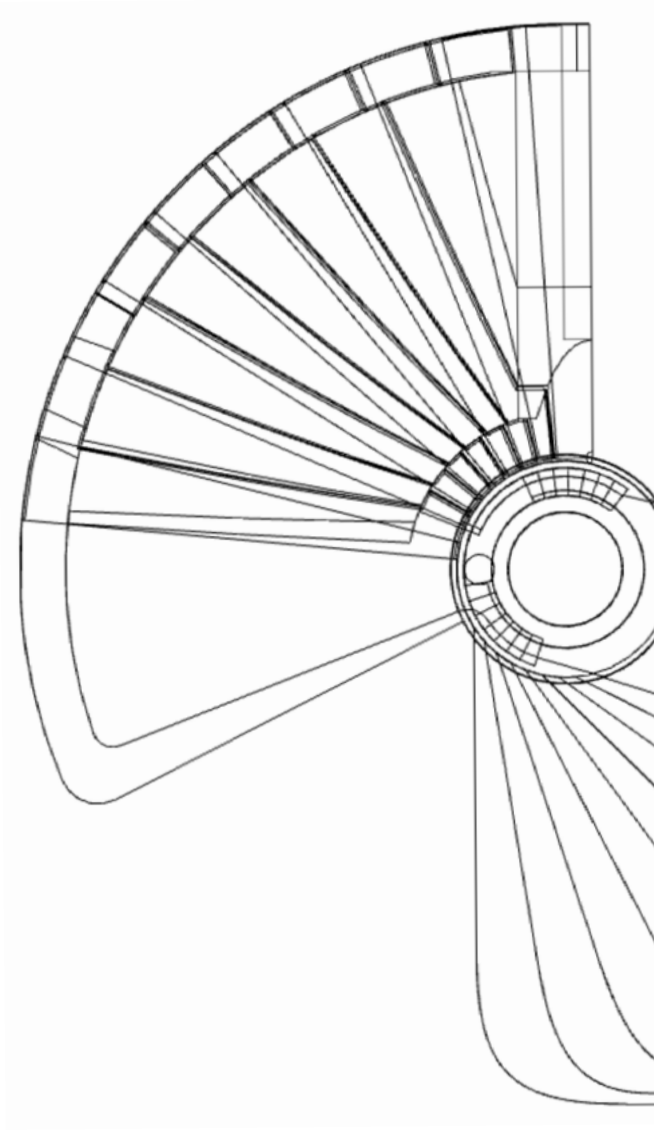
DESIGN PORTFOLIO | Explore Applications of Transformable Structures

Janet Choi



SPIN

SLIDE

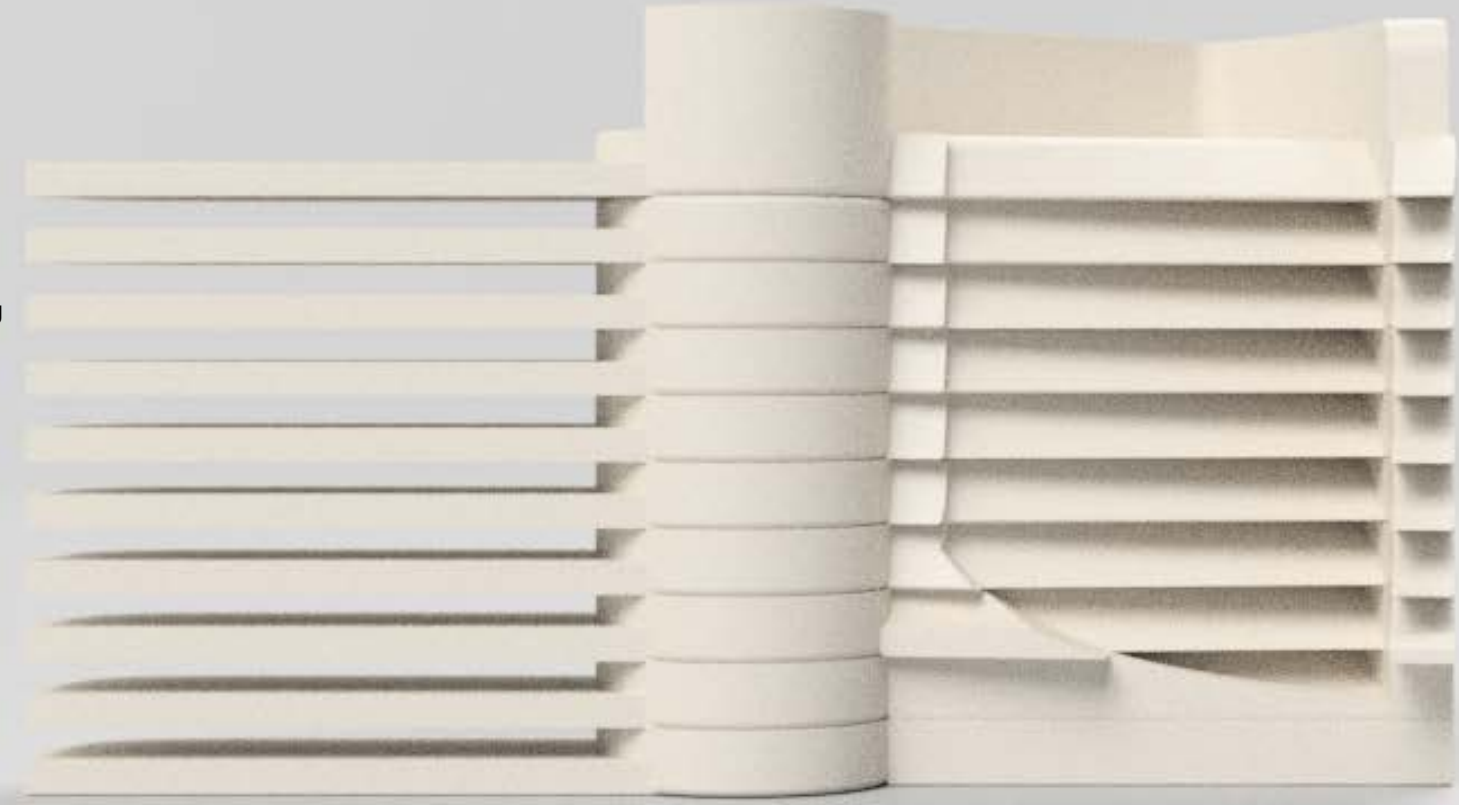
THIS IS A DOOR.

THIS IS A SLIDE.

SECURITY

Entrance for Kindergarten

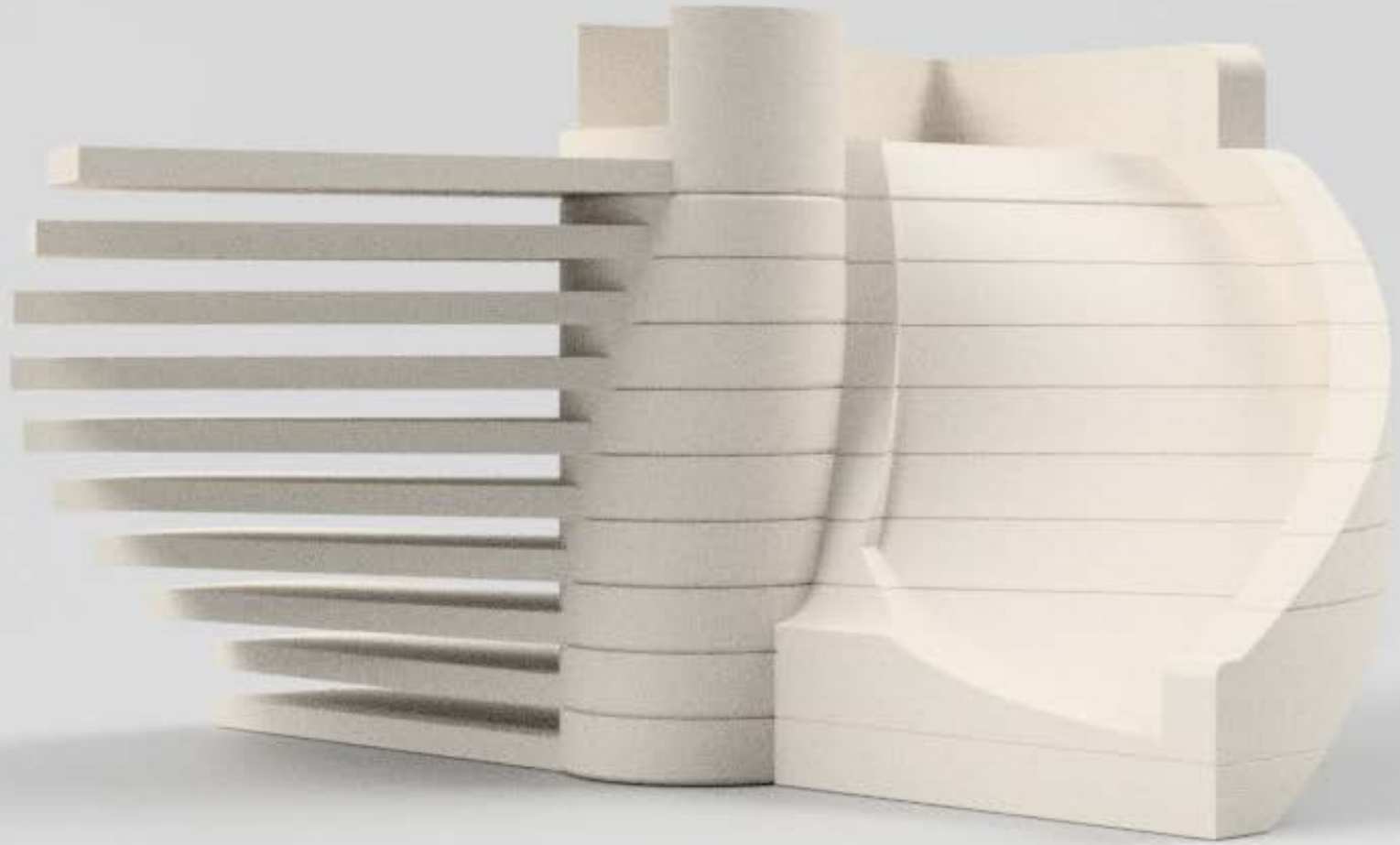
Kindergarten bring children together to study and explore. The journey starts from the entrance, transforming the entrance door to a playable installation when they go and leave the school everyday.



