluating them best on the goals and priorities of the criteria. The intent of the process is not to come to specific optimized values, but instead frames how data output can be used to guide and inform designers without disrupting common design processes. The following steps of criteria integration further explain how data, computation, and parametric workflows can aid a design process, and not necessarily change it entirely.

Figure 16
A diagram describing the contradictory glazing levels needed to optimize each criteria based on each facade.
INTEGRATING CRITERIA

INTRODUCTION TO INTEGRATION

Referring back to the process map in Figure 5 on page 14, the sequence of steps following individual optimizations involves integrating criteria by combining them one at a time. This allows the process to systemically build complexity so that is can be further and more deeply understood in a progressive manner rather than inundating the designer all at once with the implications each criteria may have when combined. Furthermore, it can also be understood at this point that the process described in this study is not specific to the chosen criteria, nor to the quantity of criteria.

INTRODUCTION TO PRIORITIZING CRITERIA

The following segments outline the process for integrating each criteria. However, in order to meaningfully apply influences of multiple criteria on the design, a process of prioritizing the criteria is required. Given the divergent nature of the optimal ranges of glazing per criteria, satisfying multiple criteria means that certain sacrifices must be made. This process allows these to be managed and controlled through parametric simulation, data management, and visualization.

Within the scrip that controls the glazing variables and runs the simulations, a component is used to measure the weight of prioritizing the various criteria. The results of which will be demonstrated following the processes of integrating criteria. The graphic in Figure 18 shows how prioritizing criteria can be visual and interactive.
MULTI-CRITERIA OPTIMIZATIONS REQUIRES PRIORITIZATION

Figure 17
Highlighting the following portion of the process

Figure 18
A component generated in Grasshopper to assess criteria priority

I: ENERGY  II: DAYLIGHT  III: VIEWS  IV: COST
INTEGRATING CRITERIA

CRITERIA I+II: ENERGY AND DAYLIGHT

The initial criteria integration begins with energy and daylight. As explained in the sections on individual optimizations, the simulation process for both energy and daylight utilized the same set of iterative parameters. Therefore, the first step in this integration is to overlay the output of daylight and energy to understand their relationship, as well as to distinguish glazing orientations and the effects on energy and daylight. Figure 19 shows the graphs of orientation based analysis, while Figures 20-21 show the visualizations overlaid, and indicates an overlapping range of south glazing that suites optimal energy and daylighting results, whereas the north overlay shows the contradicting impacts on daylight and energy glazing ratios have.
Figure 20
Overlaying EUI and UDI for the South facade with highlighted optimal ranges for each

Figure 21
Overlaying EUI and UDI for the North facade with highlighted optimal ranges for each
INTEGRATING CRITERIA

CRITERIA I+II+III: EVOLUTIONARY SOLVERS

Furthermore, as indicated in the individual optimizations each façade was studied independent of the other. The surface charts in Figure 19 show how the simultaneous simulation results of north and south glazing variations affect one another. It can be seen how energy results in a fairly linear relationship, meaning that optimal energy use will be found at fairly similar glazing parameters as found in the independent optimizations. However, in the daylight surface chart indicates that the rate of return for optimal UDI is achieved much quicker with increasing north glazing than south glazing. In this case, if daylight became a higher priority than energy use, the design could use this information to determine that more glazing on the north than the south will satisfy their design intent.

Figure 22
The criteria priority component for only energy and daylight
Figure 23
The evolutionary solver (Galapagos) for energy and daylight for the North facade

Figure 24
The evolutionary solver (Galapagos) for energy and daylight for the South facade
INTEGRATING CRITERIA

CRITERIA I+II+III: ENERGY, DAYLIGHT, AND VIEWS

Building off of the previous integration study, view analysis is woven into the criteria and comparison, and introduces variation into the glazing treatment of the North façade. Stemming from the view study, the diagram in Figure 26 represents the areas of the façade that contain opportunistic views to the downtown skyline. This equates to larger glazing components. Figure 25 represents how this affects the glazing treatments when weighted against energy and daylight. When views take a higher priority, opportunistic glazed areas have much larger windows than those without a view to preserve energy performance, primarily.

Figure 26
Using projection lines to generate areas that are deemed opportunistic for downtown views
Figure 25
The results of various prioritization differences for the three criteria

DAYLIGHT: 2
ENERGY: 2
VIEWS: 3

DAYLIGHT: 3
ENERGY: 1
VIEWS: 4

LOCALIZE OPPORTUNISTIC AREAS FOR SPECIFIC AND VARIABLE GLAZING
INTEGRATING CRITERIA

CRITERIA I+II+III+IV: ENERGY, DAYLIGHT, VIEWS, COSTS

Once again, as another criterion is introduced into the integration studies, the outcomes and findings of the prior simulations and comparisons are retained and built upon. Once cost is introduced, two primary factors influence the outcomes to the facades. First, the ratio between metal panel and curtain wall is best optimized for cost when the square footage of the curtain wall is decreased. Second, the amount of variation directly increases costs. Therefore, as the final parametric weighting diagram shows, cost is optimized with limited to no variation in window size, and when window sized are the smallest. The influence among the four criteria is seen as weighting values are shifted between them.

