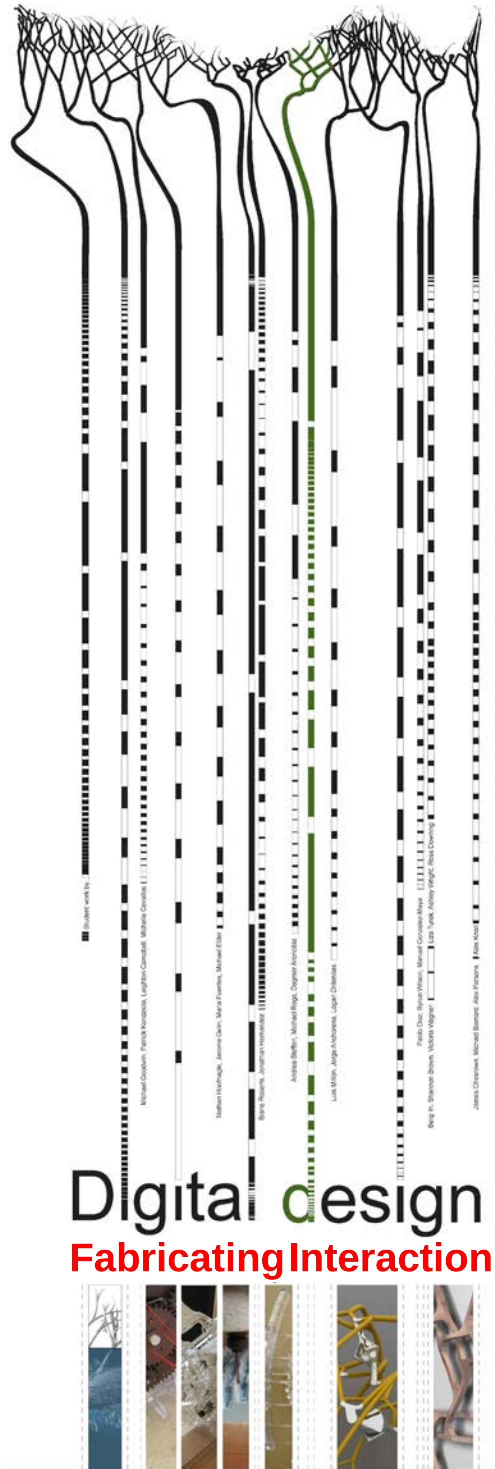
ACSA Creative Achievement Award

2015-2016 Winner Submission Materials

EMMANOUIL VERMISSO
Florida Atlantic University



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[Porftolio submitted to ACSA in support of Creative Achievement Award nomination]

Design Portfolio
teaching + research integration

Design Computation & Biomorphic Design 1

Architectural Robotics & Smart Materials 2

The work presented here tries to discuss an evolution of pedagogy which considers integration of both Analogue and Digital tools as complementary. My primary interest is that of adopting technologies and theoretical practices towards the establishment of a bottom-up design methodology. The "Emergent Form" course lies at the core of this intent, and is supported by earlier teaching research seminars and design studios which allow the refinement of such technologies and their eventual implementation into a course on Design Computation that is not relying on specific software/hardware but rather on the realization that Architecture can directly borrow rationales from external disciplines like Engineering and the Sciences at large.

Design Research ***integrating research & teaching***

Biological Analogy / Design Computation / Robotics

CNC-manufacturing

Ornament: Design of Affect on Plywood (Material Surface Consideration)

Prototyping: Formula SAE open-wheel race-car

Shape Optimization: Design options

Smart Material Systems

Shape Memory Aloys: Passive Responsive Building Facade System

Carotid Thermo-Regulator: Responsive wearable clothing

Responsive Habitats: Hammock Veil

Self-Organization: Synthetic Landscapes

Emergence & Self-Organization: Computational Design Methods

Soft Grids: Conformal Mapping Deformations

Wet Grids: Minimal Path

Elastic Grids: Force-Active Structures

Layered Grids: Hybrid Laminate Materials

Drained Grids: Aggregate Casting

Adjustable Casts: Analogue Algorithms

Structural Morphogenesis: Morphallaxis

Integration of simple motor: Bio-inspired LEGO machines

Nature & Technology: Vessels of Consilience

teaching + research (Computational form-finding)

EMERGENT FORM: Computational Design Methods

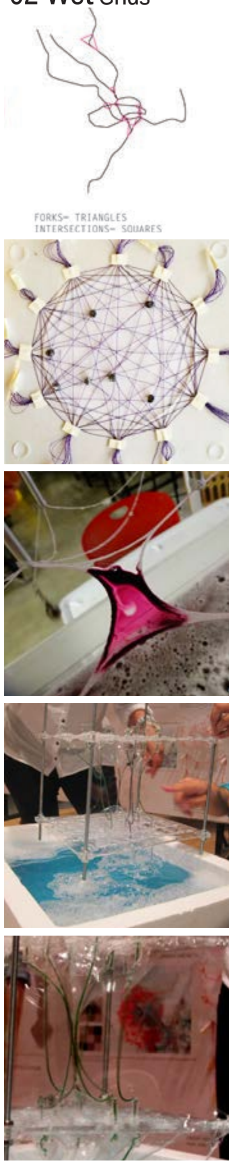
Student work: Design by J.D.Bernal, A.Borodi, C.Calderon, G.Campusano, C.Casseus, L.Espinoza, I.Fomina, F.Jawhari, F.Liscano, S.Penaranda, L.Rodriguez, M.Siles, K.Valdez, J.Villaman, N.Zuta]

[3 credit course/duration: 6 weeks]

01 Soft Grids

Conformal Mapping Studies

02 Wet Grids

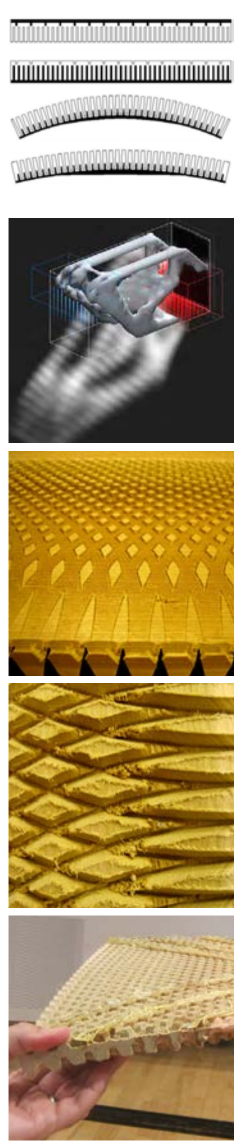


CA Neighboring Influence

03 Elastic Grids

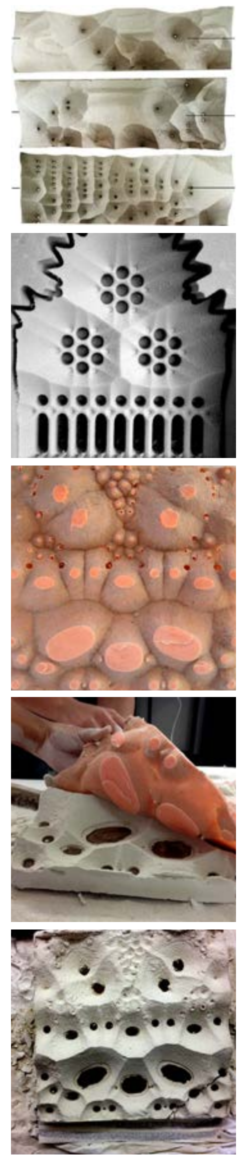
Force Equilibrium: Woven Silk

04 Layered Grids



Structural Hybrid Topologies

05 Drained Grids



Soft Casting: Angle of Repose

06 Adjustable Casts

Analogue Algorithms

Material Intelligence

Rule/Parameter

Simulation

Analogue

Digital

DESIGN COMPUTATION

Self-Organization

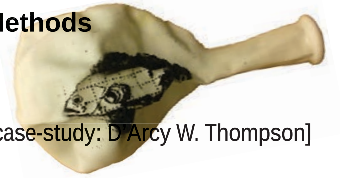
Emergence

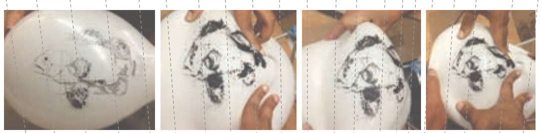
Form-Finding

Bottom-Up Methodology

Can we 'design' bottom-up processes?

teaching + research (Computational form-finding)





EMERGENT FORM: Computational Design Methods

STUDENT WORK: Design by J.Villaman, G.Campusano, S.Penaranda
[duration: 4 weeks]

Soft Grids: Morphological studies for generative design: [case-study: D'Arcy W. Thompson]

homologies: *projection → hyperbolic geometry → morphological studies/ conformal mapping*

Latex Studies
Manual shape deformation

These morphological studies involve the mapping of a shape or geometry within a Cartesian coordinate system. Subsequent controlled deformation of this system aims to establish ***quantifiable continuities between known states of evolution*** of the original subject or identify successful mathematical rules for developing further stages of evolution.

It is important to assess both the subject of deformation (shape) but also - if not primarily- the notational vessel for this deformation (grid) separately. Interesting observations can be made by studying these "soft grids" that can frame more experiments. In "On Growth and Form" (1917), D'Arcy Thompson sought to mathematically deform "instances" of evolution on paper; we have decided to enlarge the potential of the system by physically defining it: A separate, physical vessel should be accounted for in our case, that of material- this provides specific constraints which affect the system's performance. A fourth parameter/ element in the system is the contraption which regulates the material behavior and implements the analog rules for deformation. Paint studies: we have either used latex as an elastic agent to allow the grid to soften, but gone further to 'laminate' the latex with paint/gypsum in order to visualize/manifest the forces under which it's subjected and try to empirically understand the refinement of the rule/ Algorithm. In the case of D'Arcy Thompson skull studies the mathematical rule for achieving the deformations is not listed in "The Theory of Transformations". Based on further investigation which made clear the complexity involved, we questioned the suitability of 2-Dimensional deformation relative to the prospect of a 3-Dimensional one in capturing these extremes (human to chimpanzee to baboon).

Another context was proposed, that of deforming these within a ***Non-Euclidean frame of reference***: Hyperbolic Geometry. A formula for inversion was used, where the coordinates of the subjects were inverted in reference to a circle (2D) - this is also known as using the Poincaré disk model (also known as *conformal disk model*) - or a sphere (3D). The results were much closer to the original studies conducted by Thompson and fellow scientist Heilmann, thus raising the question of method in D'Arcy Thompson's work:

Did D'Arcy Thompson employ Non-Euclidean geometrical references in his "Theory of Transformations"?

ANALOG

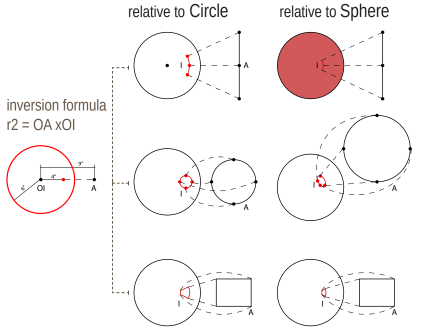
Paint fracture studies from latex deformation

Analog experiments using Latex and custom-made contraption

Hypothesis: Evolution of *Sarcopterygyii Fin*

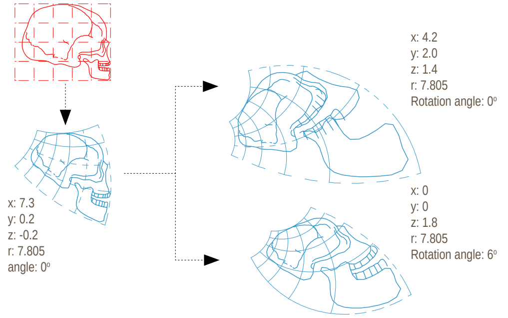
DIGITAL

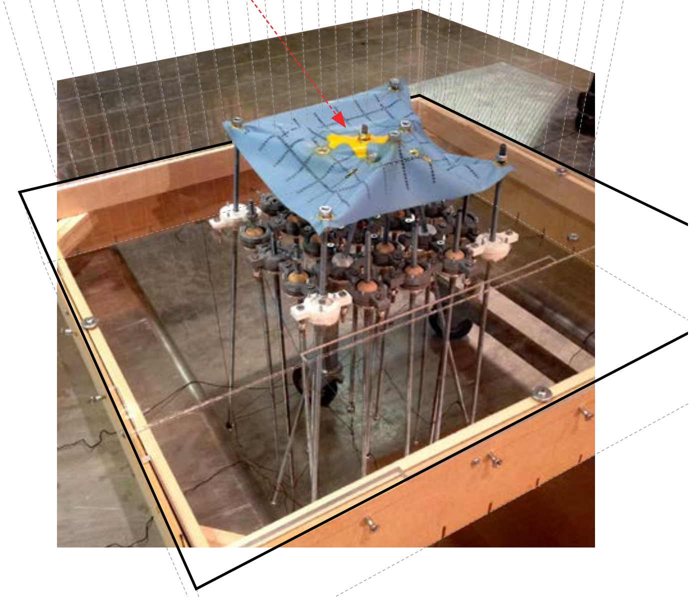
Hyperbolic Inversion of geometries [line, circle, rectangle]



Species Deformation using Inversive Algorithm

Hypothesis: evolution from Human skull to Chimpanzee skull



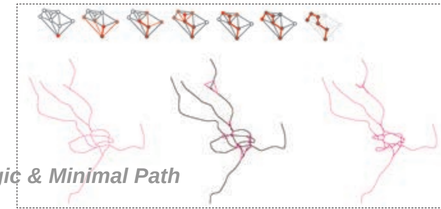


teaching + research (Computational form-finding)

