Reprogramming Architecture

Learning via Practical Methodologies

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This paper aims to address innovative approaches in the pedagogical aspects of architecture by describing the work of AA Summer DLAB and Athens | Istanbul (AI) Visiting Schools of the Architectural Association (AA) School of Architecture in London. The presented work is part of a research which enables a more seamless transition from design to fabrication and from academia to profession. The paper formulates the pedagogical and methodological approach towards the integration of generative design thinking, large-scale prototyping, kinetic/interactive design, and participatory design. As such, a discussion on the methods of overcoming the fragmented nature of architectural education via the elaboration of the methodology, computational setup, fabrication strategies, and interaction / kinetic modes of the selected programmes is aspired.

Keywords: *Computational design research and teaching, Biomimetics, Generative Design, Kinetic / Interactive design, Participatory Design*

INTRODUCTION

Natural systems demonstrate interrelated levels of complexity by recycling their materials, allowing for change and adaptation, and utilizing energy (Frazer, 1995). The complexity that is observed in natural systems has provided the inspiration for a new approach to design and construction, becoming an established part of the architectural discourse in the recent decades. This approach is equally applicable to the educational aspects of the practice, thus enabling us to rethink in full the norms of the design discipline. While architecture is defined as the style and method of design and fabrication of physical structures, it reflects the technological and socio-economic circumstances of its' own time.

The digital revolution in architecture, marked by the integration of CAD/CAM tools into all design-related practices, has substantially reconfigured the interaction between architecture and natural systems. With the vast range of digital tools, the architect is now able to explore the correlation between the multiple subsidiary systems operating across a range of scales in all design related fields.

Situating itself within the complexity paradigm and its design-oriented implications, the research posited in this paper aims to investigate the contemporary applications of interaction which animate the architectural piece according to user feedback, thereby creating the potential for dynamic spatial experiences which enhance the way by which we perceive, learn and practice architecture. Concepts of real-time feedback loops and temporality in architecture can play a key role in shifting the paradigm both in practice and in theory. These concepts and their applications are demonstrated with examples from a series of ongoing international programmes, where students are organized into design teams, designing proposals in the creative atmosphere of collaborative, unit-based learning environment. As such, the paper formulates the pedagogical and methodological approach towards the integration of generative design thinking, large-scale prototyping, kinetic/interactive design, and participatory design.

AA VISITING SCHOOLS

Moving away from the conventional educational paradigms, the Architectural Association Visiting School introduced in 2008, reforms the way architecture is being taught world-wide. While deductive reasoning and the knowledge of the classics remain as part of the teaching module, the main objective is to purge the invisible wall between students and tutors.

The AA Visiting Schools are highly flexible educational modules which run for any length of time from three days to a whole term depending on the agenda and design goals. Regardless of geography, what all the programmes share are exciting and radical levels of invention and experimentation, all of which are to help in developing skills in different modes of analogue and digital, 2D and 3D production using the myriad of mediums at one's current disposal. Many of these 'laboratories', 'building programs', 'nomadic studios' or 'schools' are formed with collaborating partners - academic, industrial, commercial and/or creative - while others venture out independently to forge their own paths (AA Visiting School Prospectus 2013-2014, p.20-21, 2013).

The aim of AA Visiting Schools is to re-organize the architectural education in response to today's challenges. As part of this aim, the pedagogical format of these programmes is set to recognize students for their ability to shape the future; students and tutors interact on the same level, combining knowledge with new ideas, expertise with eagerness for novelty. Learning here occurs in a diverse, international group of students and professionals. In some cases there is a very small cohort of no more than 15 or 20 students, which facilitates specialist input, while in others tutors work with as many as 100 students on the construction of 1:1 prototypes of large-scale ingenuity. A number of programmes are based in the world's largest global cities, others in some of the world's remotest and harshest locations.

AA Summer DLAB, commenced in 2006, takes place every summer at AA's London home, Bedford Square, and its Hooke Park facilities in Dorset. Athens | Istanbul (AI) Visiting Schools, which have been initiated in 2011, take place every spring in Athens and Istanbul as a series of consecutive programmes. Each series of Visiting Schools lasts for two weeks, and student numbers range from 20 up to 40 participants. Both Visiting Schools are organized around the concept of experimentation, which involves the testing of non-precedent approaches, novel techniques and design thinking by analysing existing design problems thoroughly, evaluating the outcomes of the analyses, and offering original interpretations for potential outcomes. The outcomes do not present themselves as ultimate answers to the design problems, but as part of an ongoing process of design experimentation. More specifically, the system followed in these programmes is a set of methods and principles which interact with each other in multiple ways. It is a system of complexity. This is applied both in the design generation processes as well as with regards to theoretical and physical parameters of a project.