Figure 27
Graphing the optimal cost ranges based on an assumed module of the curtainwall
Figure 28
Results of medium cost priority with larger windows and some variation

WINDOW VARIATIONS: 2
OVERALL GLAZING RATIO: 85%

Figure 29
Results of higher cost priority with smaller windows and minimal variation

WINDOW VARIATIONS: 2
OVERALL GLAZING RATIO: 35%

Figure 30
Maximum cost priority with small windows and no variation

WINDOW VARIATIONS: 1
OVERALL GLAZING RATIO: 25%
DIVERGENT SOLUTIONS

The results of the criteria integration provide a landscape of data driven solutions that are dependent on decisions of prioritization. The intent of the process as explained is not to converge on a single design solution that optimizes all criteria simultaneously, but rather present divergent solutions that are validated based on the intent of the project. Based on this direction, the results of each study so not serve to explain exact building performance based on specific parameters, but they instead provide the designer with information regarding the impacts their design decisions have.

Figure 31
Design options presented along the landscape of criteria based on which criteria was prioritized - creating divergent solutions.
Implementation of data driven design practices does not need to entirely replace traditional processes of design that define the artistic side of the profession of architecture. However, the implementation of the process explained can allow traditional processes to be rooted in more intelligent data driven solutions. With this ability provided by the process the diagrams below describe a generalized approach to two ways it can fit into a design process. ‘Data feedback responding to design intent’ and ‘design intent responding to data feedback’ describe how data driven processes can initiate design ideas or respond to them.

Figure 32
The diagram describes the research process as cyclical and the roles of the project team

Figure 33
A simplified representation of the cyclical process describing how data analysis fits into design
DESIGN INTENT RESPONDING TO DATA FEEDBACK

In this example the previously executed process with the given criteria is taken as an initiation of design iteration. Because the data driven process of integrated views with energy and daylight performance, the opportunity for variation in glazing treatment arose—creating specifically located larger opening to respond to view. With this information, the designer could then take on an iterative process of façade designs that stem from the results of the data.

Figure 36
Highlighting design intent responding to data feedback and examples of design iteration sketches based on data output
Figure 35
Examples of potential analysis of the design iterations
DATA FEEDBACK RESPONDING TO DESIGN INTENT

For this example, the process takes on new criteria and application. Intuitively it could be understood that the east and west facades of the building are susceptible to glare. Therefore, one could assume an opportunity for unique shading devices to alleviate glare. The following figures show how data feedback responds to design intent by taking the sculpted shading device iterations and applying simulations to validate their performance.

Figure 37
Highlighting data feedback responding to design intent

Figure 38
An example of sketching a design intent to analyze -East and West shading in this case
Figure 39
Examples of sculpting shading devices
Figure 40
Experiential analysis of the design iterations
Figure 41
Analytical analysis of glare for the design iterations
CONCLUSION

There is promising potential for integrating data driven processes into design. Analysis and design can be integrated and mutually dependent rather than falling into separate processes as they are commonly found to be in current practice. As parametric design, computation, and energy and daylight modelling become more common place in a designers’ toolbox, there is significant room for the process described in this study to grown and have greater effects on the design of buildings, particularly their generative potential. In addition, current trends in the applications of data and computational tools in architecture provide the process described in this study to find even more robust methods of data mining, sorting and application. Furthermore, the process in this study is centered on creating large amounts of data to be used in design application, and therefore there is potential to apply principles of ‘big data’ by storing and accessing results of analyses to apply to various design options.

As technology takes a stronger hold on defining the processes by which buildings are designed, it is critical to understand how specific tools find their place within a process. The sections ‘Data feedback responding to design intent’ and ‘design intent responding to data feedback’ are examples of how the technology driven process fits into design methods independent of specific tools. This is not a straightforward assumption, and is specific to every project and designer. However, understanding that design tools regardless of their technological advancements are still just tools can deter a project for being controlled by less intuitive processes that can strip architectural design of processes that previously deemed it successful.

As architectural processes take greater influence from technology and computational tools in particular, the analysis of the tools themselves provide a greater understanding of their applications to design. It is unlikely that single processes of design and analysis can be found to be optimized solutions, but by testing processes and applying those to real projects architects can leverage the capabilities of technology to design better buildings.


Fu, Changfeng, et al. Space Centered Information Management Approach to Improve CAD-Based Healthcare Building Design. ITcon Vol. 12, 2007