PLAYFULNESS

Transform Door as a Journey

Transforming by rotation, the door is transformed as a slide, with familiar interface and experience for children. The door transforms to become the part of the journey for them to go through.



RESEARCH

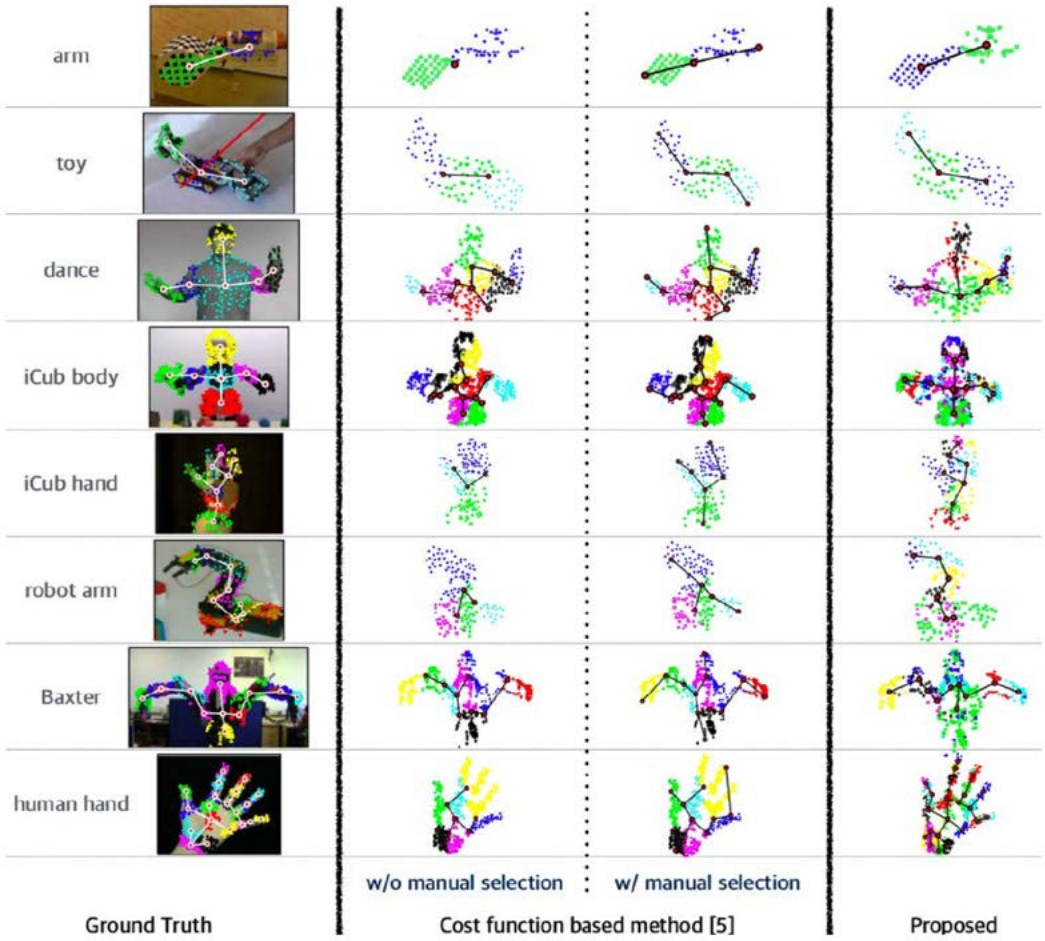
1. Kinematic
2. Kinetic Art
3. Energy Harvesting
4. Compliant Mechanisms
5. Architecture
6. Inflatable & Deployable Materials

KINEMATIC

Kinetic Transformation

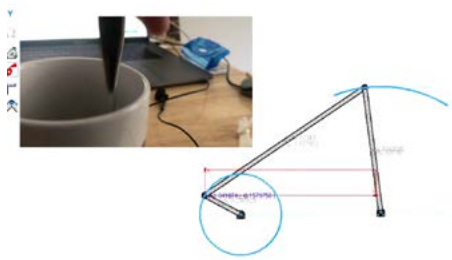
Kinematic Structures

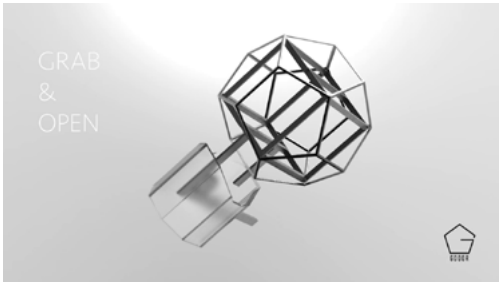
We are living in a world of motions. When you move your hand to grab your favourite chocolate bar, there is a motion path, which consists of kinetics and kinematics. Machines are developed to mimic the best way in movements to finish tasks for human, but the aesthetics of mechanics is hidden by electronics and computation. Most of these motions rely on the energy and data inputs, like electronics, motors and programmings.



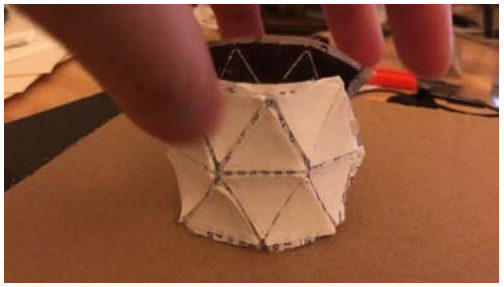
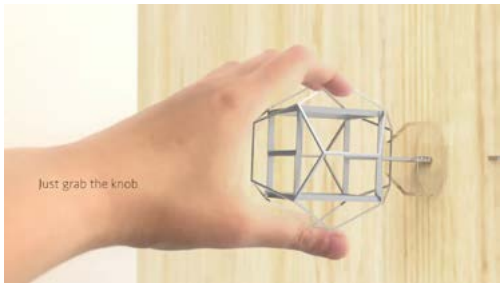
KINEMATIC

Kinetic Transformation



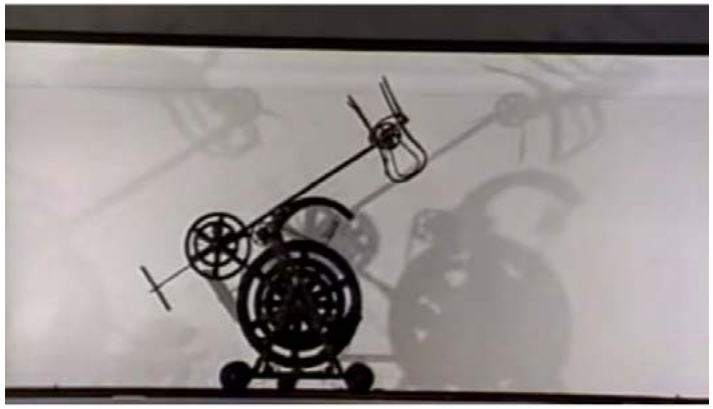
Previous Project Exploring Joint Mechanisms
I have explored the joint mechanisms in the previous project to examine the process of opening a door.

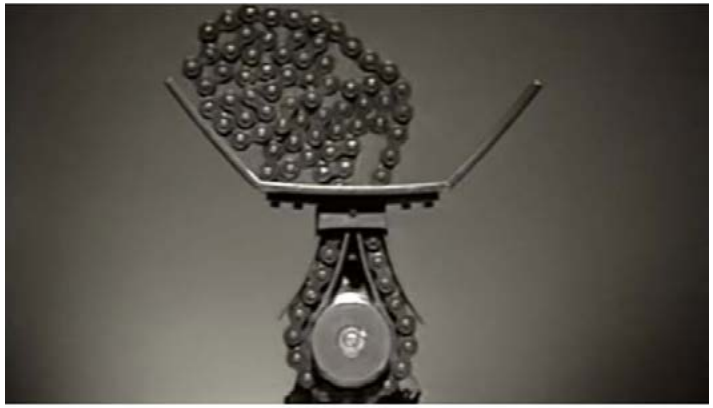
How a transformable design can enhance intuitiveness of a product design? I aim to use this door knob to skip a step in the process - just to grab and open, rather than grab, twist and open.

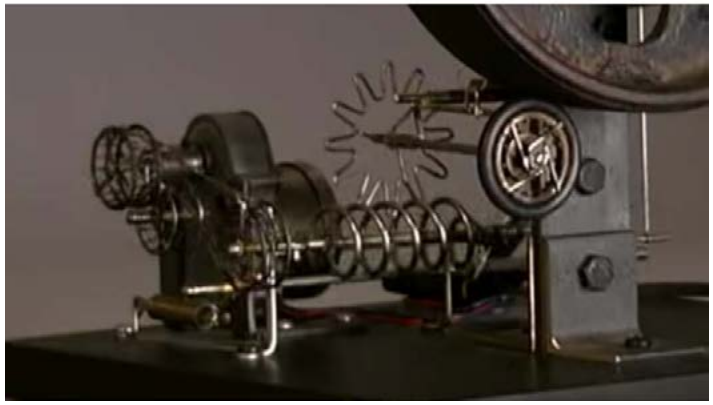
Playlist:
https://youtube.com/playlist?list=PLtDLe-TODL9E98N93zA4k3aE6-s_ZXL43r

KINETIC ART

Installation with Movements







From Imagination to Story-telling

. Inspired by nature and daily life
. Explore motions mainly with wires
. Experiment with logical flows of energy in a system

How to transform:
. Have a sense of space
. Express motions with materials
. Invent specific tools for components

ARTHUR GANSON
Artist

KINETIC ART

Installation with Movements

From Movements to Creatures

. Make the mechanisms neat and work
. Merge engineering and art - perpetual motion
. Lower friction and sound
. Experiment in both computer programmes and woodworks
. Use brass and tapes balance technique as work is not uniform
. Create wind-propelled sculptures
. Store air pressure in “walking animals”

In the process, they utilised:
. simple motion
. optical pattern
. floating motion (i.e. bird motion, combined straight line and spiral motion)
. chaotic motion (i.e. randomness)
. system of triangle
, analyze the best ways to walk
. invent mechanisms (i.e. leg systems - Jansen’s linkage)
. create artificial intelligence (i.e. survive in wild) of sculptures

