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Measurement, Uncertainty, and the Dataspace

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Measurement, Uncertainty, and the Data*space*

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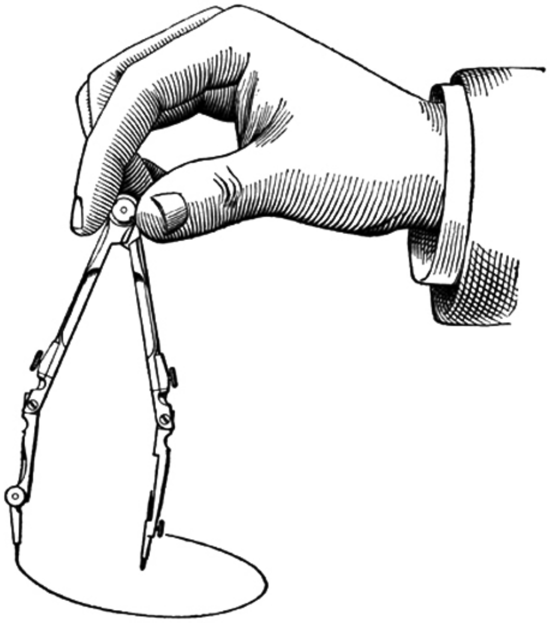


```
Dim myPoint As New On3dPoint()
Dim myCircle As New OnCircle()

myPoint.x = 0
myPoint.y = 0
myPoint.z = 0

myCircle.Create(myPoint, 10)

```

Instruments

"We shape our tools and they shape us."
Marshall McLuhan

New digital technologies are dramatically transforming our environments and behaviors. Today's vast communication networks, comprised of over 140 quadrillion transistors, filter volumes of information at rates unimaginable just two decades ago. Individuals occupy the space of the city armed with smart phones more powerful than the computers that enabled the first moon landing. Virtual and physical lives have collided on social networks.

In this context, Marshall McLuhan's observation about the feedback loop between tools and the people that use them is of special importance when considering the role of the architect and technology.

When we study the history of architectural technology, we can immediately observe significant gains in accuracy, efficiency, and portability. The move from animal skins to industrialized paper revolutionized the duplication of documentation. Equivalently, the adoption of Computer Aided Drafting (CAD) and Building Information Modeling (BIM) technologies greatly improved drawing accuracy and design coordination.

More so, the computerization of tools is of a special significance, extending beyond the purpose of efficiency. The full force of this transition to digital tools has been a slow explosion over the past three decades that ultimately gives architects and designers direct control over a new medium: information.

Information, itself, presupposes no specific type of representation. This is an important consideration. Two-dimensional drawings and three-dimensional models have traditionally represented information in a graphic form. However, other representations such as logic trees, databases, mathematical formulae, and algorithms offer a fundamentally different means of designing and producing architecture.

The digital information landscape requires an updated set of tools for precise control and manipulation of the new medium. Algorithms and computer languages, which have existed on the back end of digital user interfaces, are coming to the front end of the process. This becomes apparent as designers begin to craft their digital processes by creating scripts, applications, and plug-ins to control information directly.

Measurement

"Whenever I draw a circle, I immediately want to step out of it."
R. Buckminster Fuller

Measurement has become more than a means of quantification and documentation. Measurement is also a productive operation enabling control and investigation. With design and analysis tools, the user can computationally measure and quantify just about any aspect of the design. These tools would measure existing geometries, materials, costs and energy consumption in new ways. Over the course of a design process, generation of an unprecedented volume of information occurs.

