CBIP 2: NEW FRONTIERS

ARTIFICIAL INTELLIGENCE, COLLABORATIVE INTELLIGENCE, BUILDING INTELLIGENCE

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INTRODUCTION

In recent years, argues entrepreneur Kevin Slavin, without anyone quite realizing it, **algorithms** have assumed command of most aspects of our lives. Algorithms now control finance, public infrastructure, espionage, and movie scripts. Algorithms have migrated from the domain of data to the domain of culture, and they now offer simulations of human behavior, predictions of taste, and a new "**physics of culture**." Algorithms have even burrowed their way into the age-old categorization of narrative conflicts: man-against-nature has become man-against-nature-against-algorithms.

Our latest generation of architects and engineers is hardly surprised.

Every day these designers spend time harnessing—and combatting—algorithms in the form of scripts for generating geometry, applications for simulating performance, frameworks for building information modeling (BIM), and an unprecedented **deluge of data**. They are already on the front lines of this man-against-nature-against-algorithms conflict. They are already grappling with inefficiencies and adversarial relationships in the construction industry. And they are already warding off the threat that bottom-line performance will come to dictate all design decisions.

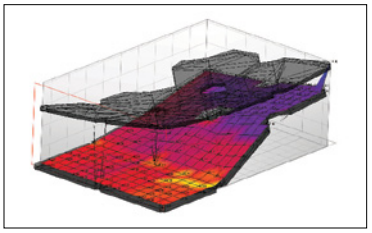
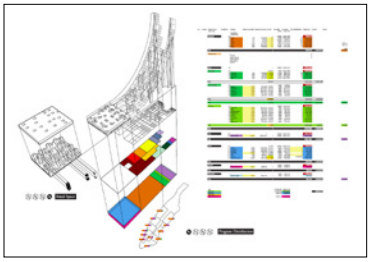
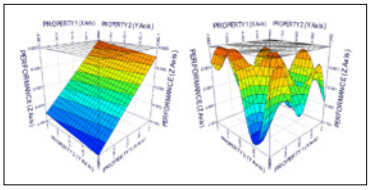
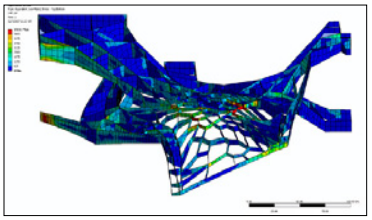
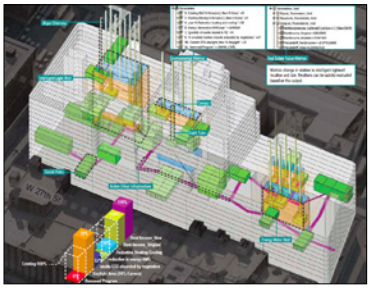
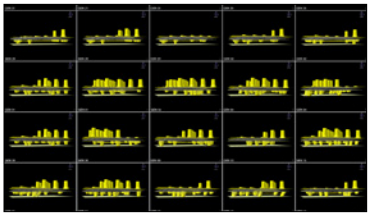
Yet the story is not over, and we still do not know how it ends.

This is the territory of CBIP 2, a new experimental design studio at the **intersection of computation, collaboration, culture, and construction**.

As a new chapter in the Columbia Building Intelligence Project (CBIP), this Third-year/AAD studio will **explore new advanced topics** and **produce new publishable research**. We will build off of modules of building intelligence from previous CBIP studios, and in turn develop new modules of building intelligence for future CBIP studios. We will draw on workflows of **open source** software development, and we will develop our own **new models of collaboration**. We will apply computation to enhance creativity, and not merely to achieve cold-blooded efficiency. We will investigate energy, environmental performance, and ecology in new ways. And over the course of the semester, we will contribute in a novel and important way to an open-ended and critical discussion of artificial intelligence, collaborative intelligence, and building intelligence.

ARTIFICIAL INTELLIGENCE

In this studio, we will consider how architecture might be defined by an **ecology of numbers**—an ebb and flood of **input numbers** and **output numbers**. To start, we will engage input numbers as a technique to grow geometry. We will use **parametric modeling** software and **building information modeling (BIM)** software (**CATIA**) to

Images (top to bottom): Basra waterfront; Metric vision (Adam Brillhart, Proof 3 Studio); Optimization of program arrangement (Troy Therrien, Proof 2 Studio); Multi-modal distribution diagrams representing complexity of design space (Proof Studio); Dragonfly structure finite element analysis (Emergent and Buro Happold); Starrett-Lehigh Building parametric model of adaptation (Alina Gorokhava, Rachel Hillery, Julie Jira, Kooho Jung, Luc Wilson; CBIP Studio); Matrix of design permutations (John Locke, Proof 3 Studio).

create adaptive three-dimensional models that are defined by precise inputs. Then we will write scripts that generate complex forms based on changes in the inputs. This general approach reflects a relatively new paradigm in **artificial intelligence**: rather than program machines to follow fixed and known rules, set up an emergent system to evolve new and unexpected results.