DAVID C. ROY
Physicist & Kinetic Scupltor

THEO JANSEN
Artist

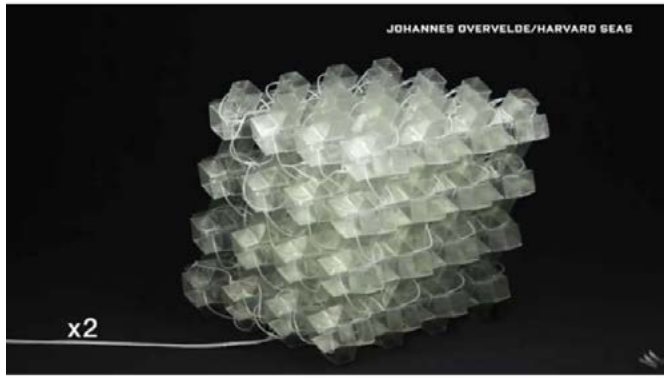
KINETIC ART

Transformable Design

From Engineering to Aesthetics

. Create transformable structures
. Input simple motion to form dynamic pattern
. Apply the designs from adaptive nanotech to flexible building materials

Methods:
. Geometry (i.e. Origami)
, Mathematics, materials and mechanics
. Programmed Paths
. Simple force input (i.e. inflation, push and pull)
. From transformation to function

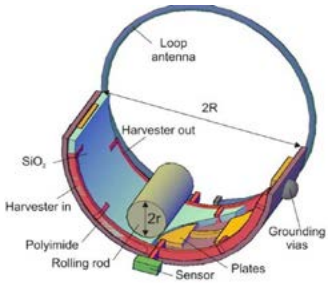


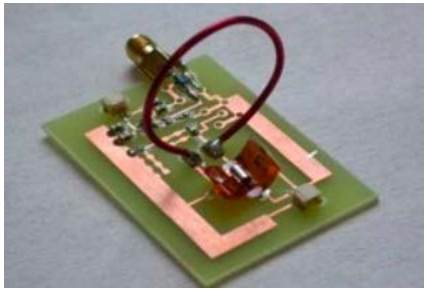
CHUCK HOBERMAN
Artist, Engineer & Architect

ENERGY HARVESTING

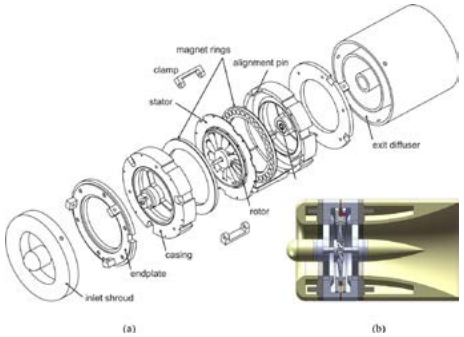
Compliant Mechanism for Human Movements

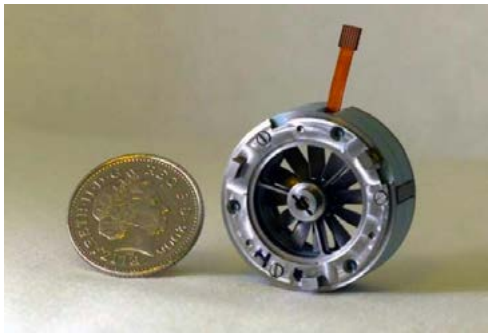
Impulse Excited Piezoelectric Generator
piezoelectric effect: rotation



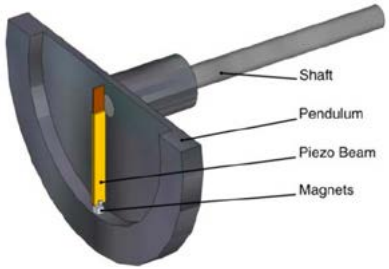


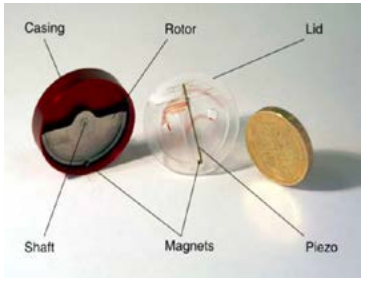
Impulse Excited Piezoelectric Generator
piezoelectric effect: rotation



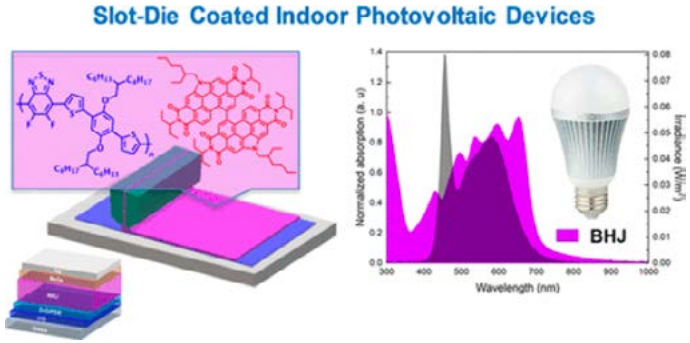


Airflow Harvesting Micro Turbine
Air-flow





Indoor Organic Photovoltaics (iOPVs)
visible light absorption: high power conversion efficiency

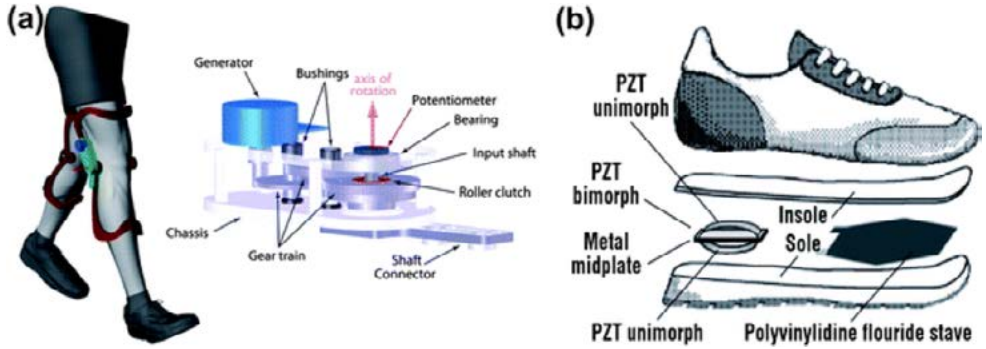


ENERGY HARVESTING

Wearable Energy Harvester

Wearable energy harvesters generating electricity from low-frequency human limb movement

Keli Li[1,2,3], Qisheng He[2,3], Jiachou Wang[2,3], Zhiguo Zhou[1] and Xinxin Li[1,2,3]



PAPER

Piezoelectric compliant mechanism energy harvesters under large base excitations

Xiaokun Ma[1,1], Susan Trolier-McKinstry[2] and Christopher D Rahn[1]

Published 9 August 2016 • © 2016 IOP Publishing Ltd

Smart Materials and Structures, Volume 25, Number 9

Chapter 4.1 - Energy Harvesting at the Human Body

Loreto Mateu, Tobias Dräger, Iker Mayordomo, Markus Pollak

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https://doi.org/10.1016/B978-0-12-418662-0.00004-0

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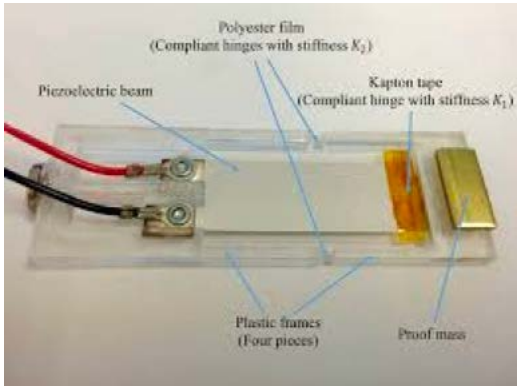
The presence of ubiquitous electronics in wearable devices carried by the user is rapidly growing, and the complexity of these devices seems to know no limits. However, one of the most important challenges on this topic is to ensure a power supply beyond the constraints associated with batteries. A solution to this problem is the development of devices capable of harvesting energy from a user's environment or body to allow unlimited operating and standby times. Either kinetic, light, electromagnetic, or thermal energy can be transformed into electrical energy. This chapter presents different energy harvesting transducers and their physical principles, as well as the power management circuits required.



COMPLIANT MECHANISMS

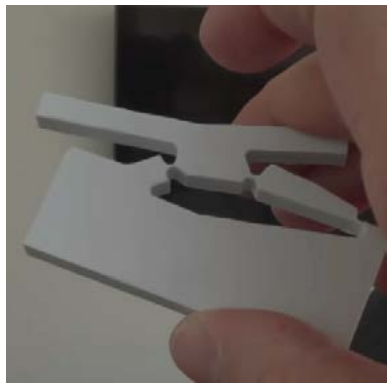
Flexible mechanism with elastic body deformation and jointless structures

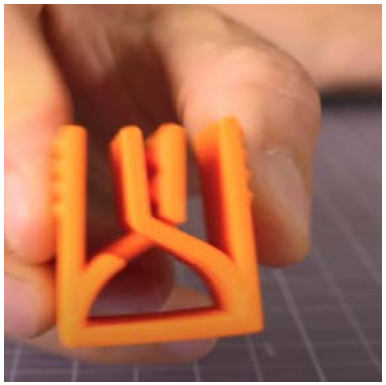
Application Problems

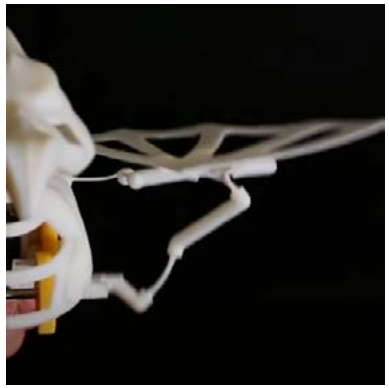
In the design process:
. Lack of design tools for artist/designer to utilize compliant mechanism
. Compared to multi-bodied structures, it required more time to design with engineering
. High accuracy in design with change in dimensions and materials

. Less components
. Less errors
. Cost and resources effective
. Higher Efficiency

. High stress concentration
. Maintenance problem
. Limited change in material and size
. Limited application on design that requires continuous motion