Parametric tools, scripts, and algorithms enable the designer to generate, navigate, manipulate, and evaluate torrents of information in innovative and unexpected ways. For example, a shortest-path algorithm may enable an architect to design a new kind of building circulation system or understand complex urban networks. Another example would be the direct use of mathematical formulae to generate and rationalize expressive geometry into cost effective shapes and forms. (Figure 1) In other instances, client and user criteria can then be encoded directly into a parametric model to control the creation of spatial volumes. (Figure 2)

With parametric software, it is possible to encode comprehensive systems of information and representations. The Hangzhou Tennis Center is an example of a complete parametric system which defined systems for geometry, structure sizing, cladding, analysis, coordination, and documentation in a single graphic algorithm with custom scripts. All of that, in a file as small as ten megabytes in size. (Figure 3)

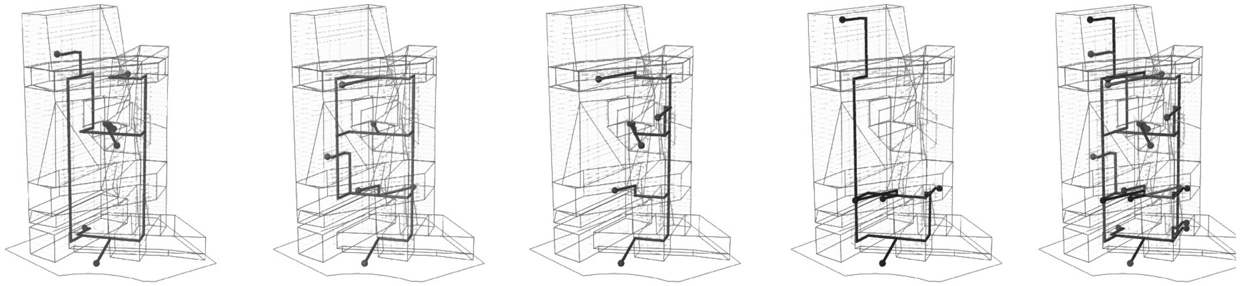
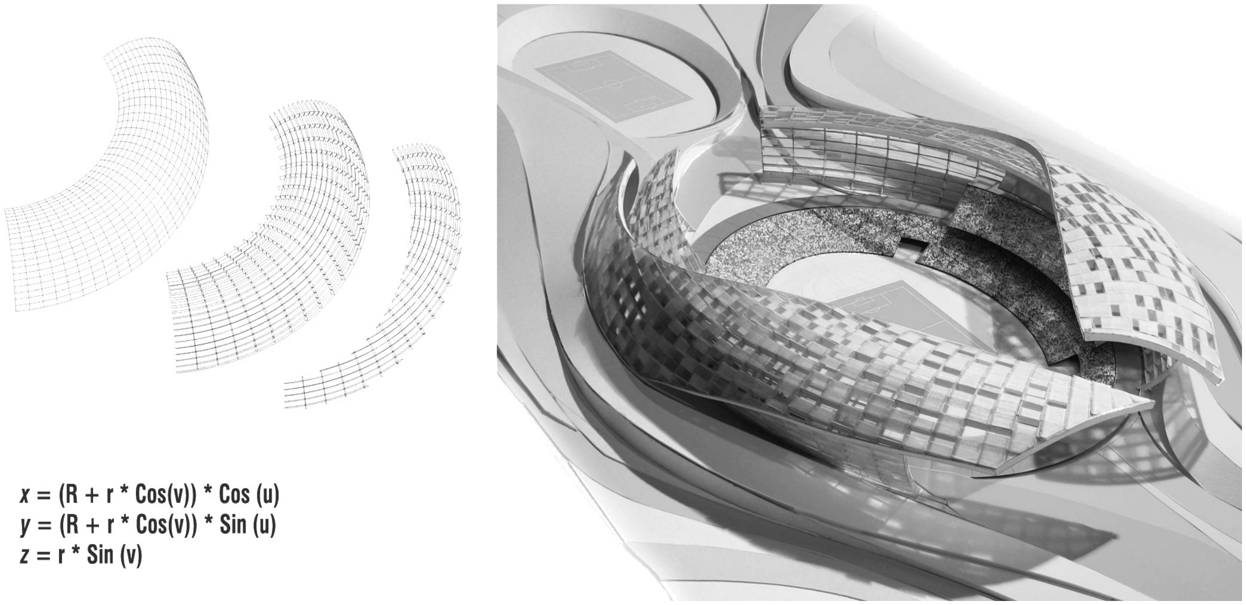