EMERGENT FORM: Computational Design Methods

STUDENT WORK: Design by F.Jawhari, C.Valdez, N.Zuta
[duration: 4 weeks]

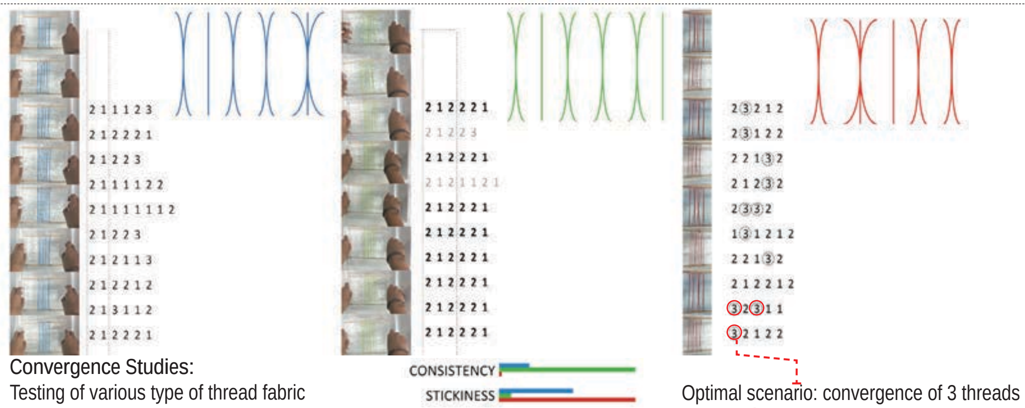
Liquid intelligence → *Cellular Automata Logic & Minimal Path*



Hypothesis: Train Route Optimization using Minimal Spanning Tree logic
[Triangles: Forks/ Squares: Intersections]

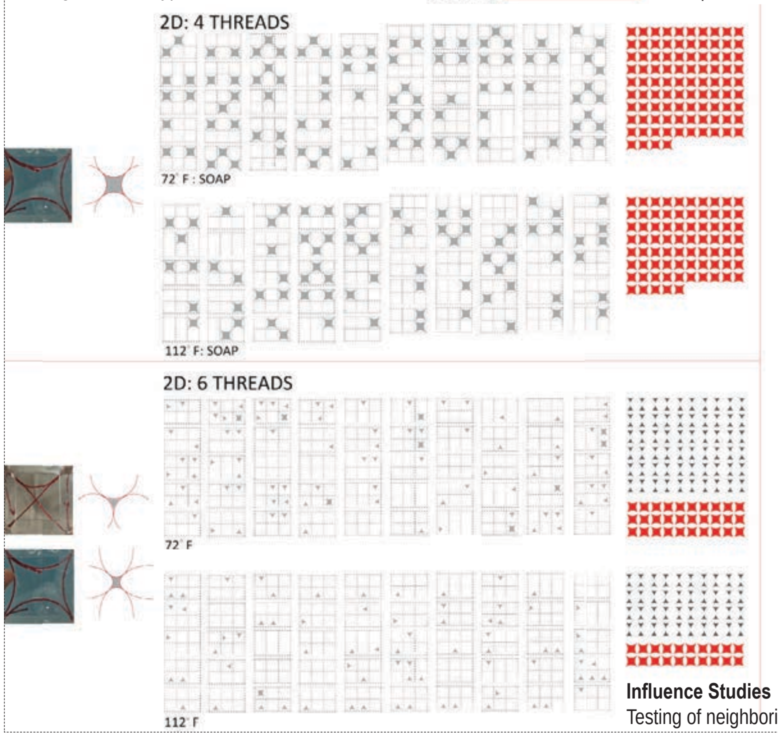
Wet Grids: Understanding of Minimal Path logic and its potential applications [case-study: Frei Otto]

These studies explore the concept of the “minimal path” by assessing the behavior of ‘wet grids’ using soap water in various temperatures and consistencies. A hypothesis is sought which could drive a design application - a possibly promising scenario to further examine is deriving optimal routes for the London Underground.

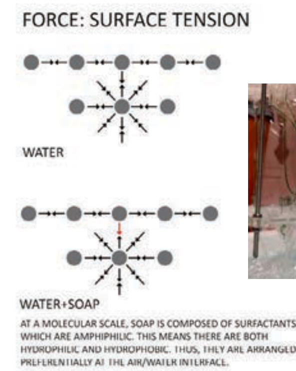


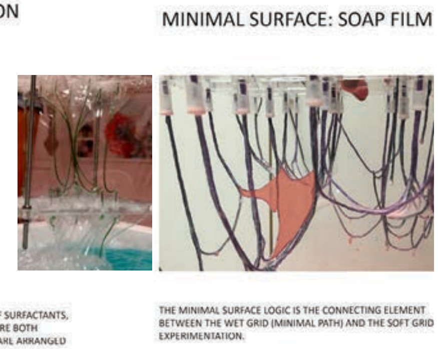
Convergence Studies:
Testing of various type of thread fabric

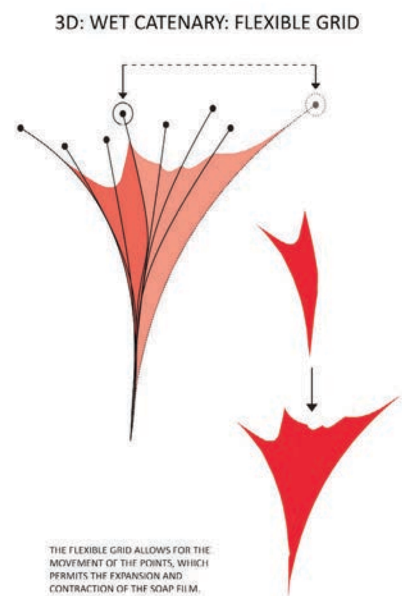
Optimal scenario: convergence of 3 threads



Influence Studies
Testing of neighboring conditions on convergence







teaching + research (Computational form-finding)

EMERGENT FORM: Computational Design Methods

STUDENT WORK: Design by J.D.Bernal, L.Espinoza, C.Casseus
[duration: 4 weeks]

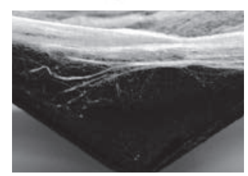
Elastic Grids: Biological behavior within force-active membranes

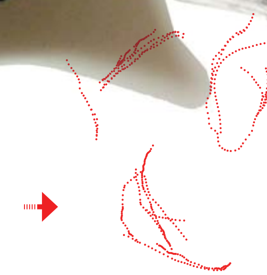
force-active systems: man-made topology → silk worm (Bombyx mori) → hybrid topology

8"x8"x8"
scaffolds for silk-worm habitat

This fast-paced workshop studied elastic fabrics' ability to portray and engage the phenomenon of emergent, self-organizing and unpredictable form. It was essential to understand emergence as the natural, decentralized, non-hierarchical phenomenon of self-organization of form as yielded by the development of manual algorithms and logical processes via analog computation, and as influenced by material properties, context and other factors.

MIT's "Silk" pavilion experiment (N.Oxman 2013), a precedent which stimulated questions on the parameters of emergence, is a peculiar case study where natural agents that don't seem to display the survival-guided social behaviors of animal groups -such as the ant colony- create emergent complex form when introduced to a man-made medium. Initially, the experiment aimed to allow free agents to determine the fabrics' points of attachment, hence allowing form-making though a bottom-to-top approach, and starting with self-organizing, basic, independent and computational agents working together in a decentralized fashion. Live silkworms were introduced to the study aiming for this approach, resulting in a system that expresses the juxtaposition of the form made by the agent -as shaped by its natural, goal-oriented reasons- with elastic fabric media. The silkworm (bombyx mori) does constructs more flexible in form under different spatial conditions not limited to two-dimensional or planar designs (more so than the spider, for example). The fabric media was initially meant to be interposed after the agent acted. Ultimately, however, experimenting with digital representations of algorithmic functions of natural growth determined the attachment points of the fabrics, and hence, their forms, after which, the agents were placed to observe their constructs. The fabric, thread and wood media, or HUBs (hybridity | unfoldings | bluntings) required parameters which would determine some of the agents behaviors (i.e. discouraging corner weaving), undermining totally decentralized emergence. Differing from the silk pavilion, the experiment was not attempt to express future possible material applications, but to express possible organic interactions between parameters of emergent form-making and man-made materials. The juxtaposition of and the interactions between natural and artificial elastic fibers was secondary. The results were organic, with most agents successfully completing their life cycles after spinning on both intended and unintended surfaces. Limitations were observed in controlling the agents' spinning behaviors, but closely observing patterns, and opening questions about further media and the wide range of possible unpredictable results, as well as about the feedback of natural systems on artificial ones became a tangible source of interest. This is a system with potential for complexity and further experimentation, and despite not fully achieving a bottom to top approach, it offers a close look at the influence of constructed spaces on natural behaviors.





Silk-worm weaving pattern

Caterpillars of different age

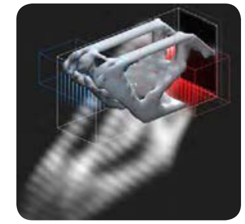
Placement in artificial habitat

Undesired Results: CORNER WEAVING (Based on organism's preference for enclosed space)

Desired Results: WEAVING ON FABRIC (Based on unknown factors)

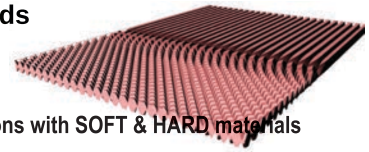
Desired Results: WEAVING ON FABRIC (Based on more constrained habitat)

teaching + research (Computational form-finding)



EMERGENT FORM: Computational Design Methods

STUDENT WORK: Design by M.Siles, L.Rodriguez, C.Calderon
[duration: 4 weeks]



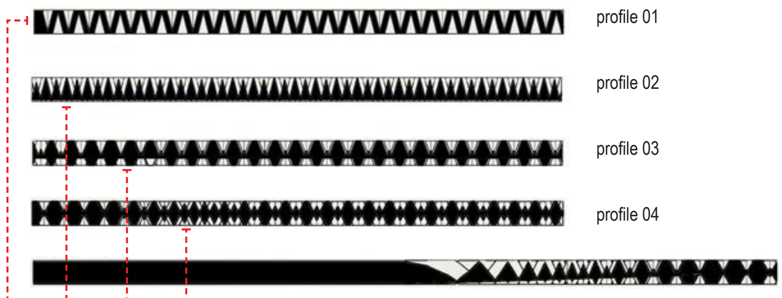
Layered Grids: Examination of laminated structural configurations with SOFT & HARD materials

structural optimization: hybrid material laminates → Soft & Hard

The objective of the final experiment was making a flexible vault-like structure with an initial rigid material by altering its design through a particular notching technique, while keeping it structurally intact and able to absorb shock forces through composite techniques. A mixture of analogue and digital techniques were used to apply certain composite materials, towards attaining a lightweight optimized form. Digital simulations in Rhino-plugins Millipede and Scan & Solve were conducted to identify vulnerable areas of maximum stress. In those areas, Kevlar and/or Liquid Silicone Rubber were applied according to the location and performance requirement (i.e. liquid rubber works better in compression, absorbing force).

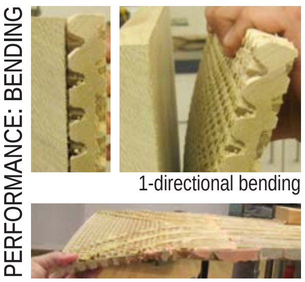
Short-term hypothesis: If a 1/8" offset symmetrical notching is made in a 1" depth piece of poplar wood and have the notching transition to a 30 degree cross notch, then the structure becomes highly flexible, yet vulnerable to failure, and therefore requires subsequent reinforcement with rubber to absorb compressive stresses, and Kevlar used to achieve greater tensile strength in areas prone to deflection. *Long-term hypothesis:* If the base material of the vault (wood) is modified or simply eliminated, how will the hybridization of Carbon Fiber, Kevlar, and Silicone Rubber alter the Form, Structure and Layer Logic in order to achieve flexibility? Will the topology resemble a barrel vault or is a new one likely to emerge?