METHODOLOGY

Computers handle vast amount of data through algorithms incorporating a set of design parameters which the architect can then use and manipulate. In AA Summer DLAB and Athens | Istanbul (AI) Visiting Schools, the mere parametric mutation of design objects with the purpose of generating variations is exceeded by the ability to produce an architectural proposal through simulation. The emphasis in design explorations becomes the process rather than the end-result. Formation transcends form. The work of Summer DLAB and AI Visiting Schools is characteristic of the benefits that derive from a generative design process, particularly one which involves interaction.

The qualities of the complexity paradigm, characterized by the spontaneous emergence of differentiated interdependent subsystems that can adapt to various external stimuli, are becoming the guiding principles in how designers think and produce architectural systems (Gruber, 2011). The underlying condition of self-organized systems posits a significant diversion from parametric towards generative design processes in the realm of architecture. It can be argued that parametric design methodologies set up rules and conditions for the creation of an anticipated outcome/set of outcomes, since there is a linear relationship between the input parameters and the output. On the other hand, generative design methodologies are articulated through the abstraction of biological principles, such as self-organization or evolution, thereby giving emphasis on the bottom-up growth of lower-level entities, namely agents (Reynolds, 1999). This phenomenon, which is realized with object-oriented design in the computational paradigm, creates the potential to correlate the complexity observed in natural systems with the complexity in architectural systems.

Initially, students are introduced to the principles of selected complex systems in nature, serving as the basis for the extraction and abstraction of specific rules which direct the local interactions of the agents with each other and their environment. These interactions lead to the emergence of complex systems, demonstrating intelligent behavior on a global level. By fusing the qualities of natural processes with the notion of spatial reconfiguration, the objective is to generate design systems where the architect does not get involved with creating an end product according to rules/parameters, but instead initiates a system whose effects will be continuously adapted on a multitude of interdependent levels. As such, while the potential of object-oriented architectures is investigated, the current role of the architect in contemporary architectural discourses is also speculated upon. Furthermore, the fact that the chosen computational method is object-oriented, in contrast with a linear setup, creates the opportunity to focus on the process of design generation, whereby the concept of formation replaces form, which would act as the sole end result in conventional practices.

The computational platform used in design explorations, the open-source environment Processing, operates as an object-oriented programming language (OOP). The association between the digital environment and the conceptual framework described above facilitates the generation of seamless digital design tools in Processing. In this respect, the computational platform exceeds being a mere digital tool and functions as an experimentation ground which students understand and test the various phenomena of complexity paradigm, such as branching, network formation, and reaction-diffusion systems (Figure 1).

More specifically, the use of algorithmic design via Processing enables participants to run various scenarios according to different conditions. Parameters which are set in the digital simulation are not ignorant of the architectural context but have direct connection to certain possibilities of each given situation. On each consecutive version of the Summer DLAB and AI Visiting School programmes, the design problems are explored with the application of explicit codes which originate design outcomes based on formulas emulating the formation process of natural constructs. The concept of agent-based systems found in bird formations or schools of fish, the theory of L-systems in the shaping of plants and trees, the recursive character of miniscule viruses or enormous natural formations are just a few examples which are referenced in the research of these programmes. Such natural conditions are translated in algorithms and are set to be adjusted according to desired design outcomes. The participant/architect interacts with the formation throughout the entire simulation process. Through this type of investiga-

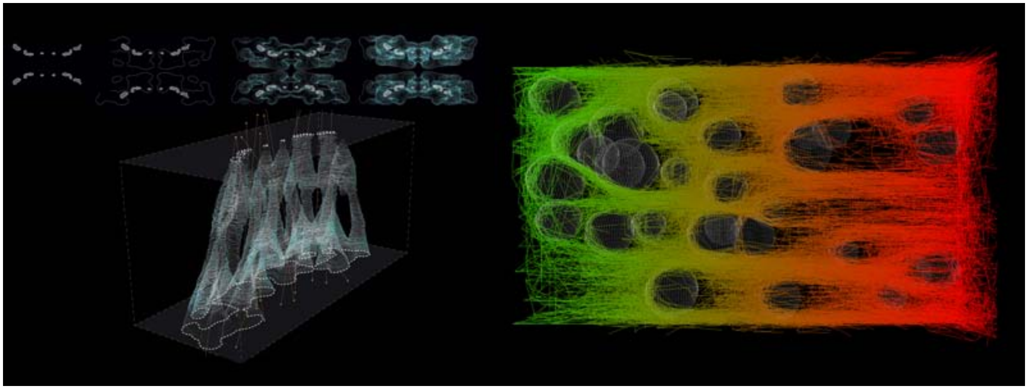


Figure 1
Generative form-finding processes exploring various biomimetic models.

tion, participants receive a direct know-how on matters which, until recently, were theoretical.