Fig. 1. A shortest path algorithm, similar to those used in map software such as Google maps, was used to describe user scenarios through a complex elevator core system. The study enabled the team to study potential areas for shared programs among different user groups.



$$x = (R + r * \mathrm{Cos}(v)) * \mathrm{Cos}\,(u)$$
$$y = (R + r * \mathrm{Cos}(v)) * \mathrm{Sin}\,(u)$$
$$z = r * \mathrm{Sin}\,(v)$$

Fig. 2. A parametric equation for representing a torus surface. The mathematical formula was used to define the exterior shell and structure of this stadium roof study.

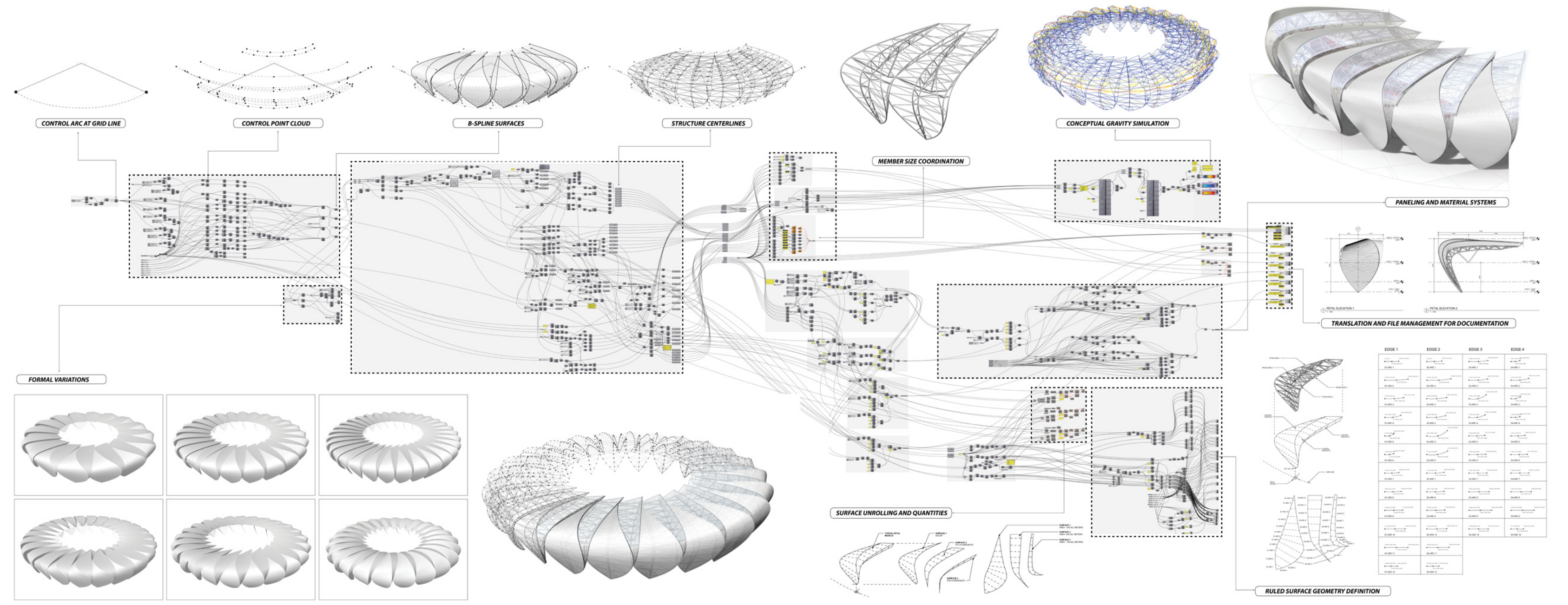


Fig. 3. The Grasshopper parametric algorithm used to generate the Hangzhou Tennis Center. The primary means of designing and documenting the exterior envelope was through the use of custom algorithms and scripts. The facility is a 10,000 seat stadium to be completed in 2013.