Prototype X: CNC-routed Poplar



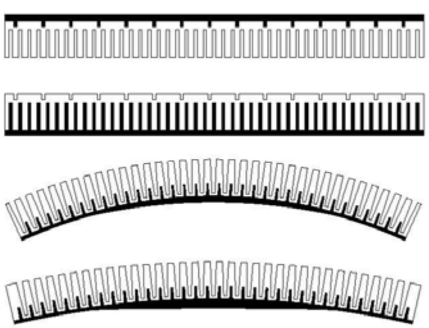
DESIGN: PROFILE VARIATION

PERFORMANCE: BENDING

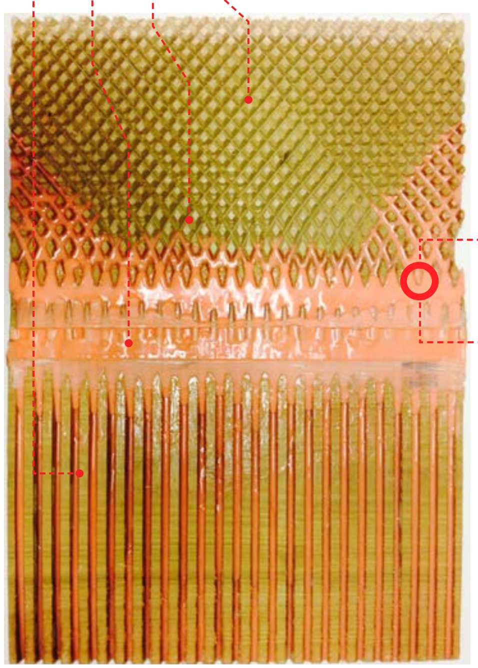


1-directional bending

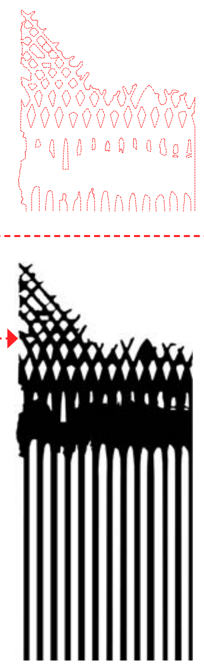
2-directional bending



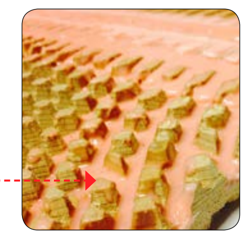
2D Hybrid Material Studies: BEAM
Prototypes A B C D: Straight vs. Cambered beams



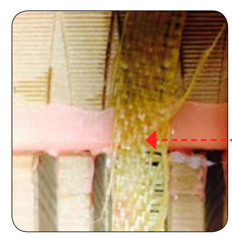
3D Hybrid Material Study: VAULT
Prototype E: Reinforced Panel (bottom)



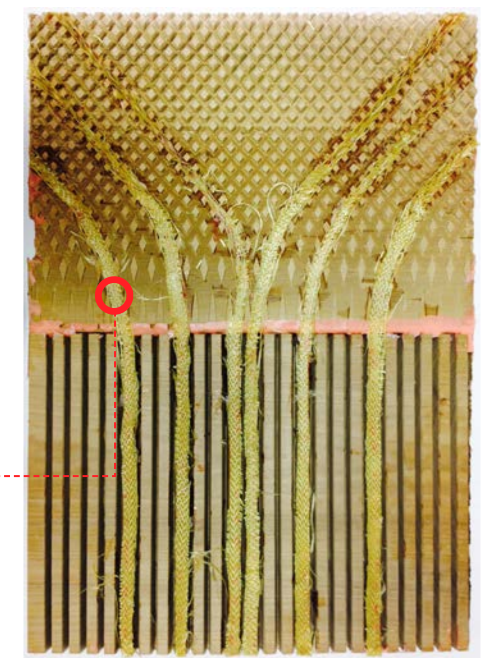
Rubber Reinforcement



SOFT: Silicone Rubber



HARD: Kevlar



Prototype E: Reinforced Panel (top)

teaching + research (Computational form-finding)

EMERGENT FORM: Computational Design Methods

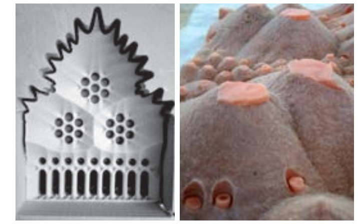
STUDENT WORK: Design by I.Fomina, A.Borodi, F.Liscano
[duration: 4 weeks]

Drained Grids: Sand Geometry Formation of Ruled Surfaces [case-study: Antoni Gaudi & Jørn Utzon]

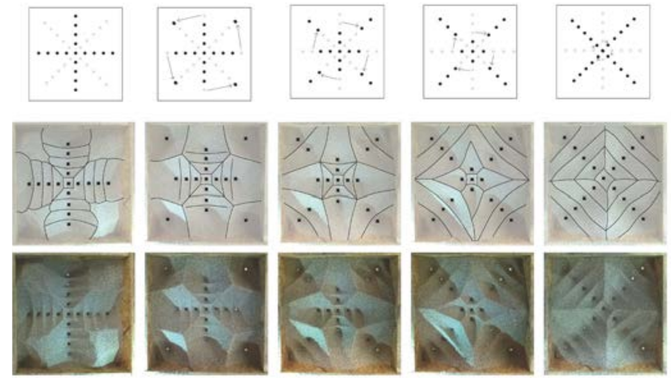
This investigation considers Sand Angle of Repose as a material factor for form-finding. Aggregates consist of finer particles which set up the behavior of the material when looked at larger quantities. Sand as the product of weathering and erosion on the smaller scale acts as a crystal of a mineral. In nature, the bigger amounts of sand like dunes, pits and landslides act to find an optimal shape to resist gravity, wind, water and earthquakes. We herewith explore Sand as an agent that delivers structural simulation and juxtapose two projects between 1898 and 1960, the Sagrada Familia by Antoni Gaudi and Sydney Opera House by Jørn Utzon. Observing the absence of beams in the Sagrada familia -accommodated by hyperboloid vaults instead- the **working hypothesis considers the integration of a parametric rule of varying profiles within a vault structure following a self-organizing process.**

In works of Jørn Utzon like the *Sydney Opera House, Kuwait National Assembly* and *Zurich Theatre*, the idea of adjustable geometry is connected to structural performance. Virtually, the structural roof modules of these projects consis of infinite numbers of structurally sufficient profiles to explore the full capacity of the system. Although an infinite number of options is impractical, the application of associative rules on a virtual level can provide endless results. Using profile succession from ‘T’ to ‘’□’’, from ‘∩’ to ‘∪’ and from ‘_’ to ‘∩’, Utzon explored the arrangement of material over applied force, space and time. These precedents establish an understanding of a bottom-up approach, although stylistic misconceptions of their time could become an obstacle during form-finding. Both the work of Utzon and Gaudi address design beyond their authors’ lifetime and challenge temporary stylistic dogma. Understanding form as a result of structure and material, both architects used analogue experiments to embed mathematical rules within a structural pattern language. *Is the application of digital methods valid compared to the analogue ones? Can we call the first virtual and the later real?* Both of systems [Analogue/Digital] are inclusive and self-sustaining, but they differ in the output information. The analogue system uses the advantages of the natural agent (sand in our experiments) when the digital ones perform though the simulation of agent established by physical rules (gravity, friction). The discovery of system potential in digital way by inheriting ‘supernatural’ qualities of material is of the same importance as experimenting in analogue ways. The first can explore the expanded system capacity and the second test the material to achieve the desired result.

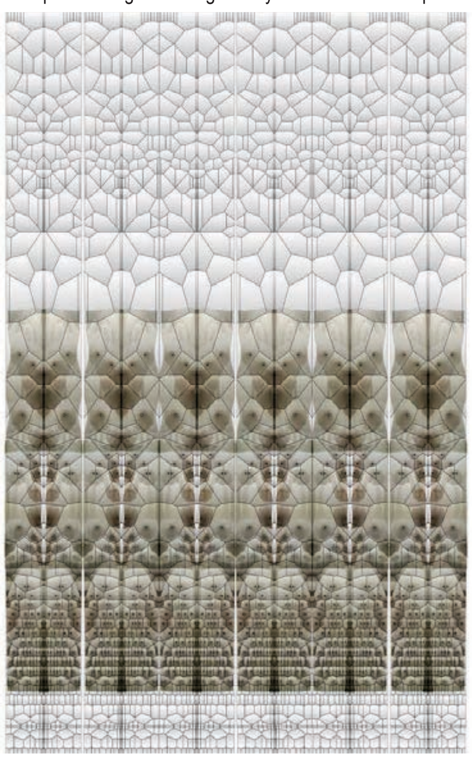
Sagrada Familia; Sydney Opera

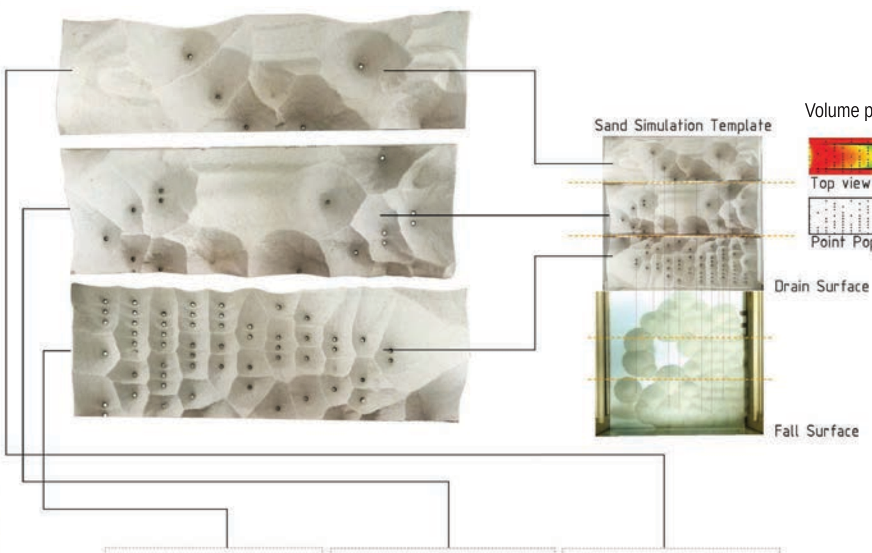


Prototypes: Parabolic Window; Rubber Mold

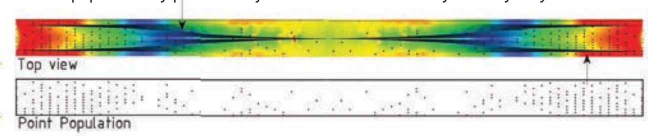


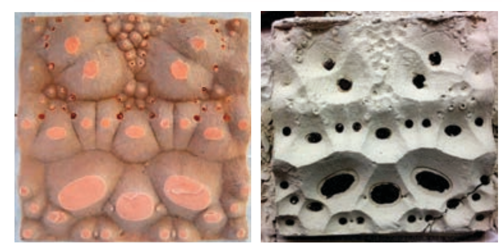
Drained Sand Studies: Transition from “+” Grid to “X” Grid



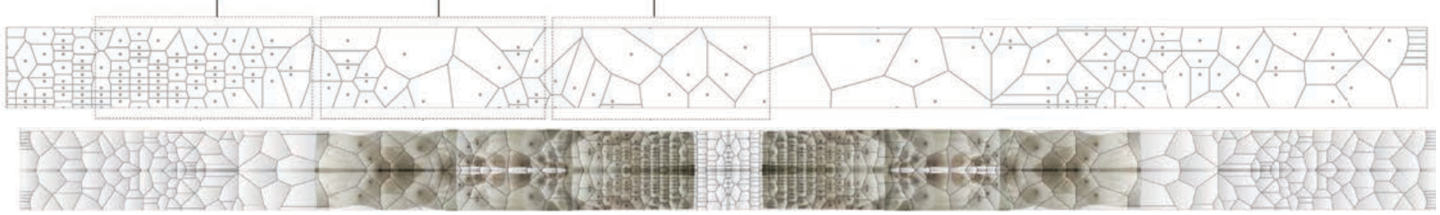


Volume population by pixel density > Scan&Solve FEA analysis of Sydney moment beam





Silicone Rubber Mold extracted from Sand Draining; Plaster Cast

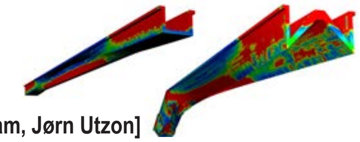


teaching + research (Computational form-finding)

Analogue Rule (Arup/ Utzon) ▸▸ Computational Form
Digital Rule (Rhino/Grasshopper ▸▸ Parametric Model: Variation of Analogue Rule

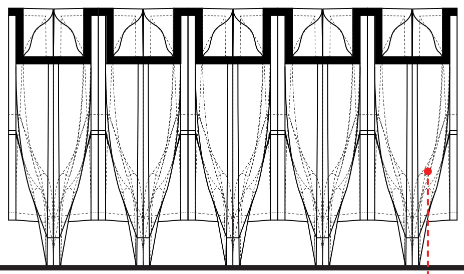
Form-Finding

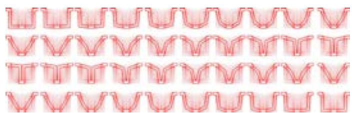
EMERGENT FORM: Computational Design Methods
STUDENT WORK: Design by J.Bernal, M.Mandra, S.Sipahi
[duration: 4 weeks]



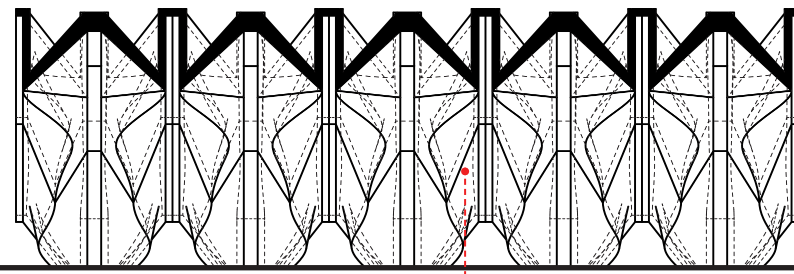
Adjustable **Casts [case-study: Sydney Opera House Concourse Beam, Jørn Utzon]**

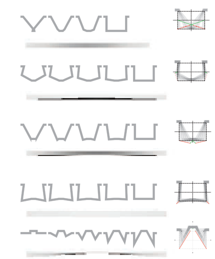
I





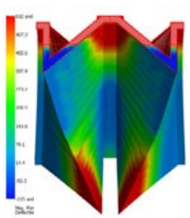
II





Beam Studies
Prototype I: Sydney Opera Moment Beam (concrete)

Prototype II: Sydney variation >> Bifurcation (concrete)