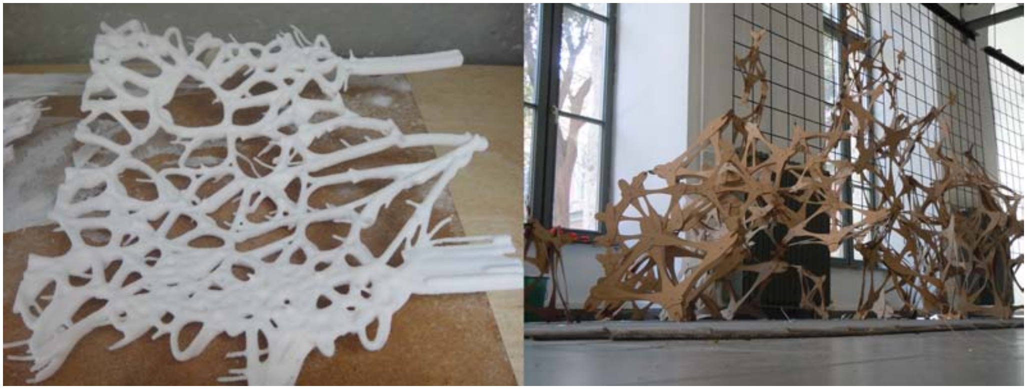
FABRICATION

In the contemporary post-industrialized world, while the architectural proposals evolve and follow more sophisticated forms and tackle aspects of economy and sustainability, design teams assigned to plan the physical proceeding for the realization are often interacting with other disciplines. Currently, design, construction, finance, and legal aspects all overlap and interrelate even more strongly than they have in the past.

One of the major objectives of the presented pedagogical approach is to demonstrate the continuity of the workflow between computational software and digital assembly procedures leading to physical fabrication. In this respect, during the development of each design unit's proposals, students fabricate physical models in various scales (Figure 2). This first step towards the realization of physical proposals demonstrates how the use of generative tools in combination with digital fabrication techniques allow for a coherent and smooth transition from the "drawing board" to the building site. At this stage, design teams also begin to experiment with the concepts of interaction and kinetics in architecture with the aim of transforming static built models into animated kinetic prototypes while considering a hierarchical design arrangement. With the incorporation of the physical computation environment Arduino in the design generation process, a continuous information loop between Arduino and Processing is formed. In this way, students are able to manipulate their design simulations in Processing according to real-world physical constraints, such as lighting levels, movement, and distance.

The notion of actively participating in the fabrication of models is integrated in the teaching modules of the AA Summer DLAB and AI Visiting Schools. Every participant deals with both the solution of the given architectural problematic and the issue of realizing his or her proposal. More specifically, the process of trial-and-error which occurs through the collaboration of different people within a team as well as the collaboration among different teams is advantageous in the understanding of current practices in architecture. As such, the pedagogical setup acts as an exemplary model of the processes being utilized in the professional world. Distinct groups work together with the responsibility of the delivery of specific aspects of the project's design and building phases. The design must not only be covering the architectural brief but must be structurally sound and appropriate for the use and location of the given design task. Inevitably, the success of every project

Figure 2
The initial transformation from the digital to the physical paradigm through scaled models fabricated with digital prototyping techniques.



is correlated with the effective management of the time given. This has proven to influence the team's design proposals as they become more aware of the constraints of the physical world. Their proposals surpass the superficial use of digital images. The investigation at this stage involves the extensive understanding of the digital three-dimensional form-making and its' application through digital fabrication tools.

Serving as a pattern of the practice in the professional world, the fabrication processes are multi-scalar. Small scale physical models are produced and occasionally disposed as their role is essential to provide the team with an initial perception of their concept's physical limitations. Similar to the digital form-finding processes, the fabrication comprises of a series of steps through which the participants gain practical, hands-on skills while interacting with each other on different levels and stages. In the final phase of the programmes, students are asked to build a one-to-one scale working prototype of an interactive installation. Working on an installation scale has proven to be highly beneficial, as the fabrication process of the installations by digital fabrication technologies and their assembly procedures by the students allow them to understand the physical behavior of the materials they work with, such as wood, acrylic, and aluminium (Figure 3).