The possibilities for innovation are endless if the design of tools for processing information occurs concurrently with the design of architecture.

Uncertainty

Garbage In – Garbage Out
Value In – Garbage Out
Garbage In – Value Out

While we can continuously generate and measure new information, there are still great levels of uncertainty present in the design process. The Garbage in-Garbage out (GIGO) maxim stipulates that the value of design inputs have a direct effect on the value of design outputs. The clarity of this concept is quickly masked by the complexity of design tools. Looking beyond this design tool, two additional design scenarios become evident: Value in – Garbage out and Garbage in – Value out.

The first new scenario is understood as Value in – Garbage out (VIGO). While certain inputs and parameters have inherent value, it is not always fully understood how these inputs are produced. What are the equations being used to generate a non-uniform rational basis spline (NURBS) surface? Or, how are the factors of solar radiation being computed? With this uncertainty, the output may be deemed unreliable and of no use to the designer.

Another scenario of Garbage in – Value out (GIVO) is based on emergent characteristics of information. It may not be completely obvious that certain inputs have inherent value, especially when these inputs may appear as "garbage." Yet, if the inputs are given the opportunity to be processed in a new way, the resulting output may be of extremely high value.

Given these scenarios of uncertainty, tools for evaluation and selection are crucial. One computational tool that can be employed to navigate an uncertain information landscape is the genetic algorithm (GA). A GA enables the designer to implement an automated search and selection process for identifying outputs that are of value given a certain set of inputs. Using a GA, hundreds, if not thousands of design options and alternatives can be explored enabling the architect to discover possibilities in a vast information landscape. (Figure 4)

Dataspaces

"Only wimps use tape backup: upload your important stuff on FTP, and let the rest of the world mirror it."
Linus Torvalds

Collaborative mediums, such as those found in social networking communities, offer a very different model for collaboration based on a kind of simultaneity not found in design tools. For example, Twitter's system of commenting, tweets and sharing other comments, retweets results in a highly complex, relational network of information exchanges and collaborations. With that, the information network takes on a life of its own.

Many things prevent the open and simultaneous sharing of information, including liability concerns, technological preferences, and delivery methods. A fractured information landscape is the natural result of a complex and diverse industry. Under these circumstances, is an open, collaborative system possible?

Freedom to move information across a complex network of users is often hindered by closed software formats and data translation issues. As these issues are overcome (sometimes with jury-rigged or ad hoc solutions) a dataspace emerges which is capable of managing multiple information sources. For example, inter-process communication is a means by which different software technologies can begin to communicate and share information directly. In addition, open relational databases are another possibility for stitching together information from multiple data sources into organized schemata.

The process for designing the Hangzhou Sports Park in China required as much attention to the development of the information network as