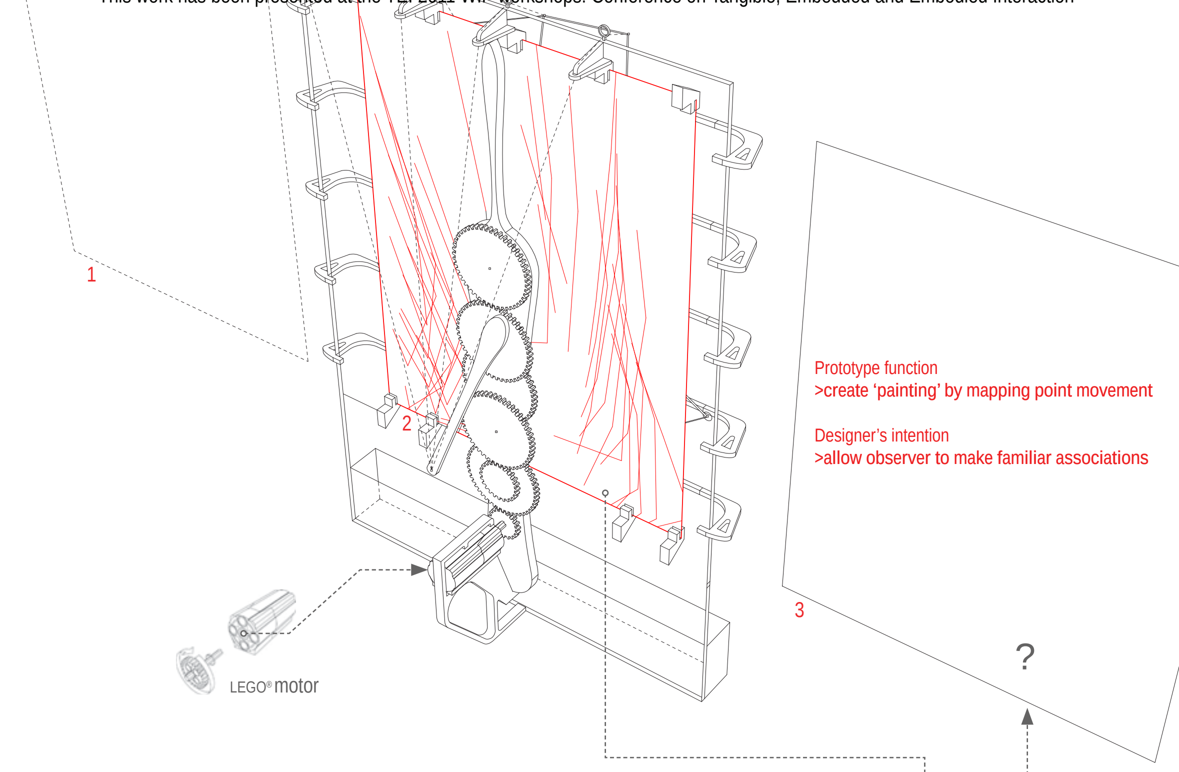
Mold Studies:
Adjustable Mold for Casting

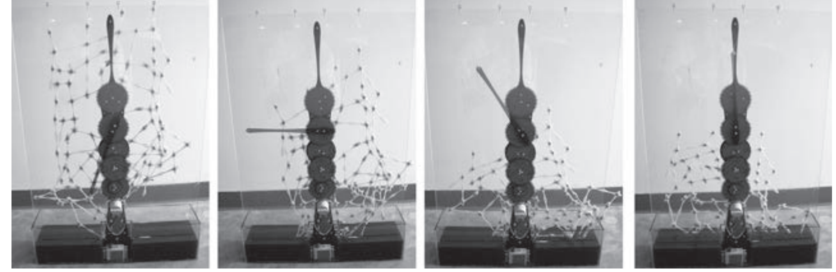
teaching + research (non-trivial machines)

Digital Fabrication: The Indeterminate Canvas

STUDENT WORK: Design by A.Wright, L.Turek, R.Downing & E. Vermisso

* This work has been presented at the TEI 2011 WIP workshops: Conference on Tangible, Embedded and Embodied Interaction



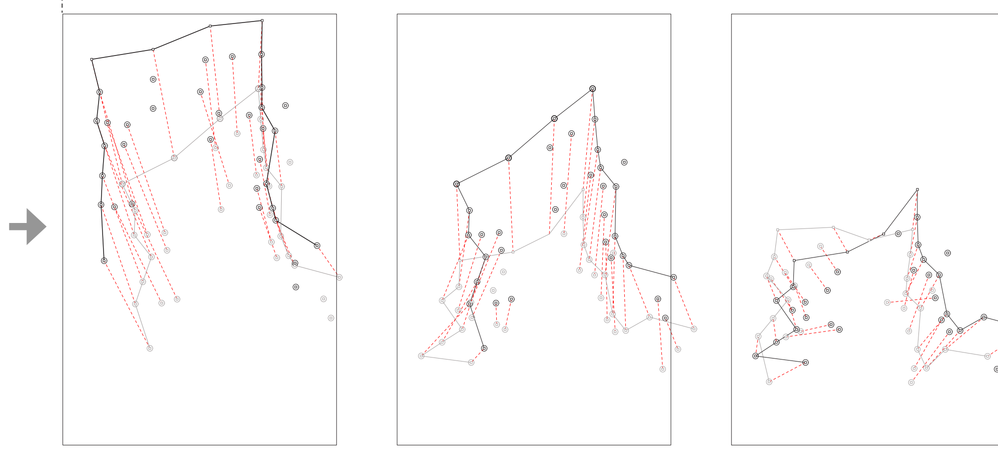


This project examines the interrelationship of moving assemblies of a familiar geometrical shape from which unfamiliar patterns gradually emerge. An installation creates a series of 'paintings' by visually mapping the trajectories of the joints of a grid assembly. The grid joints - submerged in a mix of graphite and engine oil - come in contact with a blank canvas to produce a "drawing". The machine is triggered by subsequent users, producing a unique drawing every time. The installation addresses design from a cybernetic (as "**feedback**") and architectural perspective (as "**ornament**").

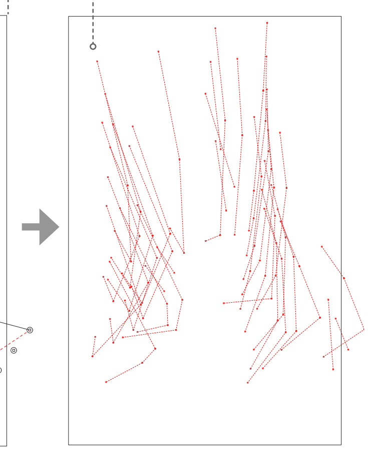
On an architectural level, the machine can operate in the form of an assembly rolling over a blank canvas, spread along the walls of a room (similar to an Entablature). Considering the machine's end product in isolation, the sequential nature of the drawings creates a relatively continuous output that may be viewed from an aesthetic perspective as a type of "ornament". Although early rationalist cybernetic theory regards Architecture independent from the user, more recent views embrace the phenomenological aspects of experiencing space. Von Foerster's distinction of machines into "trivial" and "non-trivial" identifies the simplicity or complexity that a construct can manifest to an external observer. The kinetic nature of the project relies on the use of simple (Lego®) or programmable (Arduino-servo) actuation. By integrating responsive technologies, the reciprocity between user and the installation output allows for a shifting cognitive appreciation: time is critical in the performance of the machine, as it allows one's perception of the system to change through the insertion of pieces that affect the machine's operation: such elements can change its behavior from a system of unexpected output to a more predictable one. The process itself can change from "trivial" to "non-trivial" and the final drawn canvas is essentially a product of a non-trivial process, with specific identifiable elements that make its operation trivial for certain periods. Considering Philip Ursprung's discussion on the importance of both the *Outcome* and *Process* of a design (Ursprung 2008), ongoing work will consider if the machine's process should be internalized (hidden) or externalized (exposed), as this can radically influence one's experience. Furthermore, assessment of intuitive versus rational user response towards the machine needs to be examined. *Can a 'technically augmented system' enhance our phenomenological perception of the space it inhabits?* We believe that people with higher activity on the left brain hemisphere may relate to the "process", while those with dominant right hemisphere may instinctively prioritize "appreciation of the outcome".

KINETIC DRAWING MACHINE

DRAWING PROCESS



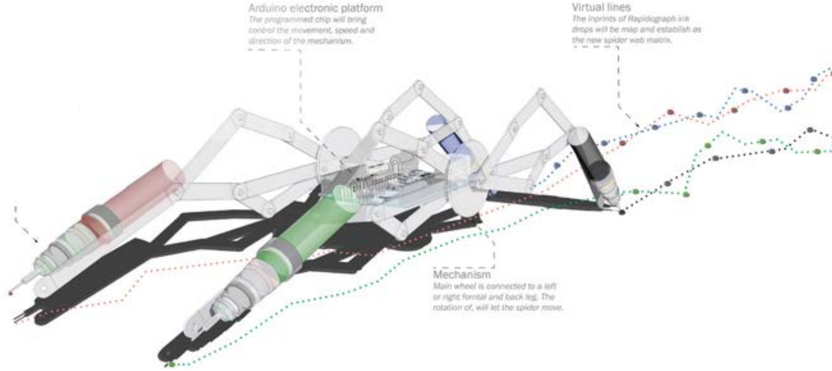
RESULTING PATTERN

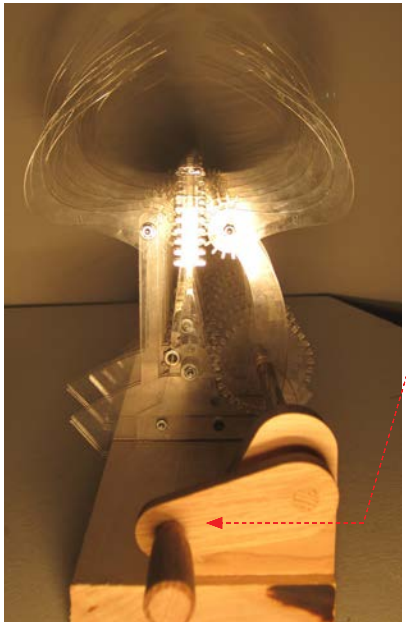


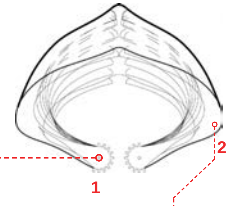
teaching + research (biomorphic design)

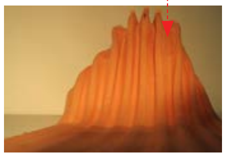
Fabricating Interactions Exhibit: Kinetic Prototypes

STUDENT WORK: design by J.Brandes, S.Brown, L.Campbell, J.Chong, L.Croca, P.Diaz, M.Fernandez, I.Fomina, M.Goodwin, J.Hernandez, D.Inn, P.Kondziola, A.Ross, B.Roberts, B.Wilson



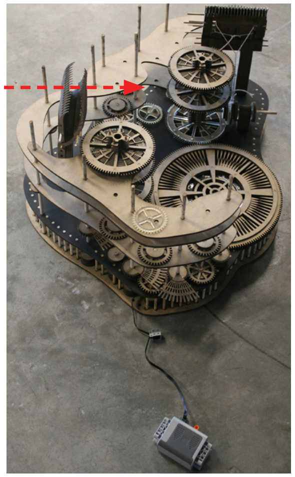




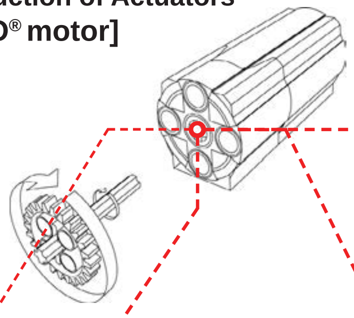


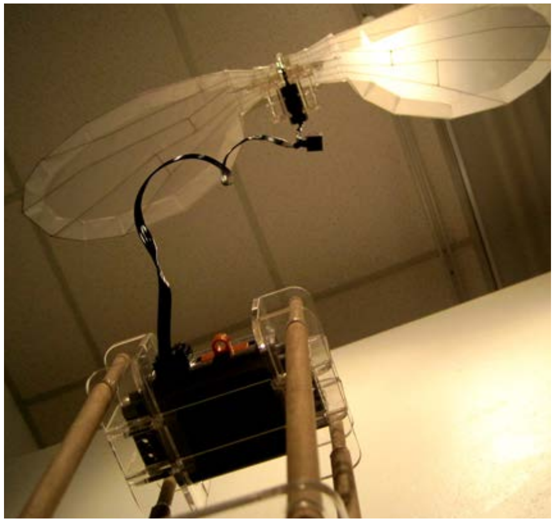
Prototype exploring flexibility during rorqual whale feeding

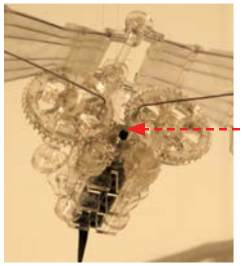
Venus-fly trap machine



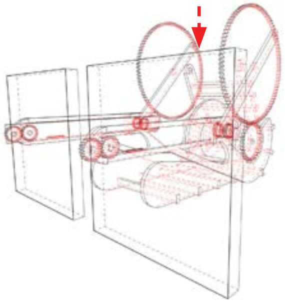
Introduction of Actuators [LEGO® motor]

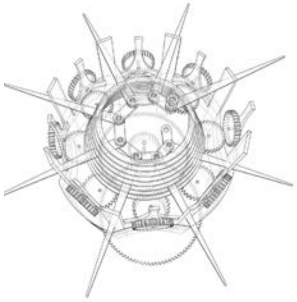


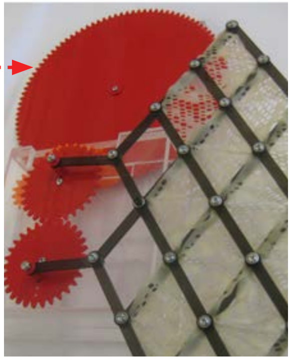




Fruit Fly Robot Installation within 2nd Avenue Gallery







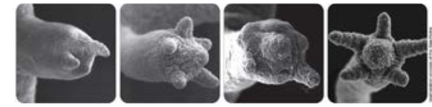
Expanding skin prototype

teaching + research (biomorphic design)

Morphallaxis: A process of structural growth

STUDENT WORK: Design by M.Elder & E. Vermisso

* The project was presented during the CAAD Futures 2011 Conference in Liège, Belgium

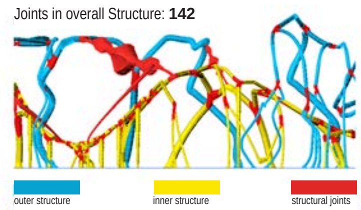


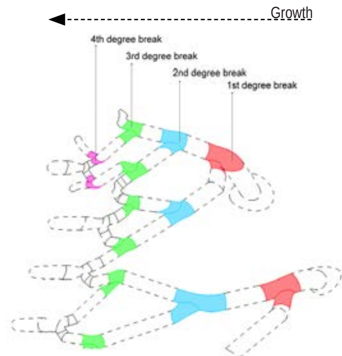
failure → *structural propagation*

The conceptual premise for this project lies in an ancient Greek myth which involves a serpent (Lernaean Hydra) that could regenerate and multiply its heads once they were severed by "Hercules". The marine organism 'Hydra' uses a similar process as a defense strategy: it can restore tissue due to loss or death of existing one, through a process known as 'morphallaxis'. This biological property is the guiding principle towards designing a structural system that manifests regenerative behavior to remedy structural failure. The responsive aspects of the project are still under consideration, while we have established a "growth logic" that can be applied as a design guide: A speculative structure has been designed (grown) within a designated shape (context). Relating to the behavior of the Sea Hydra, the morphogenesis was affected by two spatial layers, what is referred to as 'inner' and 'outer' context (endoderm & ectoderm).