INTERACTION MODES

In a world exposed to rapid technological advances, the question being addressed in this paper is not what architecture is but what architecture can do. The work completed in the AA Summer DLAB and AI Visiting Schools is one that ventures into unclaimed territory, opening up new areas of thought for research and development. At this phase, Interactive Architecture takes places as two modes of communication; one that is calibrated as User to User communication and one that is calibrated as User to Model communication.

Interaction between user and model explores the aspect of perception which users experience when they interact with the built environment and when the built environment interacts with them. The interactivity happens through use but it is also "felt" by the observation of the user and the interactive model. In the context of user to user communication, the interactive/kinetic structure acts as a vessel of conveying information from one user to another in certain ways affecting their behavior. Here, interactivity is formulated on anthropomorphic definitions. Complex physical interactions are made feasible by the use of low-tech computational hardware, Arduino, which can detect and react to human behavior. The creative fusion of algorithmic design, digital fabrication, and embedded computational intel-

Figure 3
Students working on large-scale prototypes at AA Hooke Park facilities in Dorset (image credit: Valerie Bennett).

ligence in the field of architecture is therefore discovered. The research focuses not only on the benefits of adaptation, which makes it possible to anticipate and accommodate the response mechanisms of the built structure, but also on the environmental and psychological ramifications of such structures.

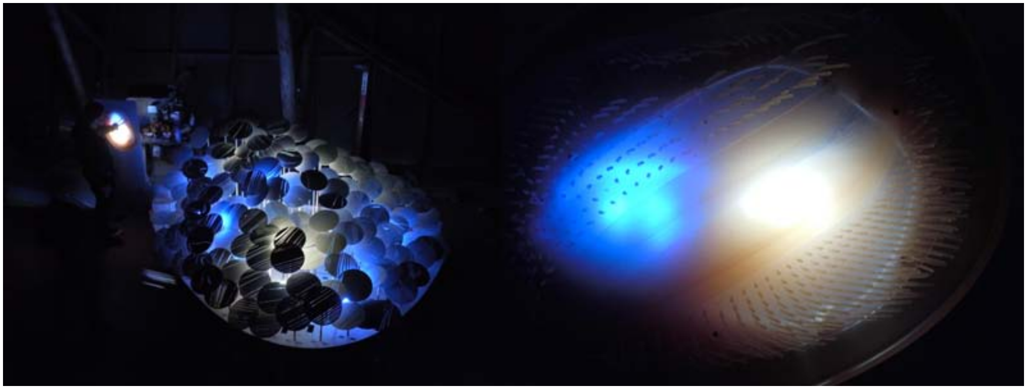
Transformation via human interaction can take place in a variety of scales and modes, ranging from kinetic morphological properties and acoustic performance to ambient lighting effects which bear the potential of altering the perception and the actual configuration of space. One of such interaction methods explored so far include video mapping, which has been realized in Summer DLAB 2012 via "Fallen Star", a large scale installation which is 4.5 meters long, 3 meters wide, and 1.8 meters high. For this installation, each design team has been asked to challenge the perception of the architectural installation through the projection of a three-dimensional natural growth algorithm. The specific parameters of the algorithms can be manipulated with an IPAD interface, which is also designed by student teams, enabling a direct interaction between the user and the installation. The segregation between the architect and the end-result diminishes even more with the progression of the user interface as an architectural tool, pointing to the extensive possibilities of participatory design in architecture. The installation reacts to the user's input on sound, choice of algorithm to run, and the manipulation of the algorithm itself by changing its parameters from the interface (Figure 4).

A different method of incorporating interaction with architecture has been the creation of a kinetic light-diffusing architectural installation during Summer DLAB 2013. The installation, "Light Forest", is a 5 meter long, 3.5 meter wide, 1.5 meter tall (at its maximum activated state) which can activate itself through motion according to the distance data received from users around it. For this design task, students have integrated light with movement by designing, fabricating, and assembling a complex body of kinetic parts with embedded lighting pieces which react to human movement. As the sensors receive data on the distances and amount of visitors in space, the tessellations of the kinetic surface react with subtle movements, generating various light formations in space. This interaction mode involves the direct communication between user and the physical structure, but also indirectly includes the communication of users among themselves through the physical structure. As such, the notion of permanence gives way to the constant flux of building formations (Figure 5).