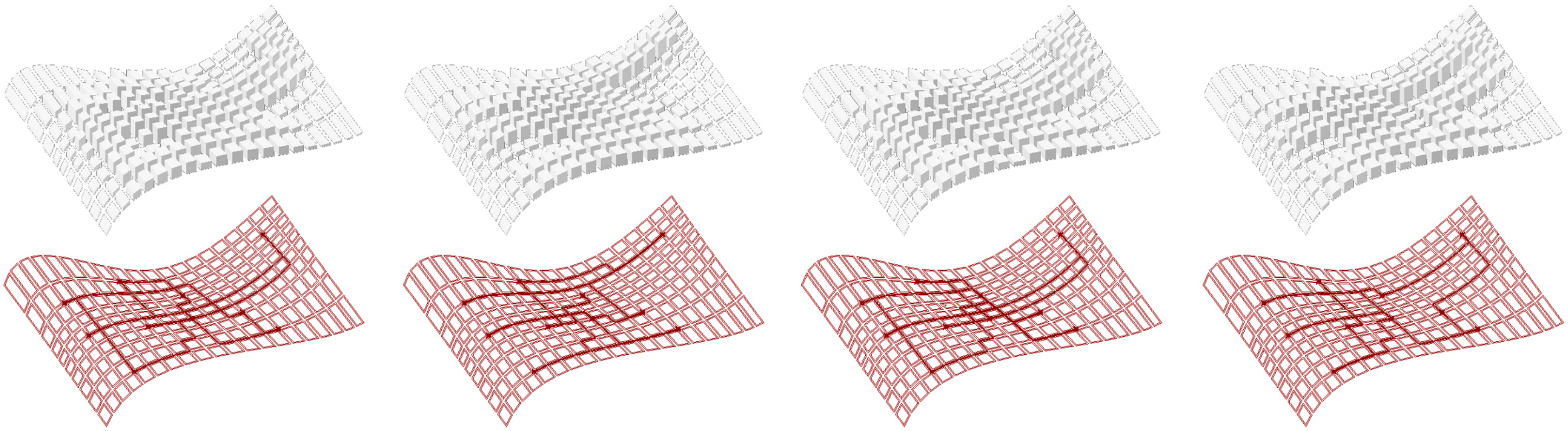


Fig. 4. A genetic algorithm was used to determine shortest travel distances between destinations within a city grid. Optimal paths are used as predictors of urban density.

Fig. 5. The Hangzhou stadium. The stadium will have 80,000 seats and is under construction. The project will be completed in 2013.