The possible advantage of such a system is the improvement of a structure's behavior as a result of its tendency for failure. Every time a break might seem likely, the damage component will break off, and that joint will grow into multiple, subsequently scaled members, affecting the formal qualities of the overall system in this way. Within a biological context, we wish to consider the analogy of the programmed death of mitochondrial cells, known as "apoptosis". Specific cells in the organism commit suicide to avoid likely cancerous mutations, thereby protecting the overall integrity of the system (similar to Hydra's behavior).

The design process began by developing a manual algorithm that relied on a sequence of actions that were triggered by the use of topological "thresholds" along a linear direction. This project will assess the resulting structures derived from this process, examine the process itself, discuss current development and propose a course of future evolution. Considering the tight integration of formal, structural and material properties present in natural systems, we would like to improve the growth algorithm based on prior performance analysis (CFD or FEA simulation). Using quantitative results we could affect the early stages of growth and develop the algorithm based on material properties and contextual behavior. These results could subsequently be compared with the original algorithm of growth based on thresholds. We believe that a growth process relying on previously acquired data may yield a more honest approach that approaches the integration that yields the robustness of natural systems.

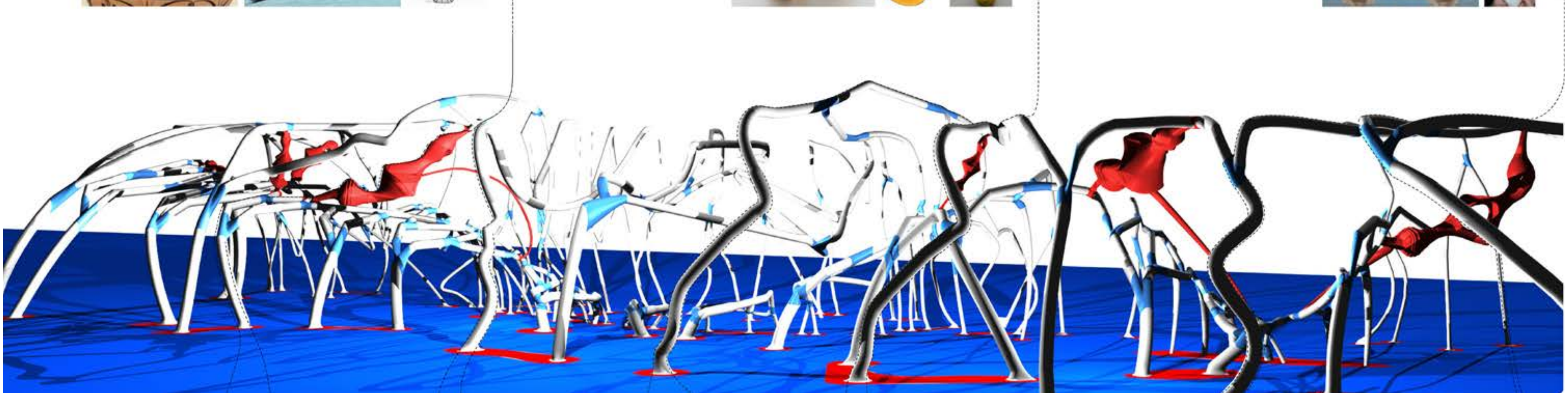




Concept

Design

Fabrication

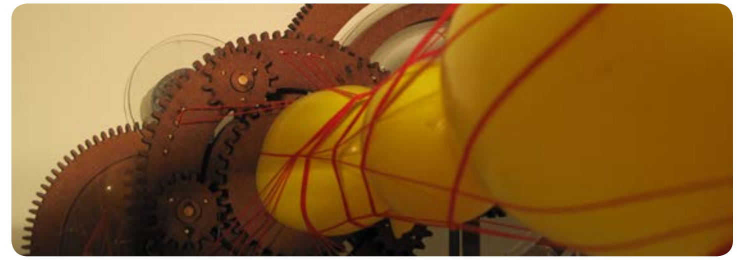


teaching + research (biomorphic design)

Bio-Prototypes: The Fibrous Structure Machine

STUDENT WORK: Design by M.Rega, A.Steffen, D.Arencibia & E. Vermisso

* This work has been published in the International Journal of Architectural Computing (issue 03, vol.10, Sep.2012)



***Precedent:** Nature/ Biology*

[Abstract]

The project discussed here was developed during a six week research & design seminar on biologically inspired prototyping (the project itself lasting four weeks). Based on the observation that nature produces infinite structural and formal configurations through re-cycling of only one material (fibers), a 'machine' was designed that would fabricate complex shapes using a variety of thread types. To understand the biological significance of fibers, one can look into the human anatomy of athletes and the fiber evolution within their body.

Types of Fibers

The fibers in the human muscles are divided into two main types: Slow and Fast twitch. **1. Slow- twitch** (ST or Type I) fibers are identified by a slow contraction time and a high resistance to fatigue. Structurally, they have a small motor neuron and fiber diameter, a high mitochondrial and capillary density, and a high myoglobin content. Functionally, ST fibers are used for aerobic activities requiring low-level force produc-tion, such as walking and maintaining posture. Most activities of daily living use ST fibers. **2. Fast-twitch** fibers are further divided into fast-twitch A (FT -A or Type IIA) and fast- twitch B (FT -B or Type IIB) fibers. **FT -A** fibers have a moderate resistance to fatigue and represent a transition between the two extremes of the ST and FT -B fibers. Structurally, FT -A fibers have a large motor neuron and fiber diameter, a high mitochondrial density, a medium capillary density, and a medium myoglobin content. Functionally, they are used for prolonged anaerobic activities with a relatively high force output, such as racing 400 meters. **FT- B** fibers, on the other hand, are very sensitive to fatigue and are used for short anaerobic, high force production activities, such as sprinting, hurdling, jumping, and putting the shot. These fibers are also capable of producing more power than ST fibers. Like the FT -A fibers, FT -B fibers have a large motor neuron and fiber diameter, but a low mitochondrial and capillary density and myoglobin content.

Co-relation of machine design & biology

The project is regarded as an attempt to learn from the efficiency of biological systems; the authors would like to extract a series of 'rules' from the properties of the three fiber types, and apply these as physical drivers for the design of the machine (see chart below). The properties that seem to offer a feasible analogy are the *contraction time*, *neuron size* and *density* (capilary or mitochondrial to be determined). These could physically translate to the SPEED OF THE MOTOR, the TYPE OR THICKNESS of the threads used and the NUMBER of threads per bundle formed (that will be determined by the arrangement of thread receivers on the machine).

Note: these analogies are not actual but rather a means to establish a working method. They have been considered to a certain degree, and the authors wish to integrate these more in the future development of the machine prototype.

This chart illustrates the properties of the three types of muscle fiber and tries to make analogies with the physical application of the fiber machine herewith discussed ie. ①·····①

① Regulation of ***motor speed***
② Regulation of ***thread thickness***
③ Number of **Bundles**

Fiber Type	Slow Twitch (ie. long-distance)	Fast Twitch A (ie. Long sprint 400m)	Fast Twitch B (ie. Short sprint 100m)
① Contraction time	Slow	Fast	Very Fast
② Size of motor neuron	Small	Large	Very Large
Resistance to fatigue	High	Intermediate	Low
Activity used for	Aerobic	Long term anaerobic	Short term anaerobic
Force production	Low	High	Very High
Mitochondrial density	High	High	Low
③ Capilary density	High	Intermediate	Low
Oxidative capacity	High	High	Low
Glycolitic capacity	Low	High	High
Major storage fuel	Triglycerides	CP, Glycogen	CP, Glycogen
③ Number of Bundles	Max. allowed	to be confirmed	Min. allowed

(Slow Twitch: Adapted motor speed, fine thread; Fast Twitch A: tbc, tbc; Fast Twitch B: Original motor speed, thicker thread)

Characteristics of the Three Muscle Fiber Types (source: http://forums.d2jsp.org/topic.php?t=...)

Image references:
- Turner, S: 2007, Ch. The Joy of Socks, *The Tinkerer's accomplice, How Design Emerges from Life itself*, Harvard University Press, p.
- http://www.athleticquickness.com/page.asp?pageid=20
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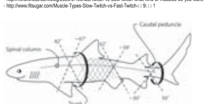


fig.01 Unhomogeneous fiber orientation in the shark's body allows for variable stiffness

fig.02 Muscle Fiber structure

a b c d

fig.0 Fiber variation in athletes: slow twitch (long-distance events 'a,b') vs. fast twitch (short-distance events 'c,d')

***Concept:** Fabricator machine*

Gear design

The human muscles consist of infinite bundles of fibers which combine to form the overall muscular mass. The smallest subdivision of the overall fibrous interconnectivity are the 'myofibrils' (fig.02). The machine presented here takes under consideration the varying scales of elements in a muscle fiber to derive the logic of its own subdivision. This is evident in the arrangement of the rotational component of the machine: it is composed of three layers of rings each one affected by the others. The largest ring holds smaller rings which in turn, have thread receivers (on each of the rings). It also features additional thread receivers spaced between the rings, each intermediate space having thread receivers. Finally, the rings are connected with a central smaller ring which holds more thread receivers. Within the robot arrangement, each thread receiver may be viewed as equivalent to a 'myofibril': a delicate minute part of a system which however becomes exponentially stronger as it is wrapped with more of the same kind to create a robust arrangement of material.

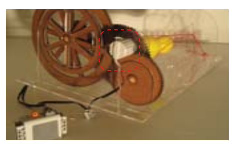
***Design/ Prototyping:** Process*

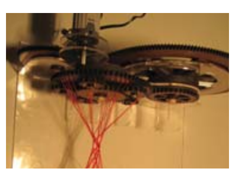
Machine operation process

The machine is fed with a ball of thread; according to the desired outcome, the string is inserted into one of several holders. This defines the density of the wrapped surface and ultimately the strength of the cured lattice model. The threads from every small ring are wrapped with each other to form bundles (a similar bundling occurs in natural muscle fibers) and are subsequently wrapped around the shape which is used as a 'guide'. The greater the number of revolutions, the more densely the arrangement of these threads and therefore the stiffer the resulting form. Originally designed to work with thread alone, the prototype is also able to wrap fibers around pre-selected objects. As a result, the creation of intertwined threads operates on three levels to create skeletal shapes (see chart *a,b,c* above).

Actuator

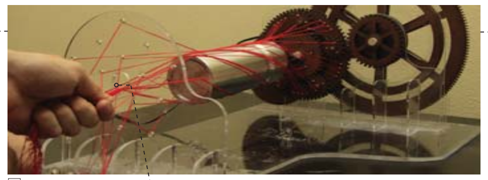
A large Lego motor was used to power the machine. Due to the predetermined speed in this type of motor, the students designed a set of gear relations to slow the motor down to a speed which allows a 'controlled' wrapping of the threads.