ARCHITECTURE

Historical Studies on Doors







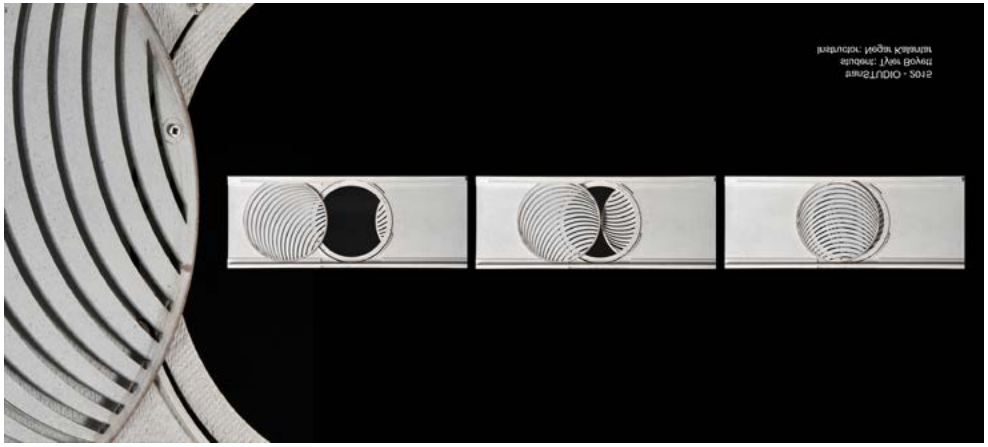


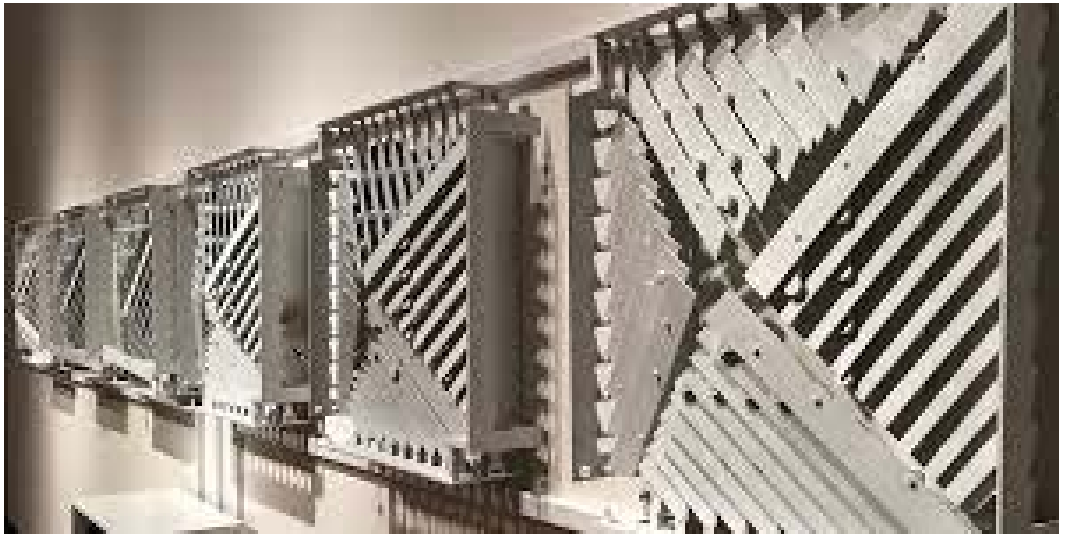

In Chinese Architecture, different shapes and lattices of door were used to harmonize the environment, establish the style and imply the status of the house owners.

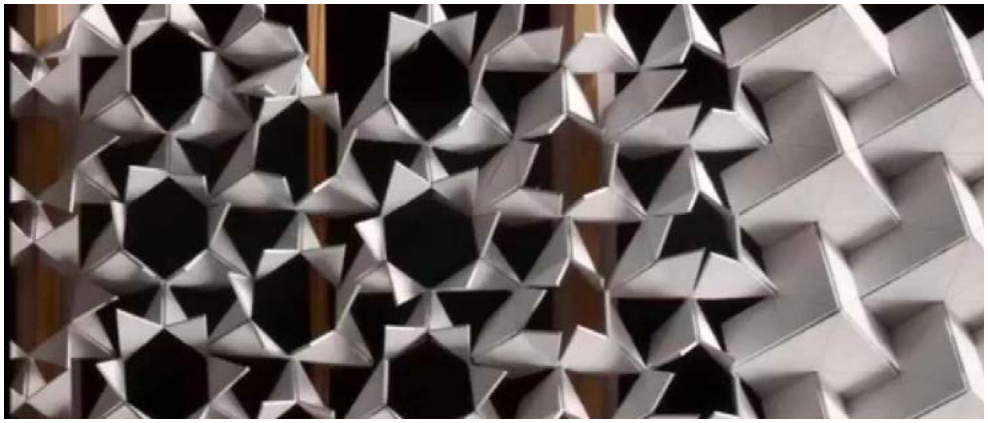
https://madoken.jp/en/research/windows-in-chinese-architecture/3506/
https://courses.cit.cornell.edu/dea668/entries_elaine.html

ARCHITECTURE

Transformable Architectural Structures







Application on Windows

. Designed with Geometric Patterns
. Rotations and Joint Mechanisms
. Design process of transformable windows
. Geometry pattern to moving parts

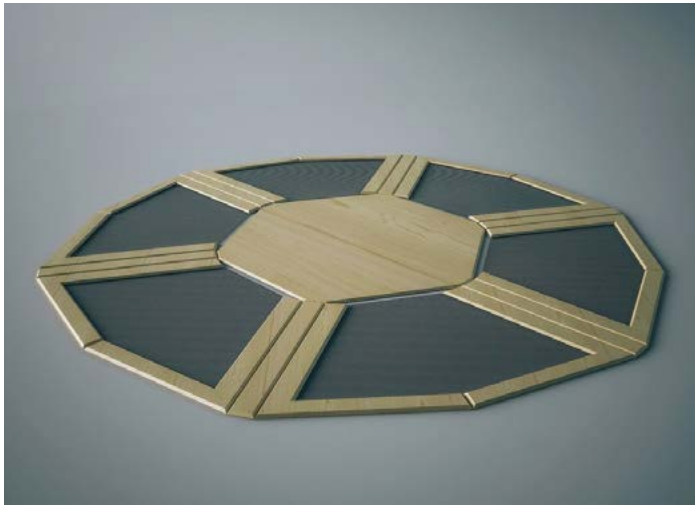
https://transtudio2019.wordpress.com/2019/01/22/the-journey-begins/