But applying scripting to generate geometry is only the beginning. The heart of our research will involve the study of how specific input numbers correspond to specific output numbers. After a set of inputs generates a precise form, how do we measure its performance?

For performance analysis, we will several **digital simulation** packages. We will use **finite element analysis** software (Robot), **computational fluid dynamics** software (Solid Works Flow Simulator), **environmental analysis** software (EQuest), and **crowd flow** software (OpenCrowd) to test the performance of possible designs under various conditions. We will also consider how to quantify objectives such as program and aesthetics in order to measure each design.

Then, we will pioneer the application of **multi-objective optimization** software (modeFrontier) to architectural design. This software will allow us to automate the process of generating, evaluating, and evolving **thousands of possible designs** through the use of **evolutionary computation** and **genetic algorithms**. For our purposes, optimization will not be about simple and cold-blooded efficiency—but rather it will be about complex trade-offs and the art of negotiation between competing architectural values.

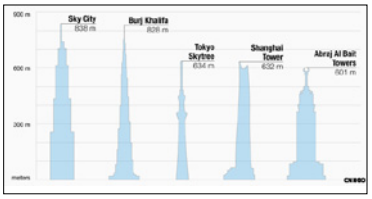
In addition to strategically applying a variety of software applications, we will investigate a series of advanced topics related to contemporary use of algorithms, including **authorship**, **wireframing**, **interoperability**, and **optimization**.

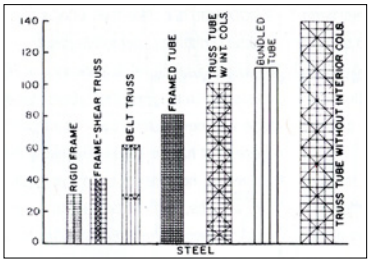
We will use software to investigate data, to explore a very wide potential design space, to minimize our preconceptions, to avoid relying on old rules of thumb, to **derive unexpected high-performing results**, and to enhance our creativity. Most importantly, we will use software to collaborate and to develop designs that are not fixed singular, but instead are **adaptive and re-usable**.

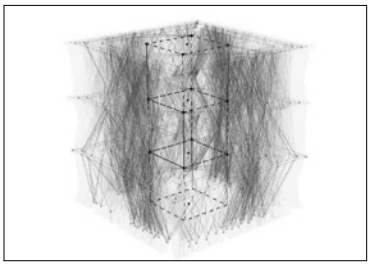
While the studio will be software-intensive, no prior experience with specific software is required. And while the studio will use sophisticated parametric design applications and serious tools of engineering and computer science, it will not limit its studies to technical performance. The studio will also incorporate into the design process more intuitive sketching software such as Rhino, as well as non-software-based design techniques. And it will explore issues of culture, program, history, and aesthetics that are difficult to quantify. Ideas, concepts, and imagination will drive the entire process.

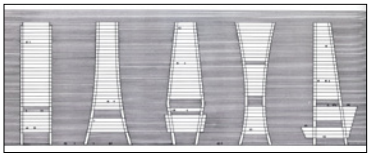
COLLABORATIVE INTELLIGENCE

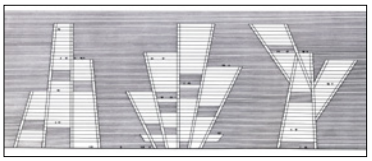
Through the targeted investigation of algorithms, data, complexity, and current practices in the construction industry, CBIP 2 will prepare the **next generation of architects** to take a leading role in developing new modes of design and practice.

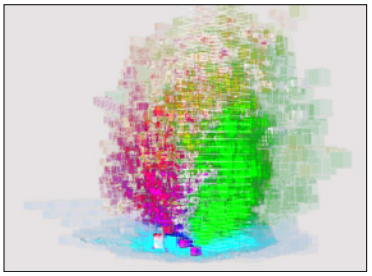


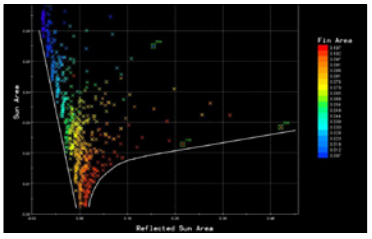


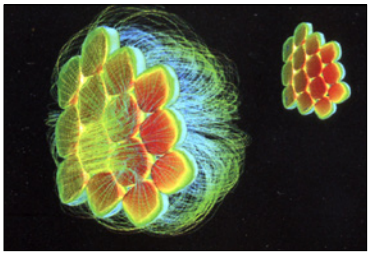












Images (top to bottom): Graph of heights of tallest buildings, including new proposed 220-story prefab skyscraper by Broad Sustainable Building; Structural typology chart and rules of thumb (Fazlur Kahn); Metric vision (Nathan Smith, Proof 6 Studio); Structure diagrams of towers (Henio Engel); Metric vision (Nathan Smith (Proof 6 Studio); Plot of multi-objective optimization (Joe Corsi, Proof 5 Studio); Fluid dynamics analysis of complex brick assembly (Defne Sunguroglu).