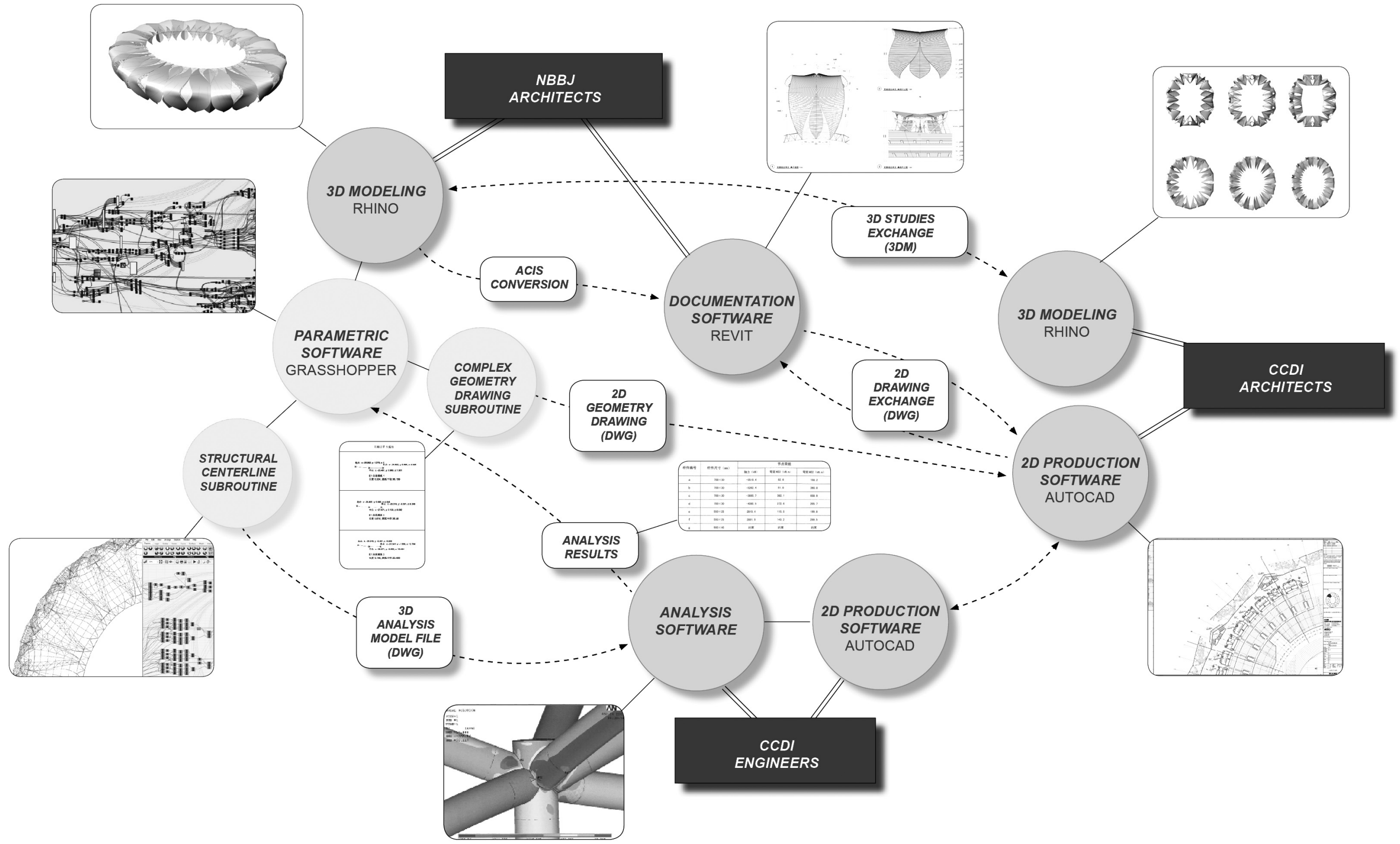
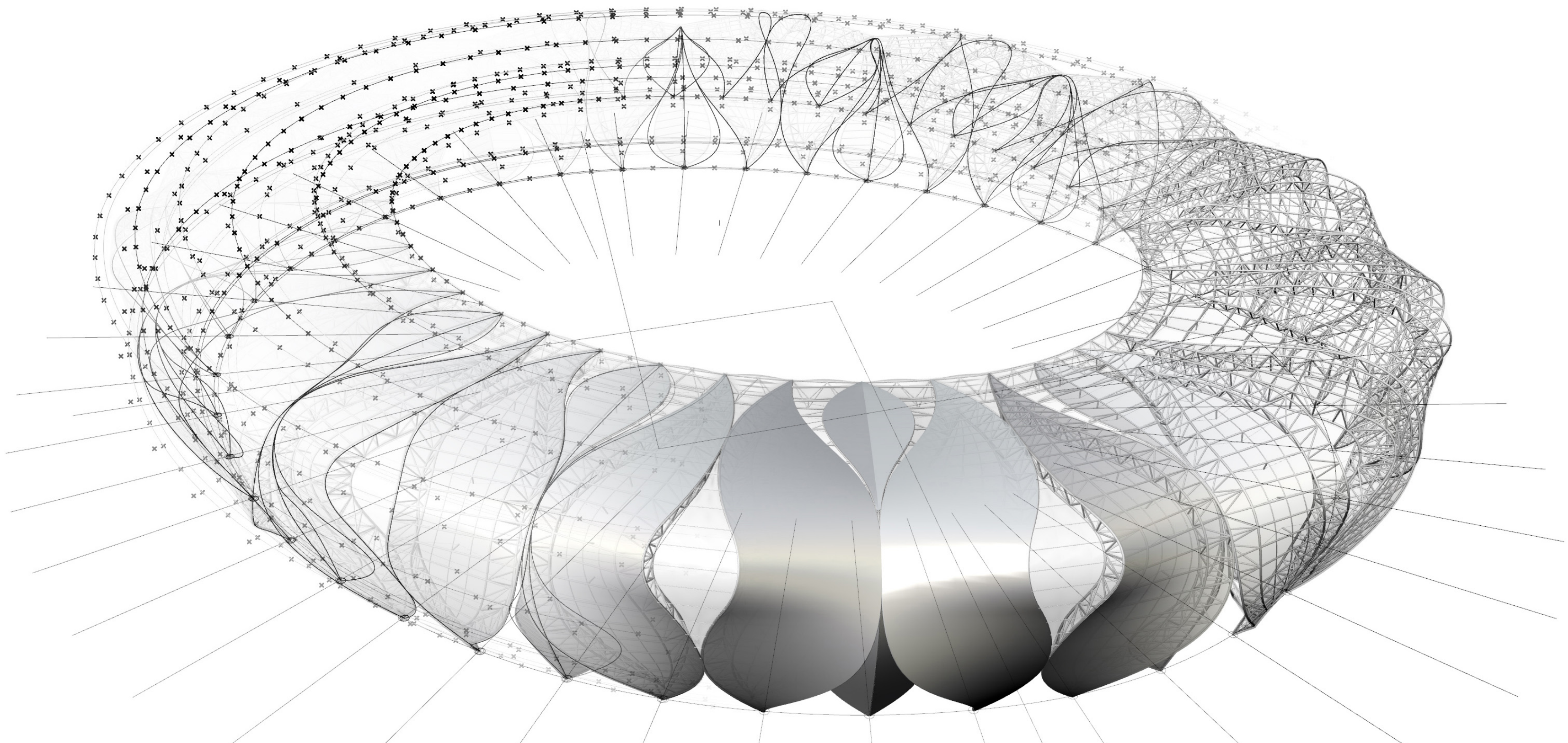