INFLAT/DEPLOY-ABLITY

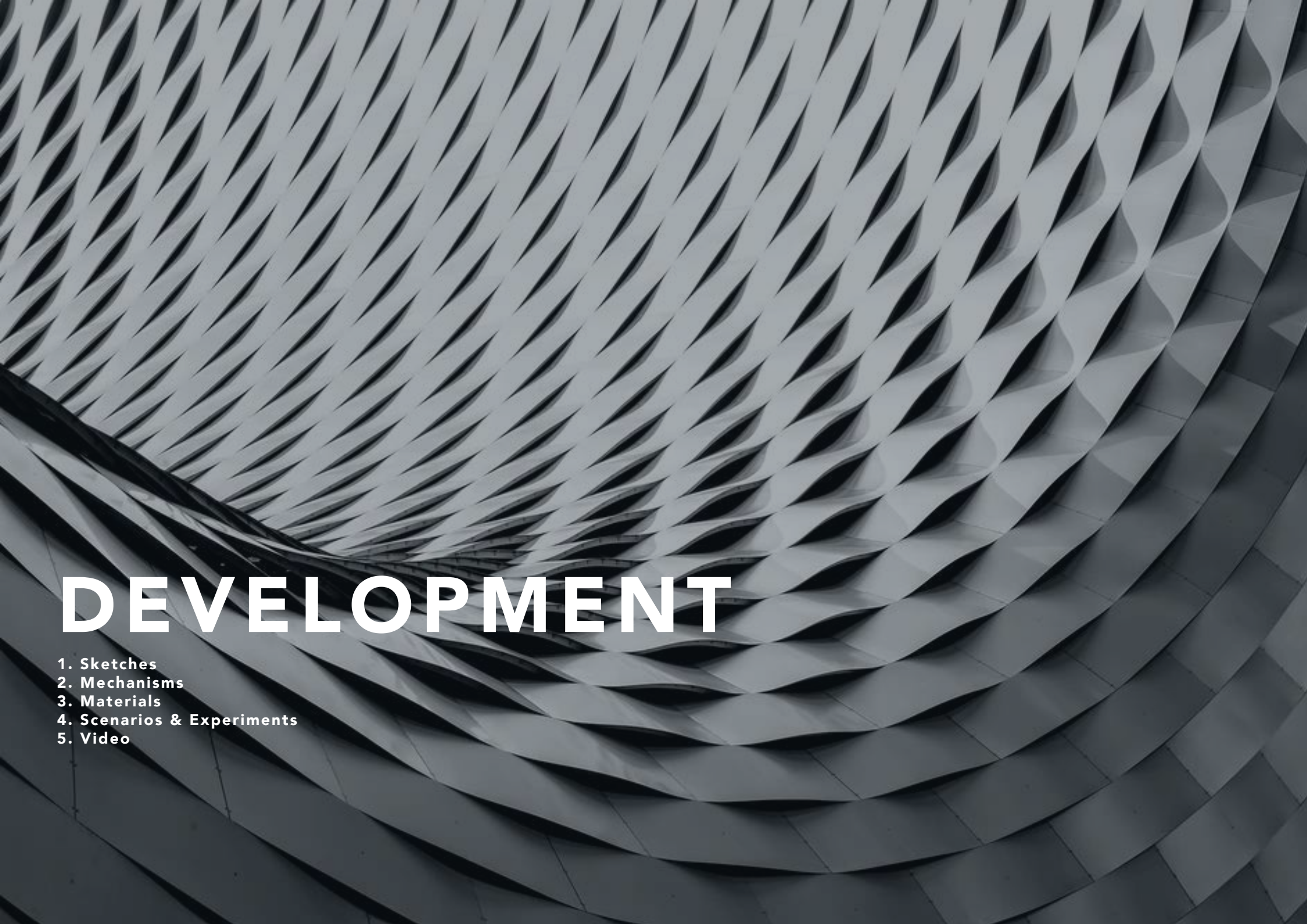
Furniture and Space

Inflatable and Deployable Structures

Portability
Convenience
Mobility
Cost / Material efficiency
Spatial Experience

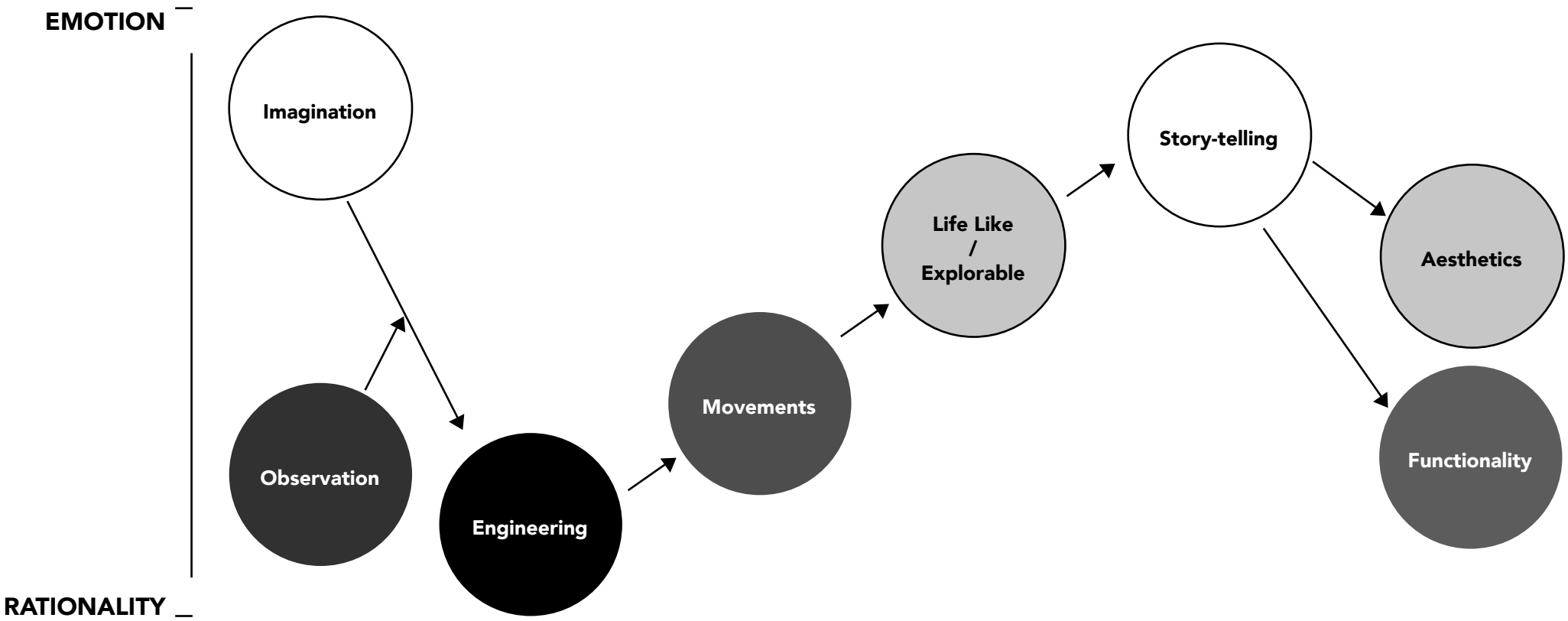


https://selfassemblylab.mit.edu/transformable-meeting-spaces/
https://selfassemblylab.mit.edu/programmable-table/