Gear relations for speed reduction (http://www.tpub.com/content/engine/1 0 7/css/1 0 7 1.htm)

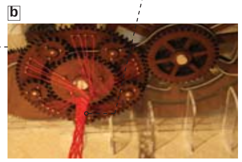
Lego Motor used in the threading machine



a

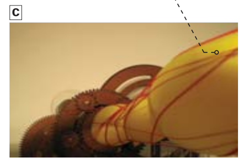
- **a.** Bundling of threads around a hard substance ie. an existing object or a laser-cut/ CNC-milled shape
- **b.** Bundling of threads with themselves (unknown result)
- **c.** Bundling of threads around a soft inflatable substance ie. a balloon (known but modifiable result)

b



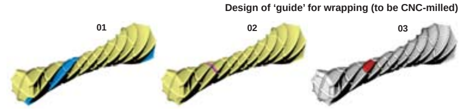
Mechanism/ wrapping threads with each other

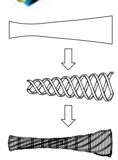
c



Wrapping threads around tied balloons

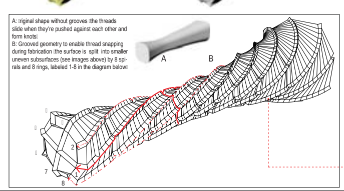
Design of 'guide' for wrapping (to be CNC-milled)





Process for creating a shape to predict thread wrapping

A: Original shape without grooves (the threads slide when they're pushed against each other and form knots)
B: Grooved geometry to enable thread snapping during fabrication (the surface is split into smaller uneven subsurfaces (see images above) by 8 spirals and 8 rings, labeled 1-8 in the diagram below)



***Application:** Structural shape studies*

Layers of Fabrication

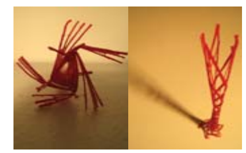
The fabrication process using the machine can be considered as a 'phased' process: the primary layer is the fabrication (or selection) of the molds/guides that will dictate the wrapping. The secondary layer is the threaded shape, while the tertiary layer is the end-result after curing the soft threads with epoxy resin.

Epoxy-Cured shape detached from machine: sets of threads each constitute a total 20 threads wrapped to form the skeleton.

***Concept:** Research Scope*

Resulting Prototypes & Materials

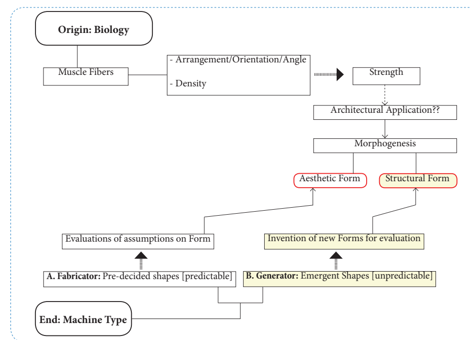
The thread models are too fragile to test structurally in their current condition so they need to be reconfigured to be stronger and possibly larger. The thread properties (we used cotton) are critical for the integrity of the shape so in the future we intend to test Carbon-fiber.
(Current material: Cotton thread- Future material: Carbon-Fiber)



The cured threads form a free-standing shape; the 'end' condition (their release from the machine) requires refinement.

Schematic Representation of Project

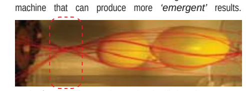
The schema below demonstrates the logical procession of the project (A) and the athor's intention to expand towards another path (B) that to our opinion is more beneficial as it may provide results that are not entirely known or predictable.



***Development:** Machine Evaluation*

Character: Generative vs. Fabricator

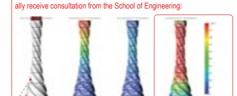
From the students' re-interpretation of fiber layout as observed in natural systems we have been able to create a model-making machine for complex three-dimensional lattice assemblies which are self-supporting. The current model raises questions about optimizing the production process to obtain data with potential Architectural value, ie. anisotropic structural properties: this trait is commonly found in organisms in the form of 'variable stiffness collagen' (see 'caudal peduncle' of the shark - fig.01). A large prototype can possibly allow some experimentation and testing of components which can display such properties relating to a non-homogeneous fiber arrangement quite analogous to the one shown in nature, but here applied to column or beams. Furthermore, the wrapping needs to be more controlled, and more than one material may be tested to identify versatile and affordable combinations. ie. silicone can be a substitute for epoxy resin - can this give lattice forms which are slightly flexible (elastic)? Finally, the CHARACTER of the machine is a critical factor in determining how successful the results are; the process followed (A) can yield forms that are structurally efficient but is not generative (B). As a result we need to make a second generation of this machine that can produce more *'emergent'* results.



Knotting formed during wrapping needs to be eliminated

Factors that influenced machine operation and are being considered for future optimization:

1. Rules of operation
(Make a qualitative assessment of the first machine generation to identify the rules of operation).
2. Scale of machine/ Scale of Prototypes (needs to be increased so that the resulting models are larger (and strong enough) for testing)
3. Control of thread feed to avoid knots
4. Design Additional accessories to enhance the machine's possibilities.
5. Testing method for resulting prototypes: FEA Analysis(?)
(To apply iterative tests requires an understanding of the behavior of fibrous structures; the current skeletal shapes are too complex to run Finite Element Analysis, so the authors are considering doing structural analysis on a series of possible 'guide' shapes that are used for wrapping. Once they have defined the more efficient shapes, these can be milled and used in the machine. The second generation of the machine is being designed with the scope of yielding results that are not pre-determined and will ideally receive consultation from the School of Engineering)



Example of FEA analysis on a 'guide' shape made of 'AISI 1018' grade Steel (Cold Drawn): considering the possibility for a high-rise structure, a vertical Force was applied on the top face of the shape, while the base was restrained (note: visual data provided is an indication of future development and not for data acquisition)

References
- Geronimidis, G: Bioinspiration for Engineering and Architecture, in Silicon+Skin: Biological Processes and Computation (Acadia 2008 Proceedings), Minneapolis 2008.
- Turner, S: 2007, The Tinkerer's accomplice, How Design Emerges from Life itself, Harvard University Press
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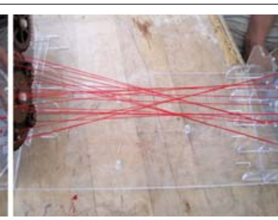
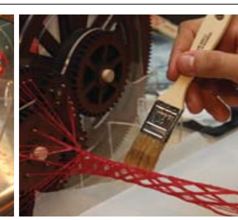


Machine Operation demonstrating the wrapping process

Thread wrapping around a single balloon



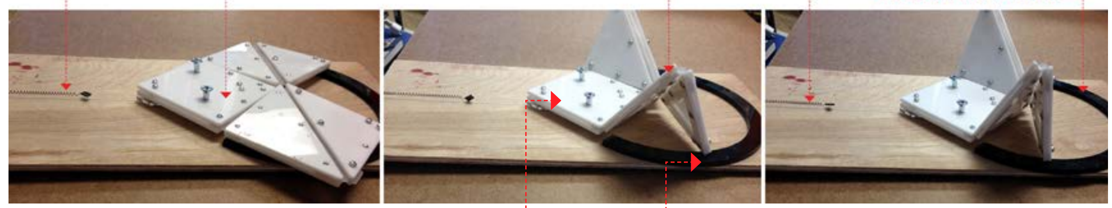
Applying epoxy resin on wrapped threads

teaching + research (Parametric Modeling &Physical Computing)

PERFORMATIVE PARAMETRIC DESIGN: Passive SMA-controlled facade system

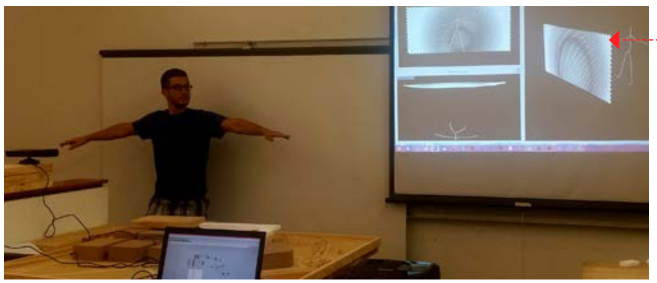
STUDENT WORK: Design by A.Martinez, J.Bernal, J. Llampay & E. Vermisso, co-instructor: M.Thitisawat
[duration: 4 weeks]

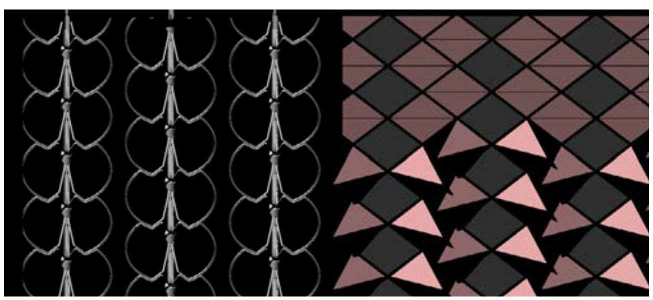
* The project is scheduled for presentation at the Advanced Building Skins 2015 Conference in Bern, Switzerland.



Simulation Scenario		Real-Life Scenario	
Analogue input	Kinnect Motion Sensor: Body Movement	Analogue input	PV Panel: Solar Radiation (Heat)
Digital output	Grasshopper/ Firefly: Facade Panel Rotation	Analogue output	Shape-Memory Alloy: Contraction (Movement)

This study investigates exchanges between digital and physical computing platforms, assessing possible workflows for kinetic responsive design using physical computing platforms like Arduino. and smart materials like Shape Memory Alloys. Various configurations were considered for integrating the SMA into a physical panel system, to control the movement and augment the resultant motion caused by the wire's contraction of nearly 5% of memory strain under 15,000 psi (103 MPa) during cooling (Dynalloy). Mechanisms which allow translation of movement from one plane to another (i.e. linear motion to rotational, folding, lifting, shrinking, etc.) were also examined. The final proposal features a triangulated shape made up of squares which are connected at the ends with nylon and attached to an SMA spring at the fulcrum point in the centre. This enables maximum deflection of the material with minimal actuation of the spring. We propose to use this system for an inclined facade which uses solar gain to trigger opening and closing of the panels.



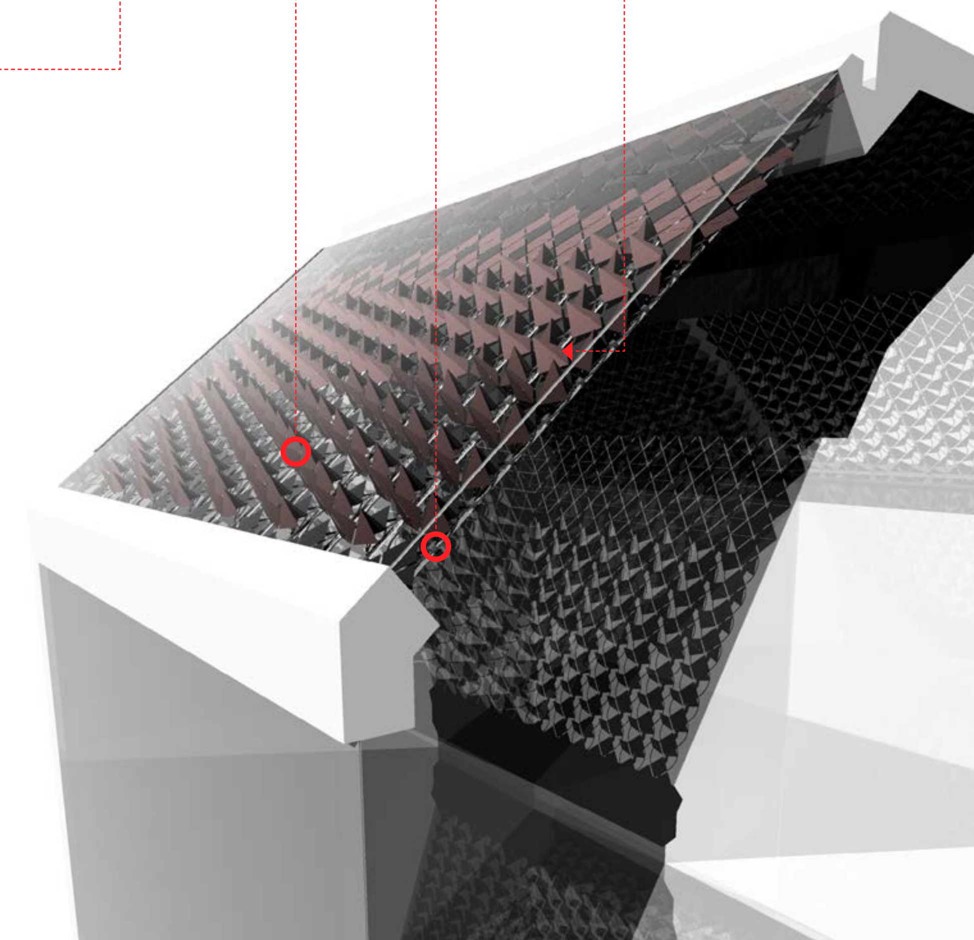


PHYSICAL COMPUTING & SMART MATERIALS

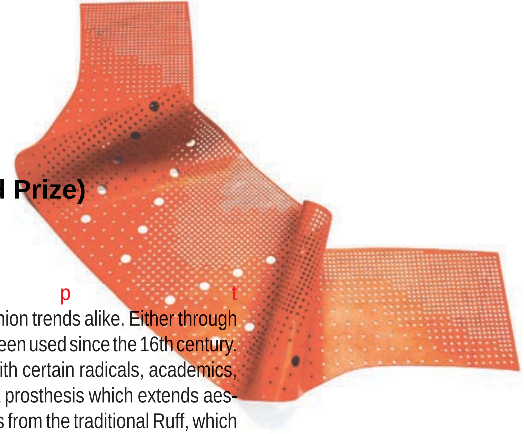
Control: Arduino micro-controller

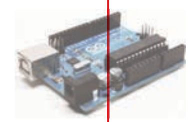
Non-Mechanical Actuation
Shape Memory Alloy Spring

Environmental Response: Passive Strategy



research (responsive wearables)





CAROTID THERMO-REGULATOR (Reshape 2015 Competition: 3rd Prize)

[Design by E.Vermisso, M.Thitisawat, H.Akers and B.Bou-Nahra]

Concept

The human cervical region has been celebrated in one way or another by historical and contemporary fashion trends alike. Either through concealment or elaborate exposure, tailored garments and accessories like the "Ruff' or "turtleneck" have been used since the 16th century. While some versions of the former denoted an aristocratic provenance, the latter has been associated with certain radicals, academics, philosophers, intellectuals and politicians. This project aims to re-imagine this area of the body through a prosthesis which extends aesthetic preoccupation to consider thermal comfort scenarios and their visual expression. Our premise stems from the traditional Ruff, which evolved from a small neck piece to high ruff or collars during the Elizabethan era. Throughout history, ruffs have been shrunk or enlarged transforming into cuff and skirt through multiple evolutions, even incorporating wooden support in some of its iterations (Hughes 2011).