In AA Athens Visiting School 2014, the interactive aspect of the design has been realized through the construction of a 1-to-1 kinetic pathway. Through

Figure 4
The final working prototype of Summer DLAB 2012, “Fallen Star”, exploring the notion of interaction with video mapping which is manipulated with an IPAD interface.

Figure 5
The final working prototype of Summer DLAB 2013, “Light Forest”, which activates itself according to distance data received from users. The image on the right shows the activation mechanism.



a series of proposals, the final design for a 5 meter long, 2.5 meter high and 1.3 meter wide pathway has been reached. This interactive/kinetic pathway consists of two sets of triangulated panels. Each set has its own purpose towards the effect of interaction for the two modes, user-to-user and user-to-model. One set has a pattern of LEDs which gets activated according to the presence of humans within the passage. The second set is made out of carefully woven elastic strands. The triangles attached to these strands rotate and twist in different manners creating openings and obstructions. The path reveals itself once two users are found in the right location in front of each side. There is the element of time that is embedded into the structure; once the users are in the passage, they have a certain amount of time before they can exit. The longer they remain within, the more agitated the structure becomes, resulting in the nervous movement of the strands. This project is eventually an experiment on the way humans interact with their environment and with each other through it (Figure 6).

CONCLUSION

The application of biomimetic principles with object-oriented architectures, participatory design, and kinetic transformation which are explored rigorously throughout these programmes bear the potential for

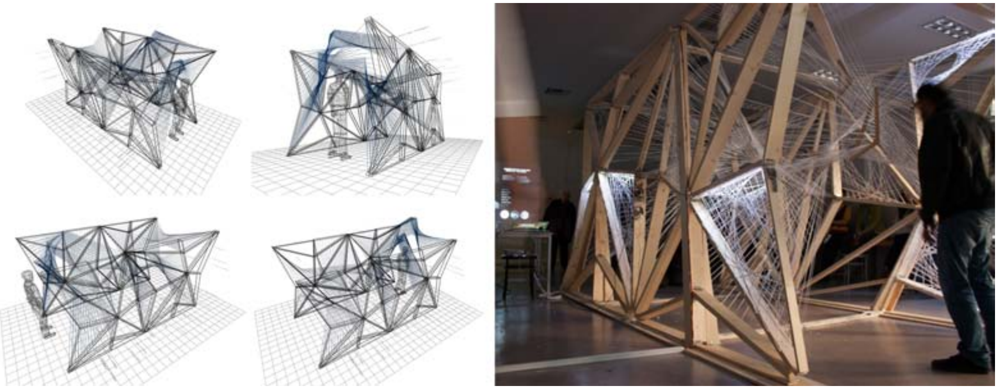


Figure 6
AA Athens Visiting School 2014 installation; interaction with a kinetic pathway.

creating architectures of adaptation and reconfiguration. As it has been demonstrated with these installations, the concept of having a structure that is related to motion and real-time reaction to external stimuli is no longer an idea of the past but can be realized by low-tech materials and technologies used in everyday life. The pedagogical approach engaged in these series of programmes aim to demonstrate how to actively interweave the conceptual and practical aspects of innovative design paradigms, enabling students to fully understand the theoretical, computational, and physical advantages and constraints of such methodologies. Active engagement and exposure to the procedural levels of creation enables architecture to evolve as a supple communication network, characterized as an authentic collaborative and purposeful convening medium.

After several years of applying this specific methodology in architectural education, various evaluations can be comprised. Among valuations on aspects like international collaborations, research on cutting-edge technology, low tutors-to-students ratio, and exposure to hands-on building techniques, one outcome is believed to be of particular significance. It is the aspect of time. This aspect has a controversial character as it is equally beneficial and disadvantageous for the goals of these programmes. On the one hand, it might be argued that the duration is not long enough while testing innovative design concepts together with interactive/kinetic concepts. Nevertheless, it has also revealed that students tend to be more engaged in an intensive learning process, whereby the limited amount of time in relation to the limitless learning resources provided renders participants to get more absorbed. Through the programmes' intensity, participants are introduced to a way of critical design thinking and performing that lingers much longer than the duration of these programmes. As such, AA Summer DLAB and the Athens | Istanbul Visiting Schools do not act as mere tutorial workshops; they build audiences for new ideas. They are designed to evolve as an unpredictable crowd, not a rational individual; re-organizing architectural education in response to today's challenges.

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