DEVELOPMENT

1. Sketches
2. Mechanisms
3. Materials
4. Scenarios & Experiments
5. Video



Subjective

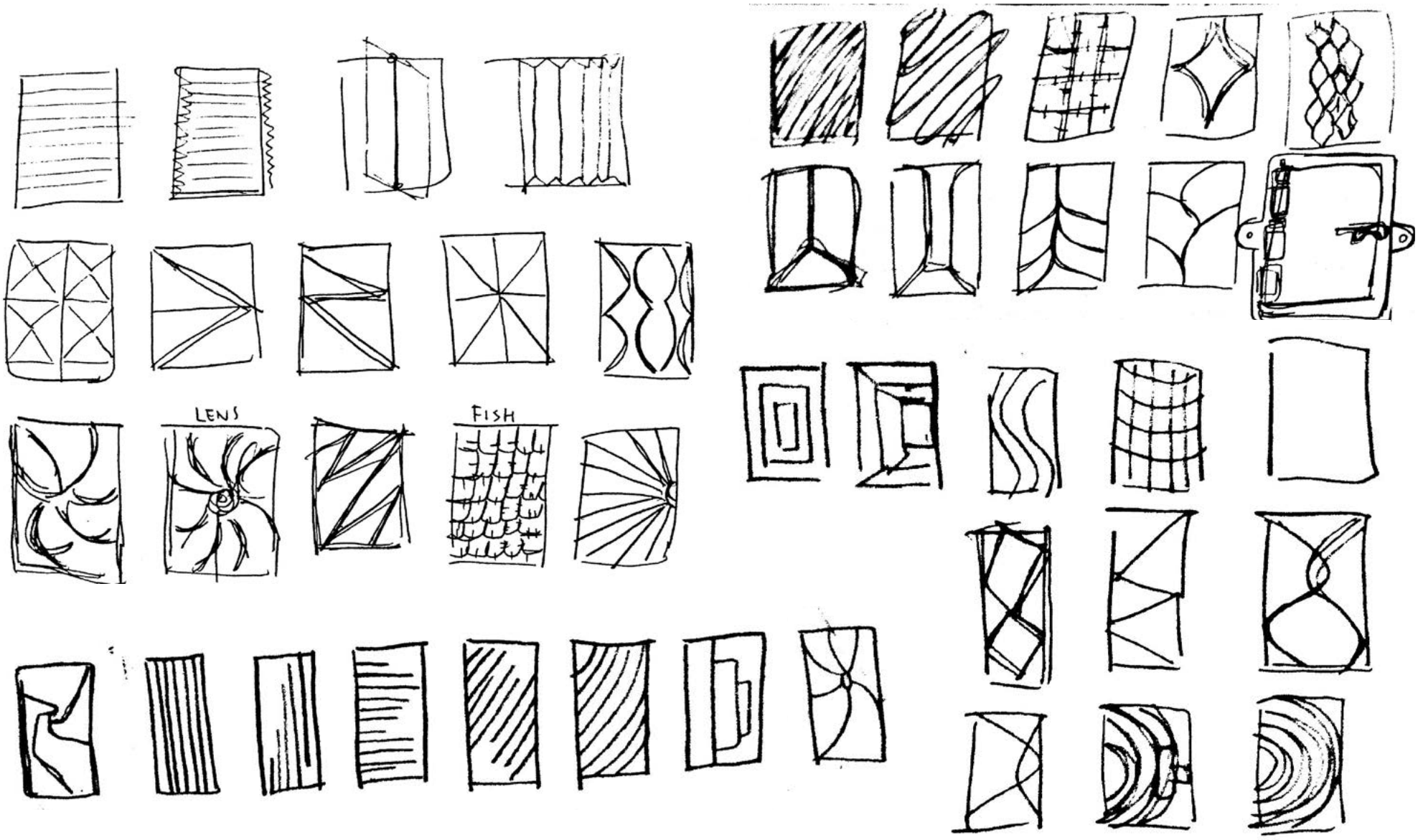
Objective

FROM【 】TO【 】

Internal Transformation of Transformable Design

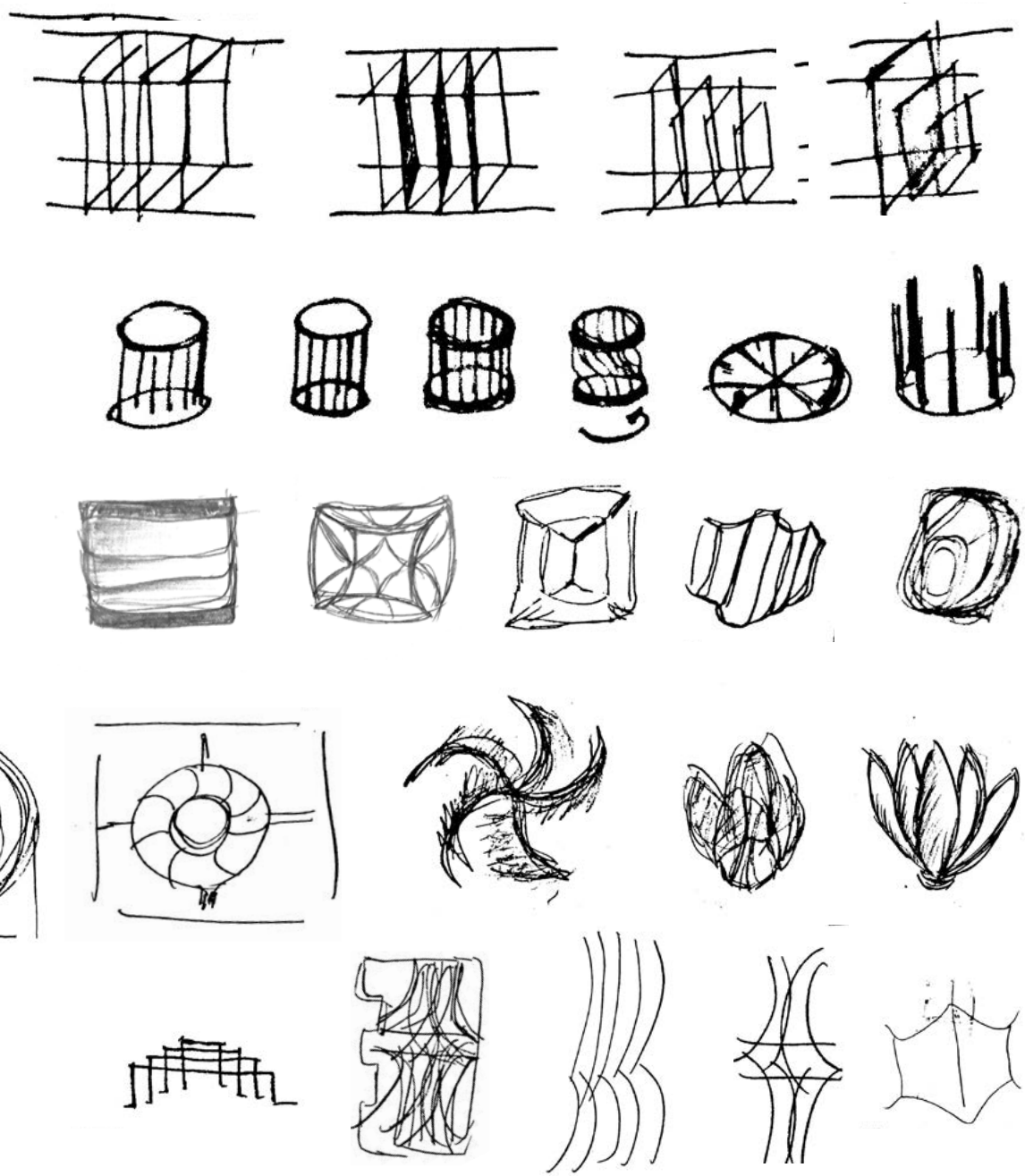
SKETCHES

Transformable Door



SKETCHES

Transformable Door



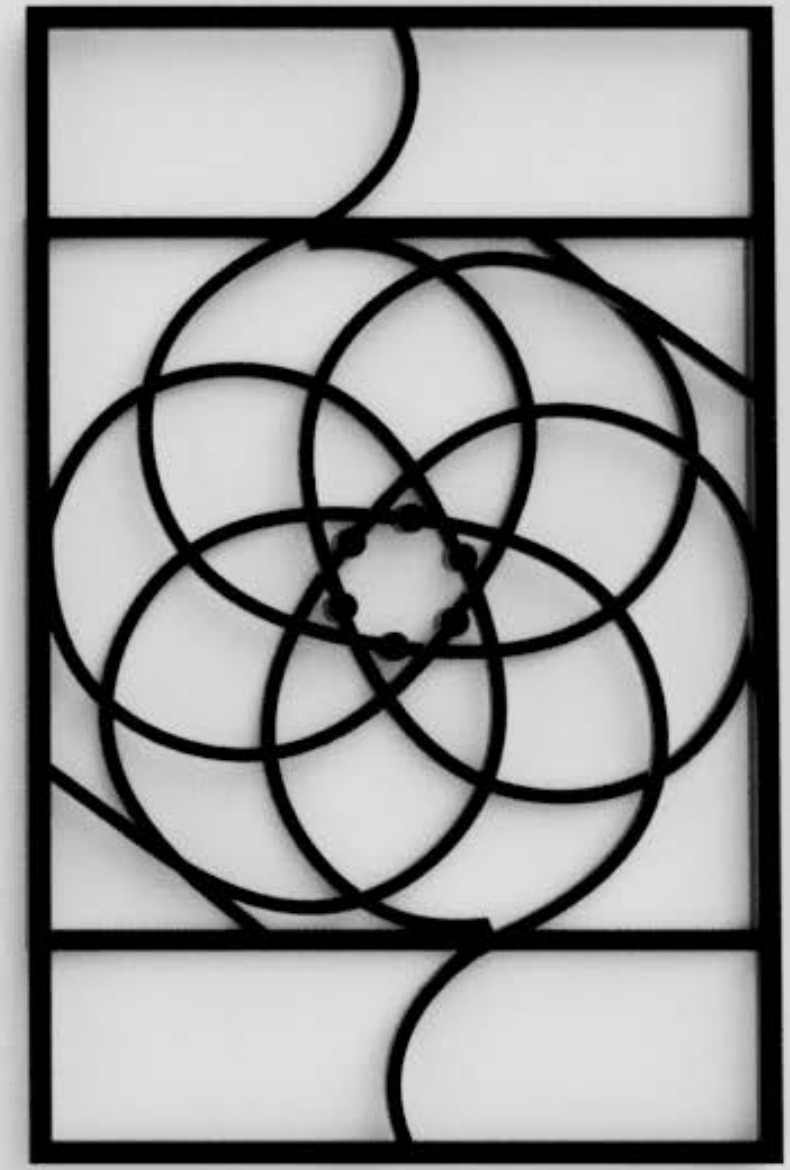
Shapes, Forms and Perceptions

In the beginning, my sketches and perception of doors were following a rectangular and flat transformation on solely 2D patterns. The perception of door is about how it's open and close, so people will perceive it as a door or a window.

The aim in the next stage is to connect the difference - using different shapes and forms to question the possibilities in door design.

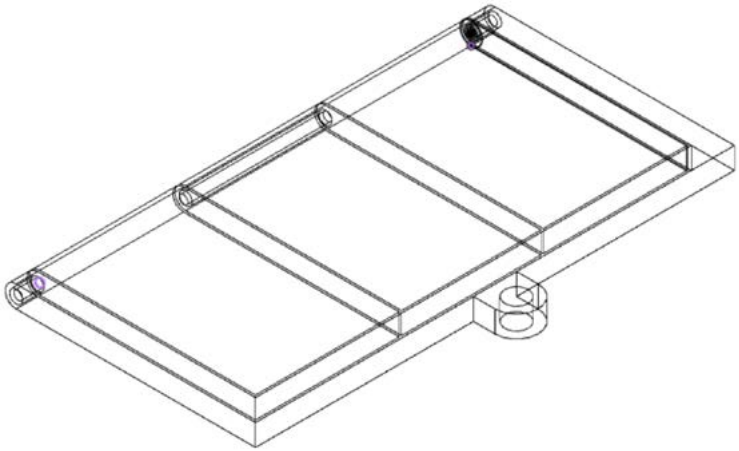
EXPERIMENTS

1. Single-bodied Print
2. Origami
3. Iris Mechanism
4. Compliant Mechanism
5. Applications

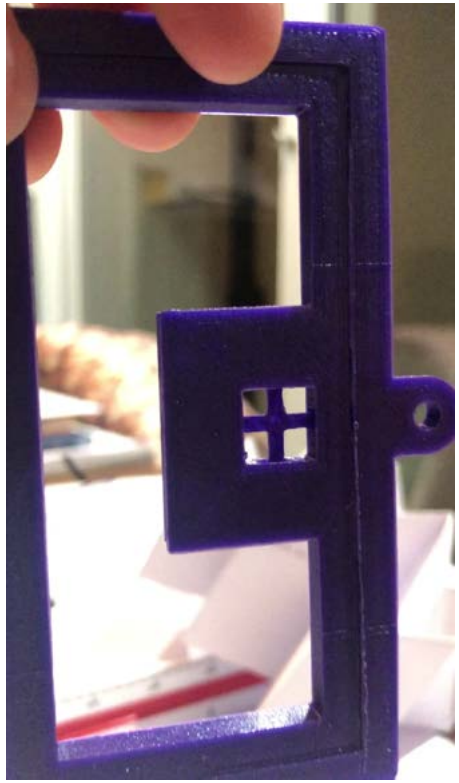


MECHANISMS

Single-bodied Print



Single-bodied Print with Flexure Lock



3D Printed Model

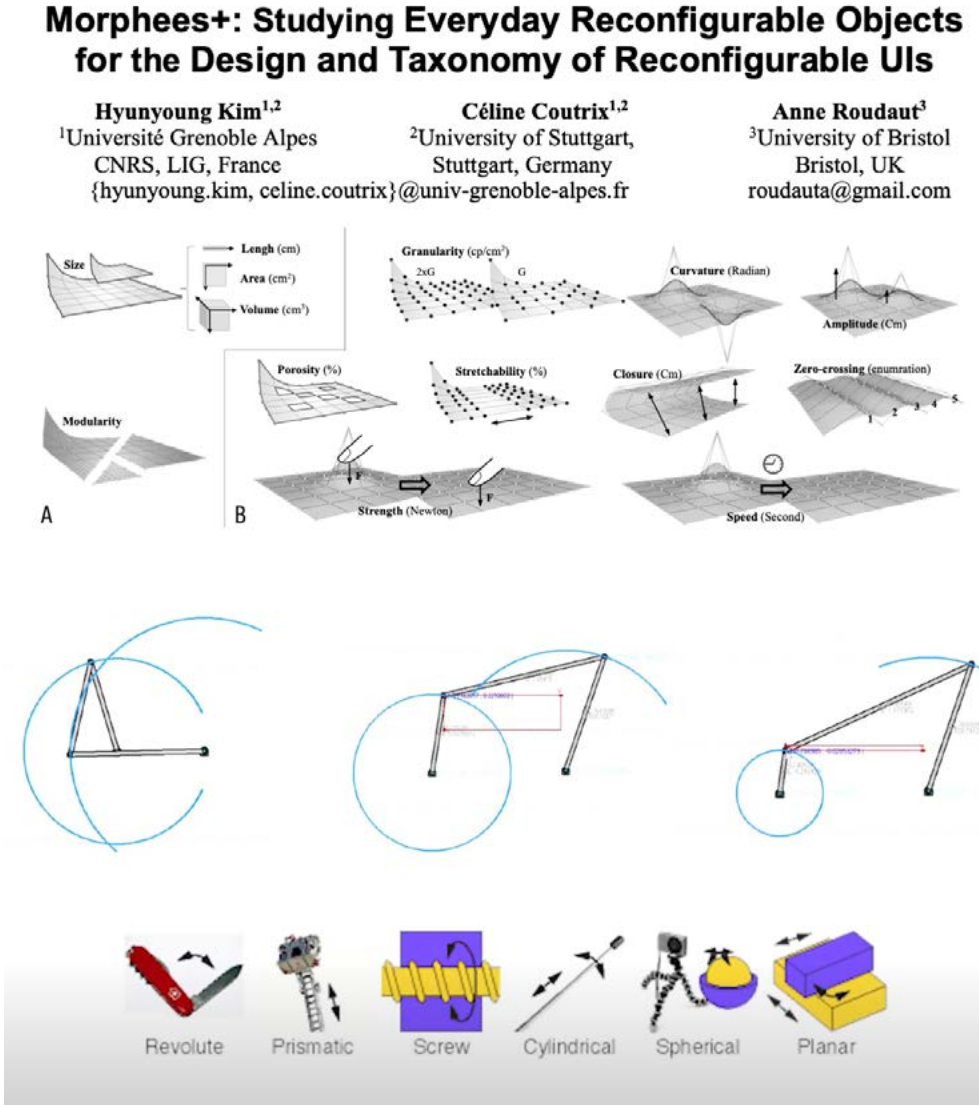
In another version of iris mechanism, less components are needed in the design, but it is more difficult to open and close because of the overlapping stack of blades. Therefore, I chose the previous design for exploration.

MECHANISMS

Functionality x Aesthetics

Mechanisms Become the Interface

In order to integrate transformable design, the project aims to merge the mechanism design and interface design together so as to enhance the intuitiveness and achieve both the functionality and aesthetics.