The studio will explore **collective intelligence** applied to architecture. As individual projects and large aggregations of projects evolve to include more and more information, as well as more and more stakeholders, how might diverse and decentralized groups make intelligent design decisions? In architecture, is it possible to leverage "**the wisdom of crowds**," as theorized by business writer James Surowiecki? Is there a way to take advantage of **crowd-sourcing**, the contribution of many distributed users toward a collective product?

Another aspect of the studio research will explore what **open source** might mean for the current state of architecture. Can this design method pioneered for software development be applied to or reformulated for architectural design? How might multiple independent parties build successive versions toward the goal of a single deliverable? Could modules of buildings and 3D files be "checked out," revised, and "checked in" by different architects, fabricators, and contractors over time durations that exceed a single project? How would discrepancies between versions be handled? If complex building components could be designed, documented, and released into a broad architectural community, how would intellectual property be handled? Might an open source model start to **change the one-off nature of buildings** and reduce inefficiencies in the construction industry?

The CBIP 2 Studio will address these questions directly as part of a **collaborative studio structure** with support from an **expanded teaching team**. We will work with dedicated consultants for CATIA and simulation/interoperability, as well as a full-time TA with relevant academic and professional experience.

Over the course of the semester, we will collaborate in multiple ways. We will collaborate within studio through a balance of individual and team projects; we will collaborate with students in the Workflow seminar being taught by Scott Marble through group discussions, field trips, and joint assignments; and we will collaborate with past and future CBIP studios through the use of CBIP modules of re-usable building intelligence.

BUILDING INTELLIGENCE

Our research will address current practices in the building industry and well as current practices in architectural education. With both topics, we will aim to develop informed positions, to generate hypotheses about new models of more intelligent operation, and to test these new models through applying them to multiple scenarios.

Despite the rise of BIM and other recent technologies, most buildings are generally designed and built the same way they were decades ago. The construction industry is still known for inefficiencies, waste, long timeframes, and adversarial relationships between contractors, clients, and architects.

The architecture design studio is known for its powerful approach to education and problem-solving, but like building construction, it is generally conducted the same way it was decades ago. Perhaps this model can be upgraded without losing the features that make it so compelling.

In this studio, we will develop **new futures for building intelligence** as it relates to industry and education. We will design new collaborative workflows, new uses of computation, new models of education, and new design proposals.

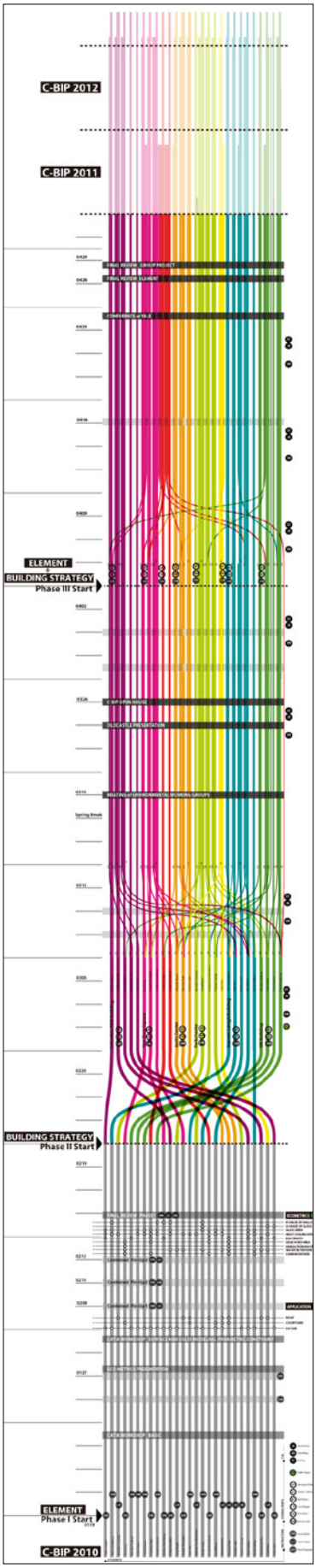


Image: CBIP collaboration diagram (2010).