Fig. 6. A data exchange map on the Hangzhou stadium project showing file formats and information transfer protocols between collaborators using different software



A graphic showing the aggregation of information to compose the stadium shell. Low-level information, such as the point cloud, is used to define high-level information for the structure and skin.

it did the development of the complex parametric geometry systems. (Figure 5) The international project necessitated that multiple, specialized software tools be used among the design teams and engineers. (Figure 6)

It became necessary to construct a "road map" of how the different teams could work together with their respective technologies. The communication solutions on Hangzhou ranged from using different file export procedures to designing custom scripts and algorithms for automating information transfer into various design and analysis tools.

When taking a macro-view of the process, design solutions are represented as both the development of architecture as well as the development of the collaborative communication systems that transmit design intent.

Computational Ubiquity

"In the course of evolution every technology is put to the question of what happens when it becomes ubiquitous? What happens when everyone has one?" - Kevin Kelly

While the architecture, engineering and construction industry is no stranger to digital tools in the design and production process, the full effects of accelerated information-based processes are yet to be realized in the form of a comprehensive "paradigm shift."

Architects and designers have become quite enamored with the ability to generate new and exciting forms and processes with scripts and parametric tools. It is possible to design just about any shape or form imaginable. In addition, the line between the software developer and the designer is blurring: the designer codes their tool as they conceptualize and develop their design. (Figure 8)

What is typically ignored, however, are the broader effects on an industry-wide scale. What happens when a script becomes deliverable for use by the construction worker? What happens when a client is given control over the design parameters so they can push and pull the project to their liking? Who is the designer if all information is built on a collaborative intelligence?

The full impact of the computational design "revolution" is yet to be realized...however, the accelerating transformations occurring today are nothing short of revolutionary.