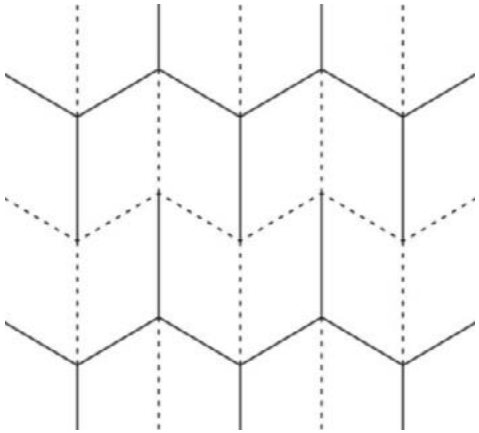


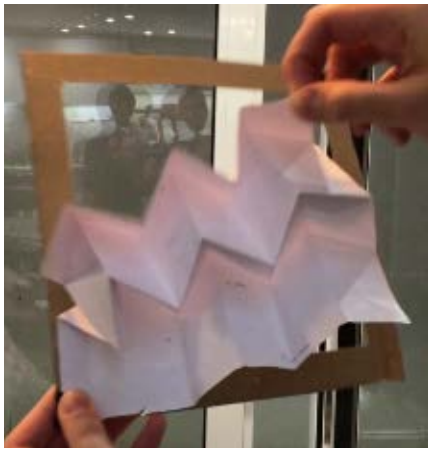
MECHANISMS

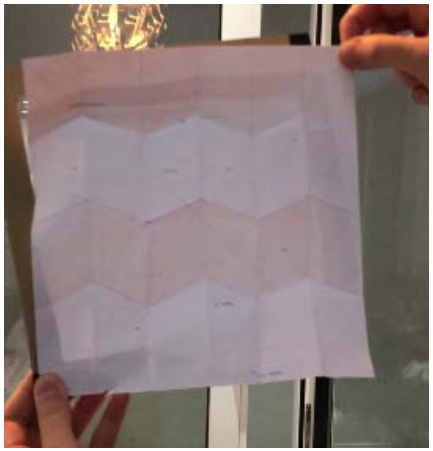
Origami Pattern

Miura Fold

Invented by Japanese astrophysicist Koryo Miura, Miura Fold forms 3D forms through patterns of tessellation and crease patterns. Adding the Frames, it can be a foldable door from a simple movement from the left to right side.





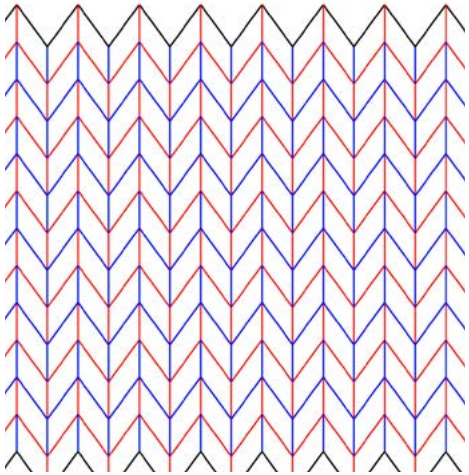


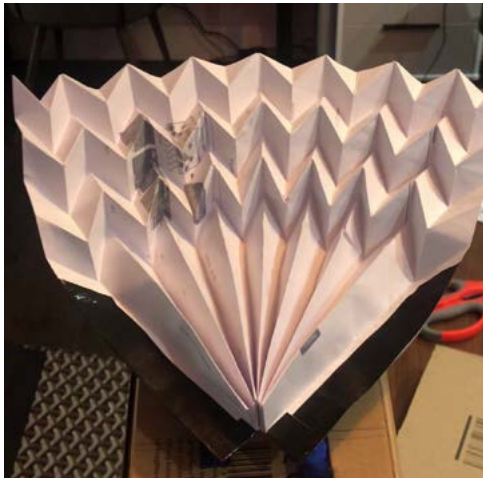
MECHANISMS

Origami Pattern

Miura Fold with Sharper Angle

Through pattern of tessellation and crease patterns with a sharper angle, a dome-like structure is created to test with the inflatable and deployable effects. In the experiment, two servo motors control the transformation to move according to the specific degrees.





MECHANISMS

Modular Origami - Sonobe and Kusudama

Transform Modular Origami

Sonobe module is one of the examples of modular origami. Sonobe ball is formed by numbers of triangular pyramid (tetrahedron). It can form polyhedron with expandable connections. 2D modular origami is transformed by slide with each module to form patterns. However, the diversity of forms is limited by the tetrahedron.

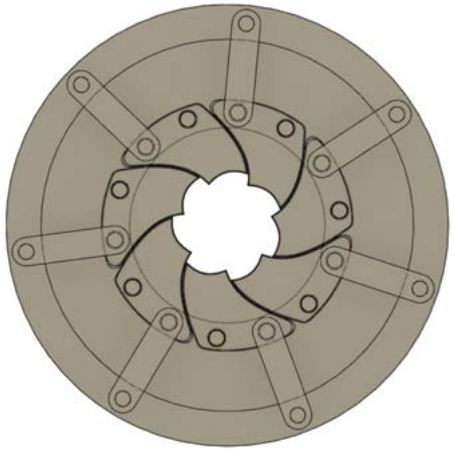
https://mathcraft.wonderhowto.com/how-to/modular-origami-make-cube-octahedron-icosahedron-from-sonobe-units-0131460/

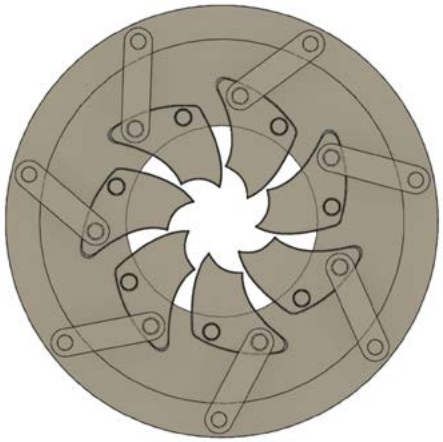
MECHANISMS

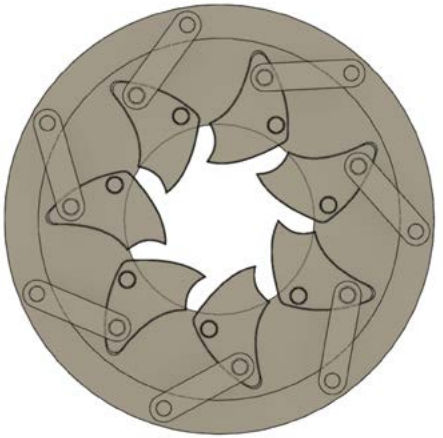
Application of Iris Mechanisms

Iris Mechanism

Working like a shutter in the camera, the iris mechanism is widely used in transformable design with different variations in the number of blades and the ratio between the dimensions. In the experiment, I created a 3D model with 7 blades and an opened center.

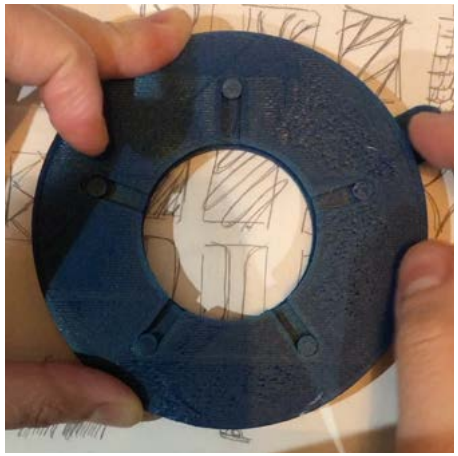






3D Printed Model

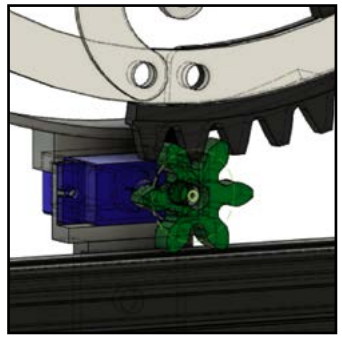
In another version of iris mechanism, less components are needed in the design, but it is more difficult to open and close because of the overlapping stack of blades. Therefore, I chose the previous design for exploration.



Mechanisms

Iris Mechanism and Application

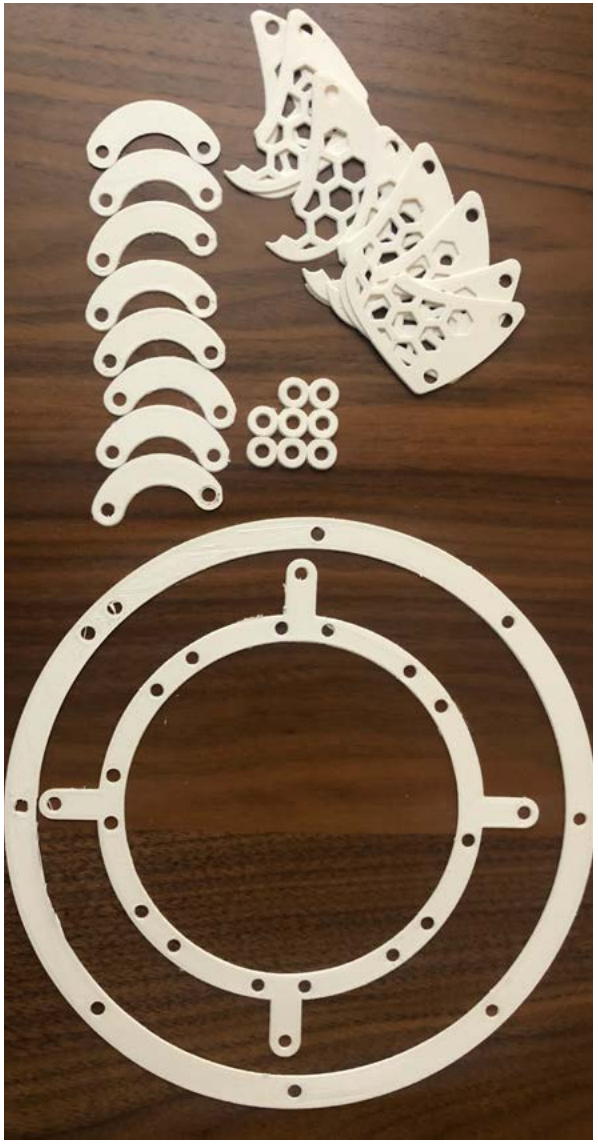
Industrial Project for Firmenich

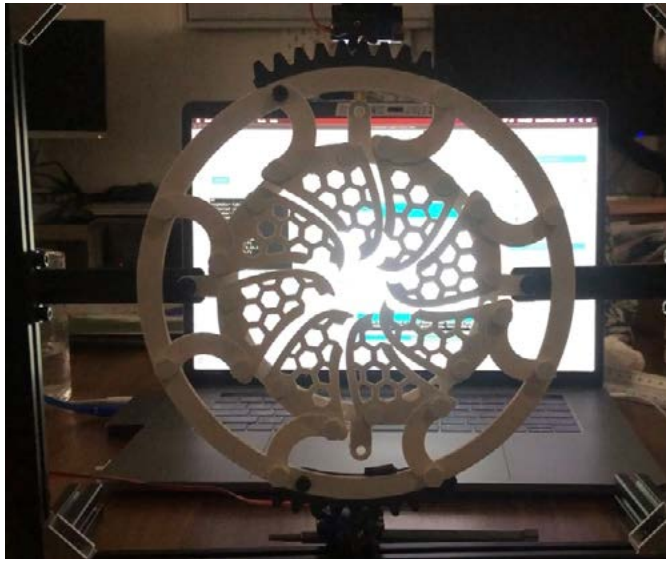


SCENT STOP

An aroma therapy vending machine that allows people to purchase an interactive experience - meditating with natural scents and transformable visual effects while sensing the heart beat rate.