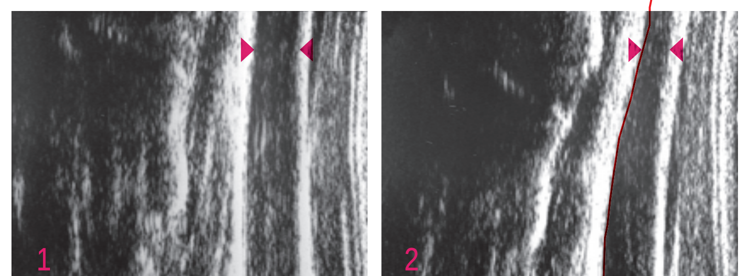
Design

Our proposed carotid prosthesis embraces physical computing and anatomical expression to create a dialogue between technology and nature. This proposal considers garment as a vessel for human thermal adaptation. Interestingly, body temperature amplitude and patterns correlate to standard biophysical incidences such as the heart and respiratory rate as well as emotion (Nummenmaa, et al. 2013; Davies and Maconochie 2009). The design includes a microprocessor, sensor, circulation control system, heat regulator and wearable enclosure. A pulse sensor's reading from the Carotid artery is used as control logic for a peristaltic pump. Fluid medium is circulated in a closed loop tubing system with an inline heat exchanger that can either collect heat from body or environment. The integration of these components within a wearable item carefully considers minimum weight and non-disruptive presence on the user. Soft materials like silicone rubber and flexible resin are employed, combining laser-cut and 3d-printed pieces to achieve geometrical complexity.

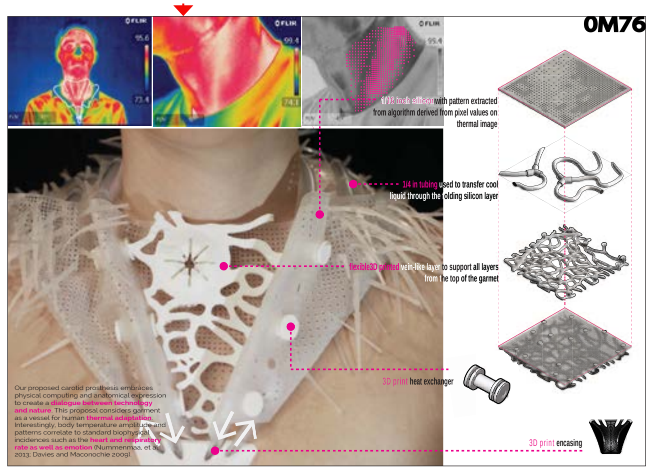
Performance

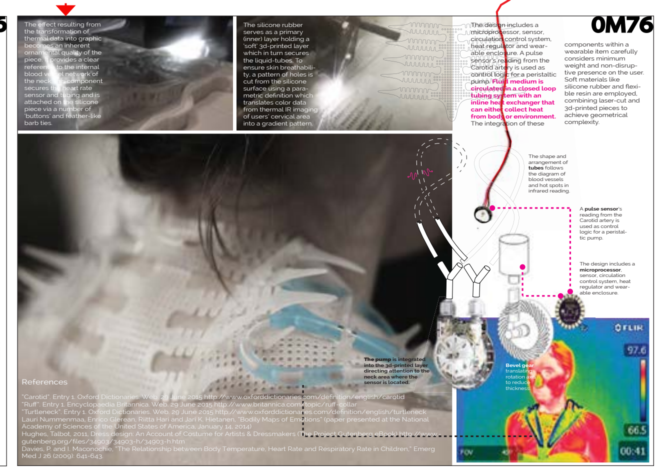
The silicone rubber serves as a primary (inner) layer holding a 'soft' 3d-printed layer which in turn secures the liquid-tubes. To ensure skin breathability, a pattern of holes is cut from the silicone surface using a parametric definition which translates color data from thermal IR imaging of users' cervical area into a gradient pattern. The effect resulting from the transformation of thermal data into graphic becomes an inherent ornamental quality of the piece. It provides a clear reference to the internal blood vessel network of the neck; this component secures the heart rate sensor and tubing and is attached on the silicone piece via a number of 'buttons' and feather-like barb ties. The pump is integrated into the 3d-printed layer in order to remove attention from that area to the higher part of the neck where the sensor is located. The shape and arrangement of tubes follows the diagram of blood vessels and hot spots in infrared reading. The prosthesis serves as a fashion statement, celebrating the importance of the cervical area as a liaison between the central body organ (heart) and the body's processing unit (brain).

Reinventing the traditional neck Ruff as a liquid translator of bodily emotion



Ultrasound imaging of Carotid Artery Pulse: Artery in Expanded (1) & Contracted (2) state
[images by R.Vermisso]

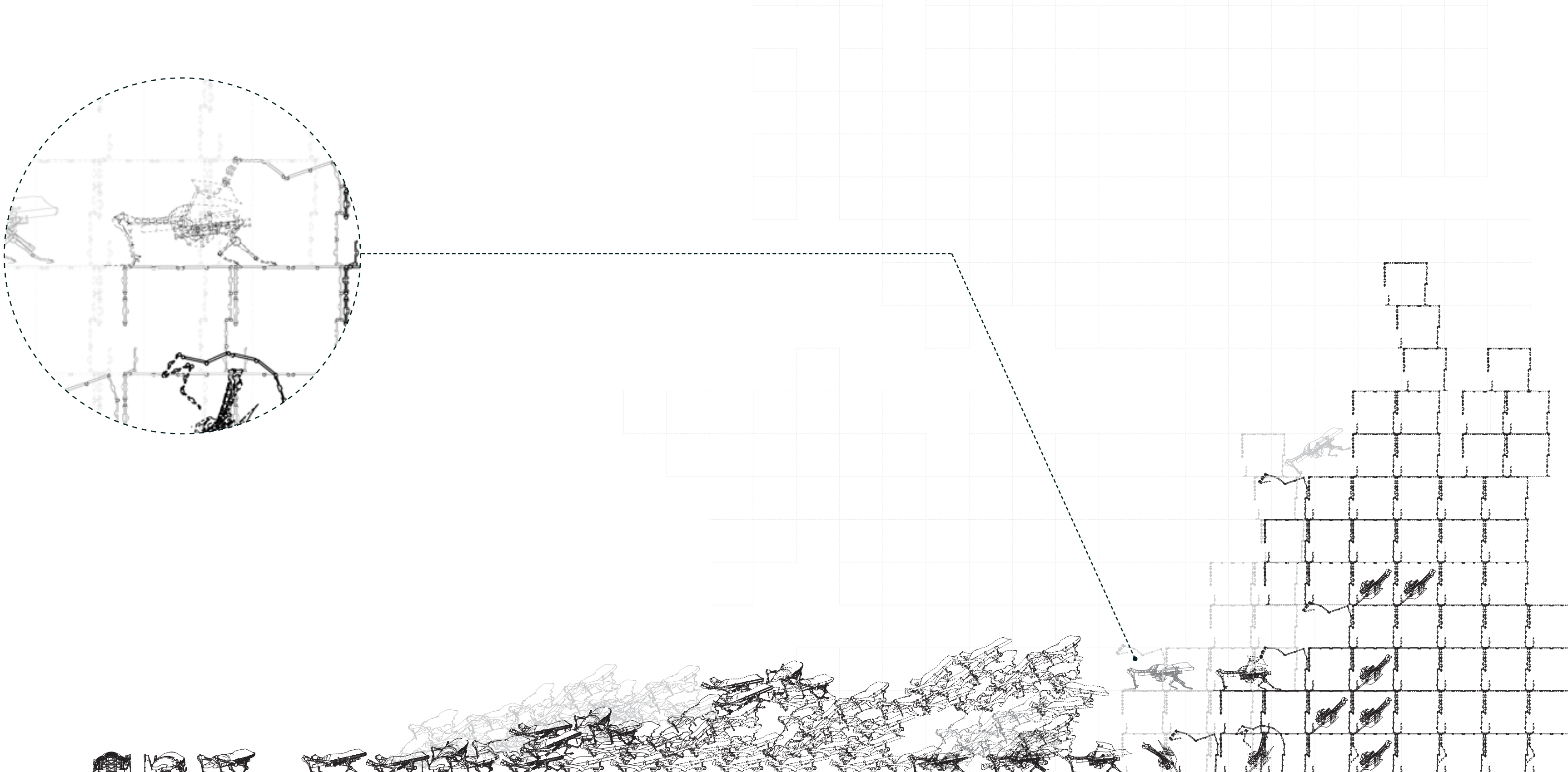




research (self-organization)

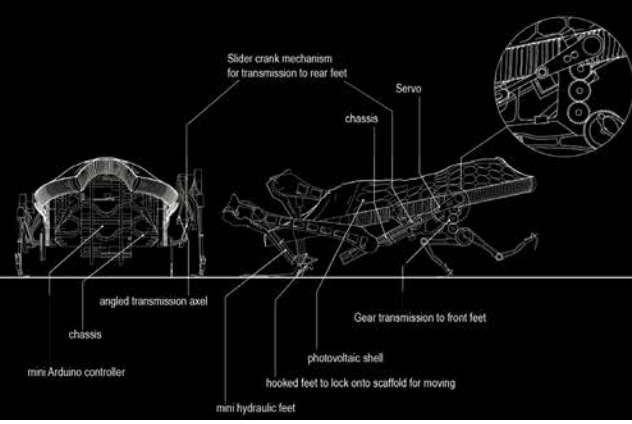
Evolutionary Role of Technology : *Self-Organizing Landscapes*

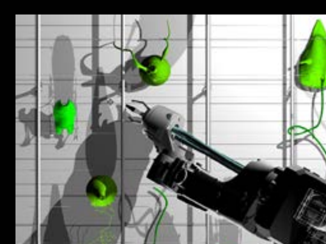
Design by E.Vermisso

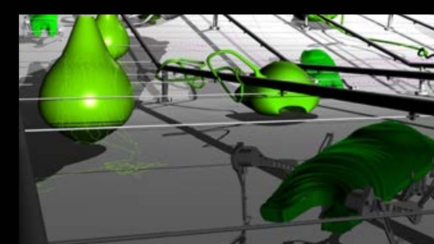


Drawing showing self-organizing behavior process of robotic agents (FAU Biennial Exhibit 2013, Schmidt Gallery)

The work discusses the stage of architectural and spatial intelligence in the near future by looking at the relationship between Nature and Technology, through the co-habitation of organic and robotic agents which demonstrate the ability to self-organize into variable spatial constructs, thus transforming our conventional experience of a 3-dimensional terrain. The agents' inter-dependence but also their rivalry in the evolutionary process is examined.

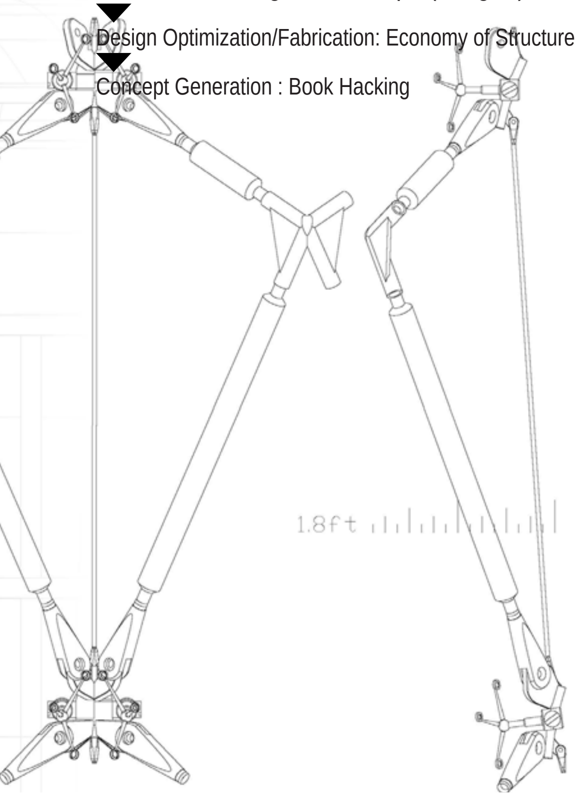




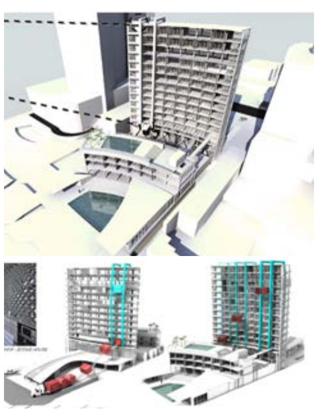
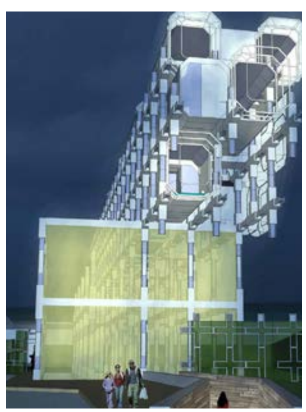