PREFABRICATION

Some of the greatest inefficiencies in the building industry may be due to the long duration and wasted materials of onsite construction. For many years, architects and engineers have experimented with prefabrication of one and two-story homes as a way to address these inefficiencies. Recent **advances in the design and manufacturing** of airplanes, automobiles, and electronics have led to new interest in bringing factory production to architecture. But we have yet to see prefabrication become a widespread model of building intelligence. The challenges of engineering issues (it is difficult to make structures more than a few stories), design issues (it is difficult to create inspiring, non-repetitive spaces), and manufacturing issues (it is difficult to achieve mass production scale and to integrate factory production with entrenched practices of onsite construction) remain formidable.

Yet in the past two years, new experiments in prefabricated mid-rise towers have emerged. These buildings would bring new challenges and opportunities beyond the single-family home version of prefab.

Forest City Ratner, SHoP Architects, Arup, and XSite Modular are working on a 32-story prefabricated residential tower for Atlantic Yards in Brooklyn. Compared to typical construction, the project will cost 15-20% less, weigh 50% less, and produce 70-90% less waste. The team claims to have figured out a way to address the difficult **engineering challenge of creating an economical bracing system** to deal with wind loads.

Meanwhile, Broad Sustainable Building, a Chinese development company, already used an innovative prefabrication system to build a 15-story hotel in six days and a 30-story hotel in 15 days. The company is currently planning to build the **world's tallest building**, at 220 stories, in Changsha, China. It claims that 95% of the building will be constructed in a factory, using only 20% of the energy that building a typical structure would require. Construction is scheduled to start in November 2012 and be completed in January 2013.

BASRA

We will apply our research to the design of a **prefabricated mixed-use mid-rise tower** in Basra, Iraq. The second-largest city in Iraq, Basra has historically been known as "Venice of the Middle East" because of its system of canals and quaint streets. The city is also an international port and home to the majority of Iraq's oil reserves. Although the city sustained significant damage in the Iraq War, Basra is now slated for extensive redevelopment with an aim of taking advantage of its waterfront location for tourism.

Basra Sport City is a new development that aims to bring international sports events and tourism to the city. Supported by $500 million from the Iraq government, designed by two United States architecture firms, and built by Iraq's largest general contractor, it will be one of the largest sports cities in the Middle East. According to the firm 360 Architecture, "Using the power of sport to unite people across geographic and cultural divisions, this history-making, multi-use complex is meant to spur growth and development in Iraq as well as reintroduce its athletes and teams to the world stage." Basra Sport City was originally scheduled to host the 2013 Gulf

Images (top to bottom): Dymaxion house, with prefabricated components (Buckminster Fuller); Atlantic Yards prefabricated residential tower (rendering by SHoP Architects); Same; Prefabricated hotel by Broad Sustainable Building; Rendering of stadium in Basra Sports City; Construction of stadium in Basra Sports City; Basra oil fields.

Cup of Nations, but security concerns and construction delays have caused the schedule to be pushed back by two years.

Our tower will be part of the second phase of Basra Sport City, and it will include components for hotel, residential, and retail.

CULTURE

Returning full circle to Kevin Slavin's claims about algorithms, we may wonder if computers have met their match in this difficult context. Could algorithms possibly gain a foothold in the complex, intertwined cultures of Iraq, tourism, war, sport, past, and future? Does the new narrative conflict of man-against-nature-against-algorithms make sense here?

More generally, what are the various **quantitative and qualitative forces** at play in the new development of Basra? What are the perceptions inside and outside of the country? How do entertainment and sectarian conflict intersect with building technology and construction? What role does architecture have in the future of Basra and the region? And what forms of **reinvention and rediscovery** will affect this city and its new development?

Our studio this semester will address these questions with our best computation, collaboration, and building intelligence.

STUDIO STRUCTURE

The studio will involve a two-week crash course on CATIA and other simulation packages and advanced computational techniques. We will have weekly software tutorials and regular sessions during studio with software consultants. In addition, at several points during the semester we will have seminar sessions to discuss broader issues with the Workflows seminar being taught by Scott Marble. Our topics will include authorship, wireframing, interoperability, and optimization. In collaboration with students in this seminar, we will develop new workflow models to be used during our studio and future CBIP studios.

The majority of the semester will involve **iterative design** of both individual projects and collective projects. All research will be tested through designs.

ABOUT THE COLUMBIA BUILDING INTELLIGENCE PROJECT

The Columbia Building Intelligence Project began as a three-year pilot project designed to explore new collaborative design workflows that have the potential to transform architectural education and its relationship to the building industry. The project has involved public **Think Tanks** with leading international thinkers and practitioners in New York, London, Tokyo, Stuttgart, and Toronto. And it has involved three large collaborative design studios in consecutive spring semesters with over 90 fourth-semester students. Now in its fourth year, CBIP will continue its radical educational experiment by expanding from second-year design studios in the spring to a combination of second-year, third-year, and AAD studios in both the fall and the spring.

Images (top to bottom): Historic photo of Basra; Recent photo of Basra; Same; Same; CBIP Think Tank New York (2010); CBIP Think Tank London (2010).