Project Information
Project: Hangzhou Sports Park
Location: Hangzhou, The People's Republic of China
Architects: NBBJ and CCDI

Project: Slingshot!
Author: Nathan Miller
Website: http://slingshot-dev.wikidot.com

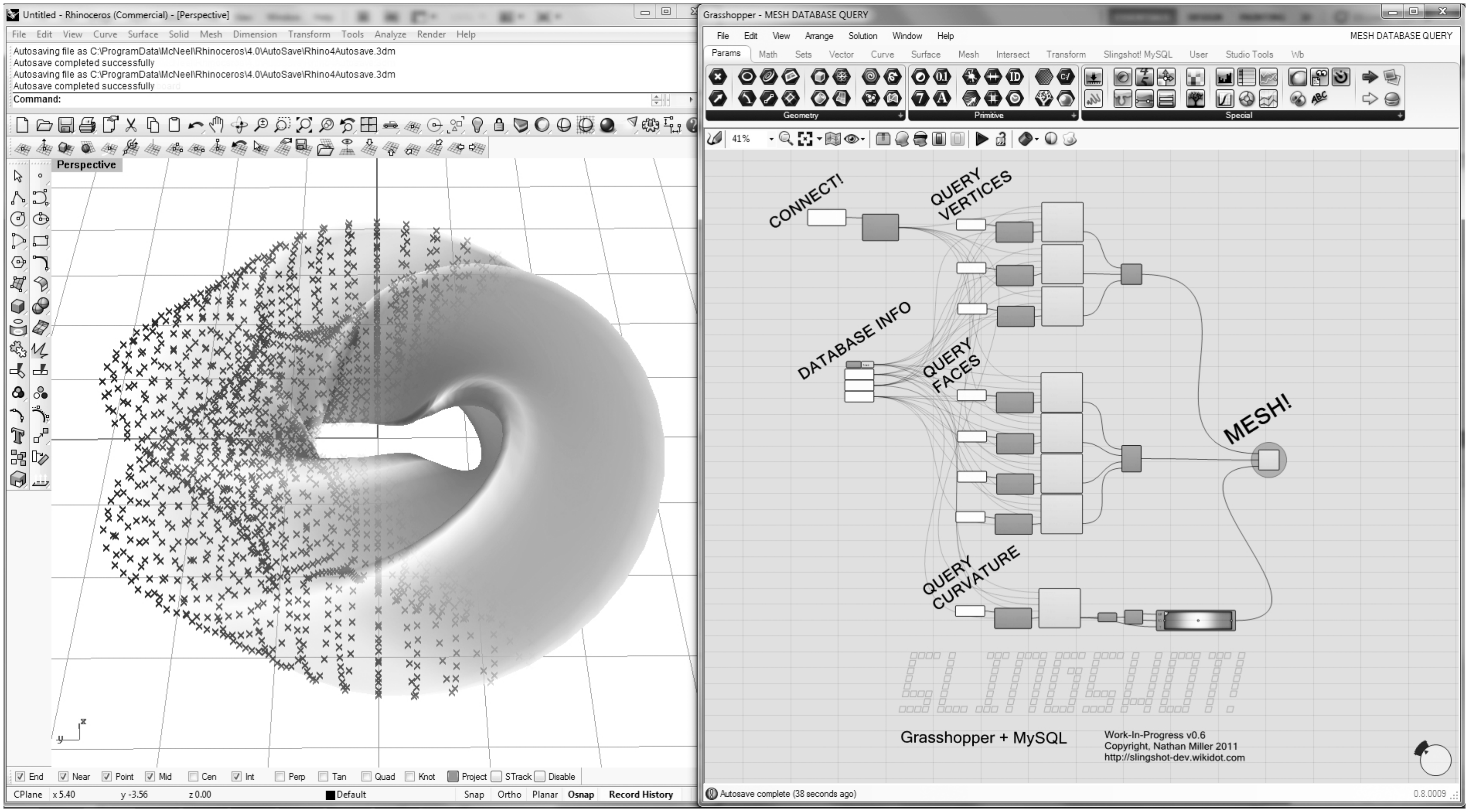


Fig. 8. The author's own recent plug-in, Slingshot!, combines Grasshopper's parametric capabilities with 'the world's most popular open source database:' MySQL. The above image shows a mesh being created using parameters existing on a remote MySQL database. Available at http://slingshot-dev.wikidot.com