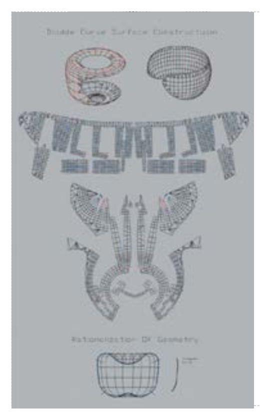
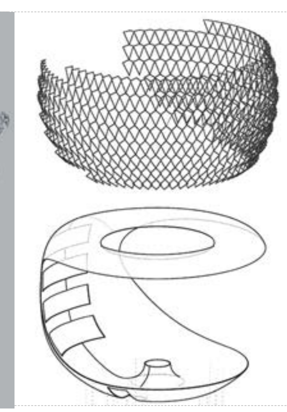
Architectural Design studio

- Future of Knowledge: Mediatheque (Design 8)
- Design Optimization/Fabrication: Economy of Structure
- Concept Generation : Book Hacking



- Ephemeral Structures: Modular Hotel in North Miami Beach (Design 7)
  - Ease of Replacement: Crane Hotel
  - Introversion of Material: Folding Skin
  - Ease of Assembly: Inflatable Pods
  - Environmental Performance: Massing from Wind Analysis
  - Detail Resolution: Design & Build Project for Modular Hotel
  - Space Economy: Rotating Pods
  - Shifting Experience: Moving Spider Pods
  - Human Response: Magnetic Facade
  - Moving Layers: Folding Balcony/Shading Screen


teaching (design & build)

Architectural Design 7: Modular Hotel Project

STUDENT WORK: design by P. Rojas, detailing with M.Zapatta & I.Fomina

[duration: 1.5+1 weeks]

Instructor Commentary:
This project negotiates issues of modular construction by looking at reconfiguring the conventional hotel typology for a proposal in North Miami Beach. The intention is to create some relative density by minimizing the surface area of hotel rooms which are replaced by 'pods'. The pods are configures as agents of multiple activities within a minimal space, by taking advantage of the overall volumetric capabilities of each pod; this happens by separating each pod into three parts: part A contains all service requirements and is fixed to the permanent part of the building. Part B is a rotating component which allows the occupant to use the space in ***three configurations: Sleep-Work-Lounge*** depending on the time of day and personal preference. Part C is a lighter construction of synthetic materials and provides a nosle type end that allows for shading and the introduction of a 'balcony' type space.

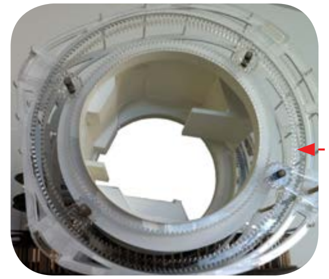
modular structure

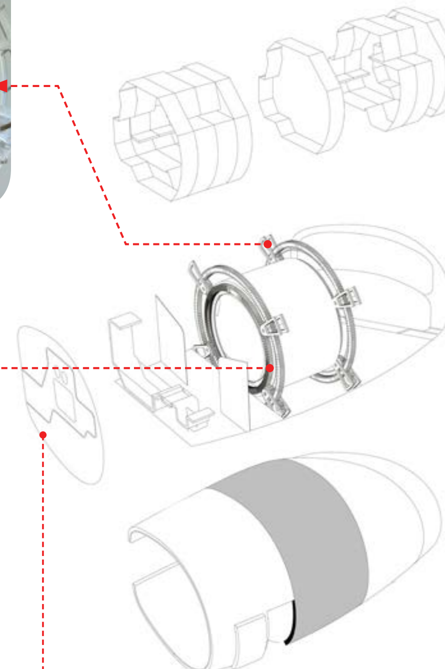
prototyping

assembly

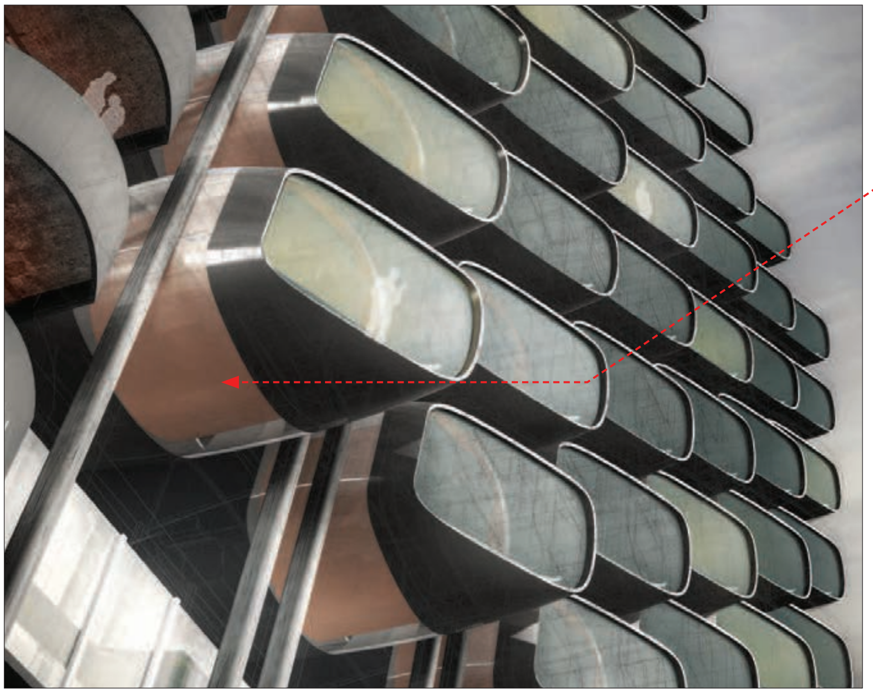
construction logistics

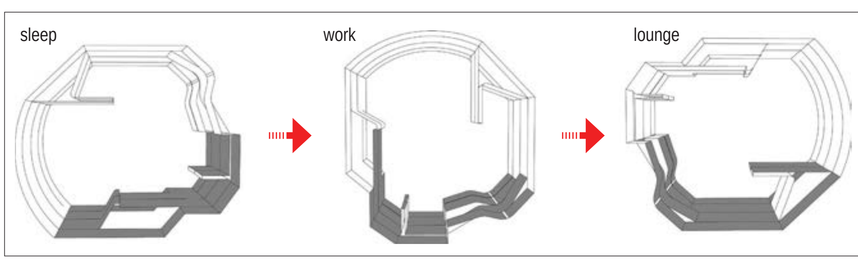
flexibility



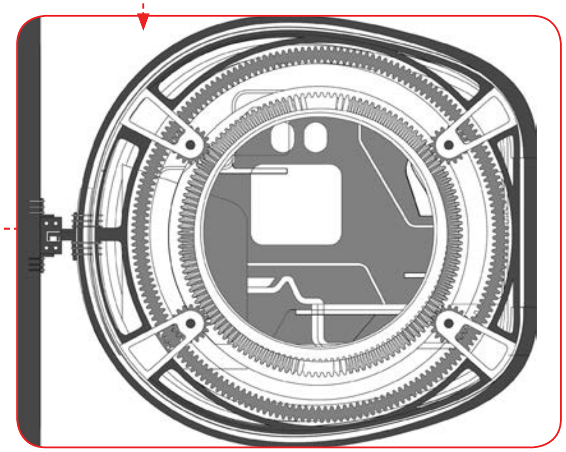


Exploded axonometric of the Pod components showing skin, furniture and rotating mechanism





Sectional Diagrams indicating activities relative to the degrees of pod rotation



Detail Section showing the rotating mechanism and pod interior

teaching (design&build)

Architectural Design 7: Modular Hotel DETAIL Project >> CLIMBING PODS

STUDENT WORK: design by C.Steixner, A.Martinez, R.Santos

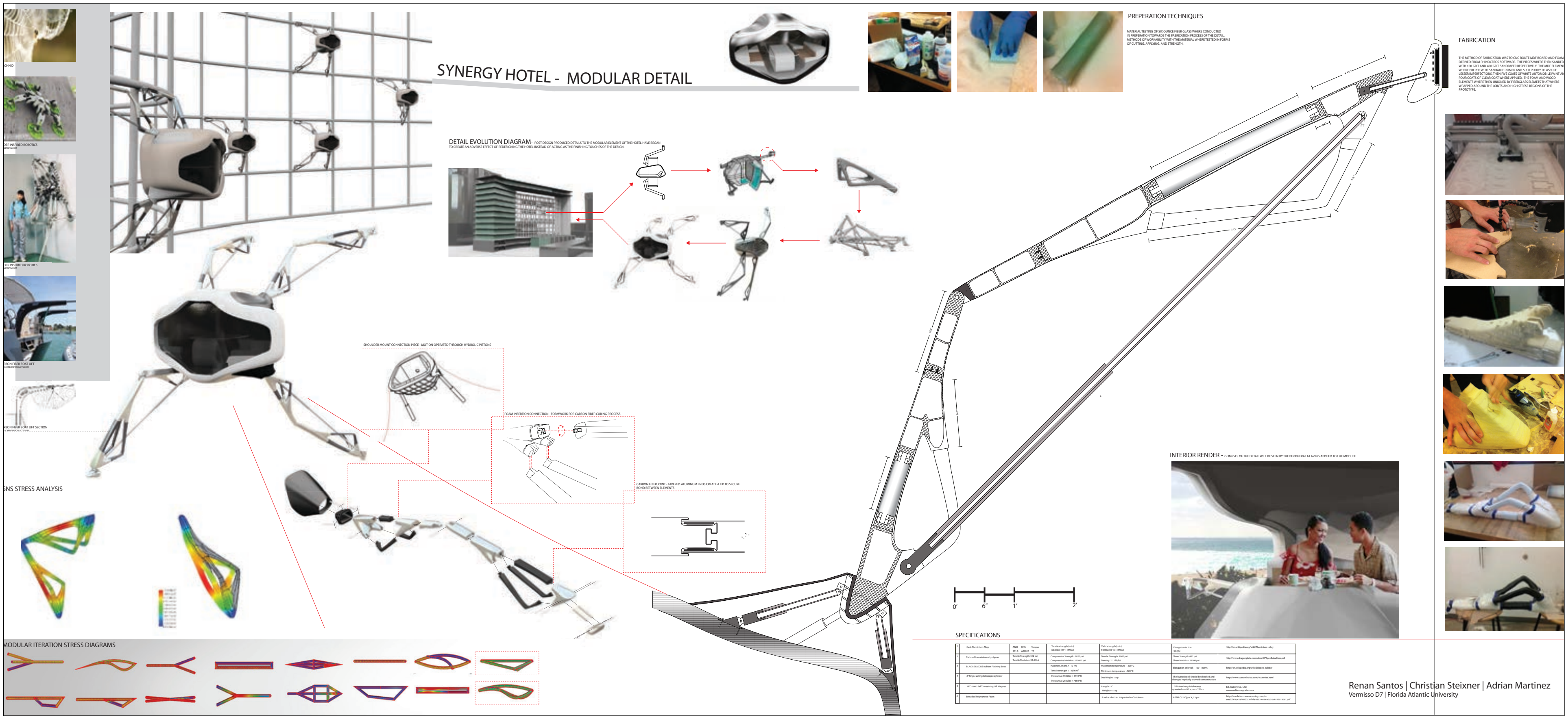
[duration: 2 weeks]

Instructor Commentary:

The scope of Design 7 is to expose students to modular building construction systems while enhancing their presentation skills. It represents an important transition from manual to digital drawing, which is initiated in the previous semester. The semester begins with a series of short iterative design projects for a modular hotel, culminating in a design and build exercise that looks at the potential of detailing as generative design tool.

This project examines impermanence and mobility in public aspects of a mixed-use program like a hotel. Intimate spaces (pods) which can function as lounge areas are proposed to inhabit a vertical facade looking into an atrium. The pods are able to move along the vertical surface using spider-like legs and magnetic locks to secure themselves. This movement, albeit not intentionally relevant to the pods' function causes a spectacle in the public lobby area, where the orchestrated movement of the pods is visible to the visitors checking in the hotel.

design → ***detail*** → ***revised design***



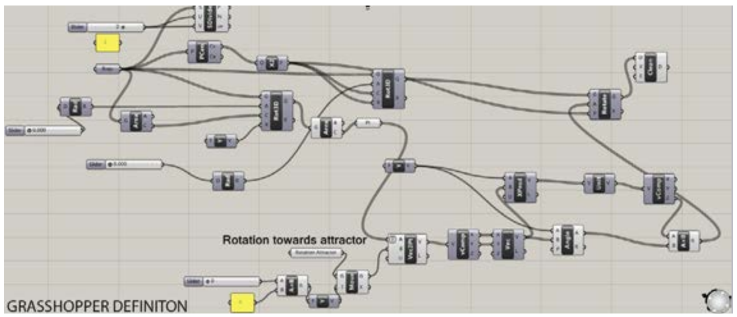
teaching (design&build)

Architectural Design 7: Modular Hotel DETAIL Project >> MAGNETIC FACADE

STUDENT WORK: design by B.Bou-Nahra, A.Luna, S.Sipahi
[duration: 2 weeks]

Instructor Commentary:
The scope of Design 7 is to expose students to modular building construction systems while enhancing their presentation skills. It represents an important transition from manual to digital drawing, which is initiated in the previous semester. The semester begins with a series of short iterative design projects for a modular hotel, culminating in a design and build exercise that looks at the potential of detailing as generative design tool.

This solution for a modular panelization facade system filters natural light based on human circulation inside the building, therefore integrating occupancy with local facade modulation. The diamond shape geometry allows for an aggregation of panels which pivot around a horizontal structural subframe. Each panel houses a set of neodymiom magnets. A larger magnet, placed on a track situated on the ceiling space above the circulation corridor, maps human presence; this causes the magnet to move ahead of residents, therefore repelling the magnets in the diamons panels and allowing sunlight inside the corridor space.



design ➔ ***detail*** ➔ ***parametric scripting***