Industrial Project for Firmenich





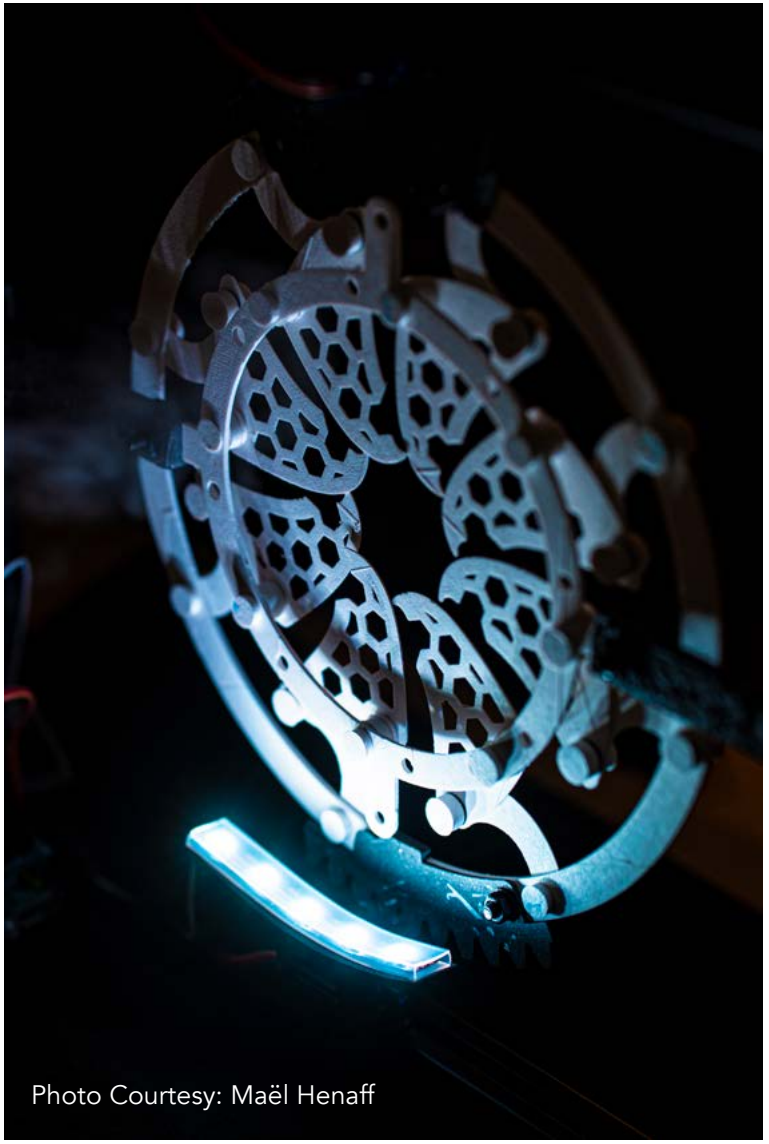


Photo Courtesy: Maël Henaff

Mechanisms

Iris Mechanism and Application

Mechanism as the Design

Comparing to iris mechanism used in product design and references, the design objects hide the components and only show the parts for functions - shutter or window. However, in my installation prototype, the whole design is integrated with the iris mechanism and the simplicity, functionality, aesthetics of automata.

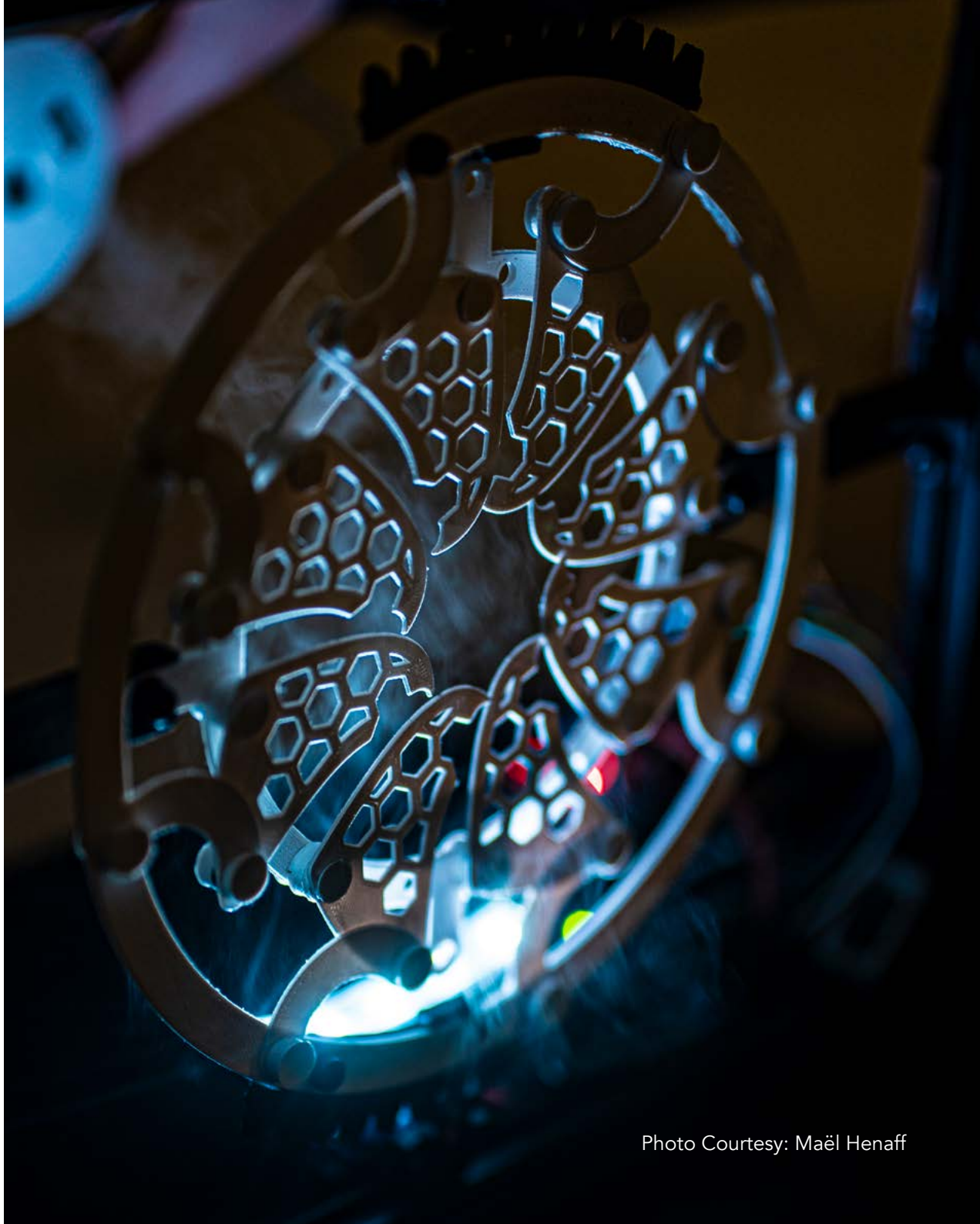
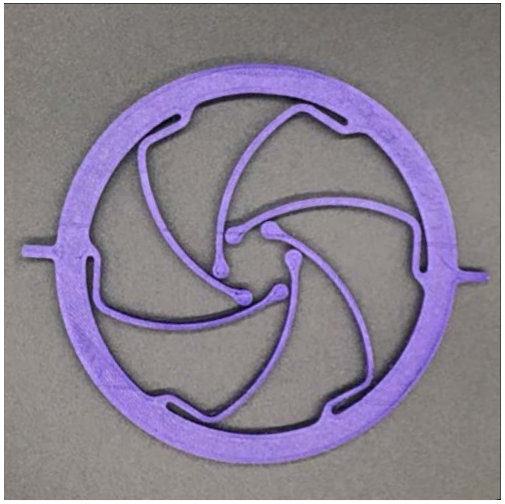


Photo Courtesy: Maël Henaff

MECHANISMS

Compliant Mechanism



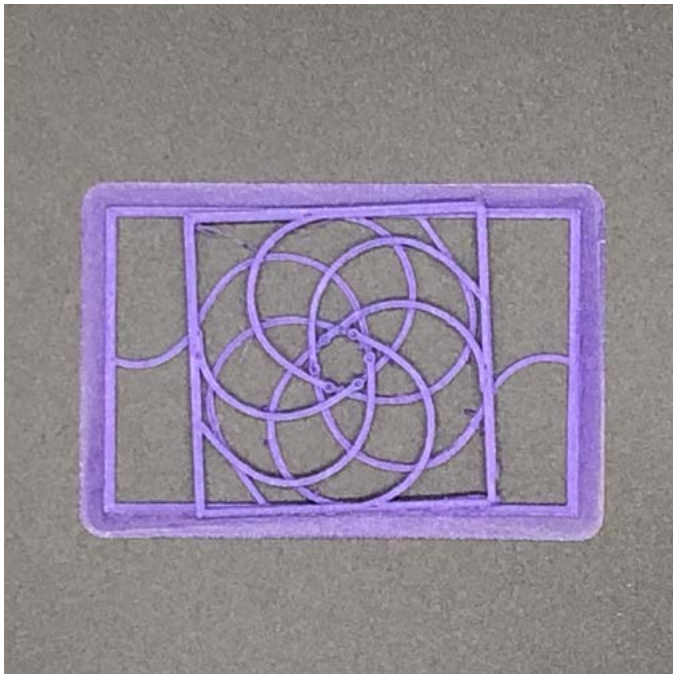

Iris Mechanism &
Compliant Mechanism

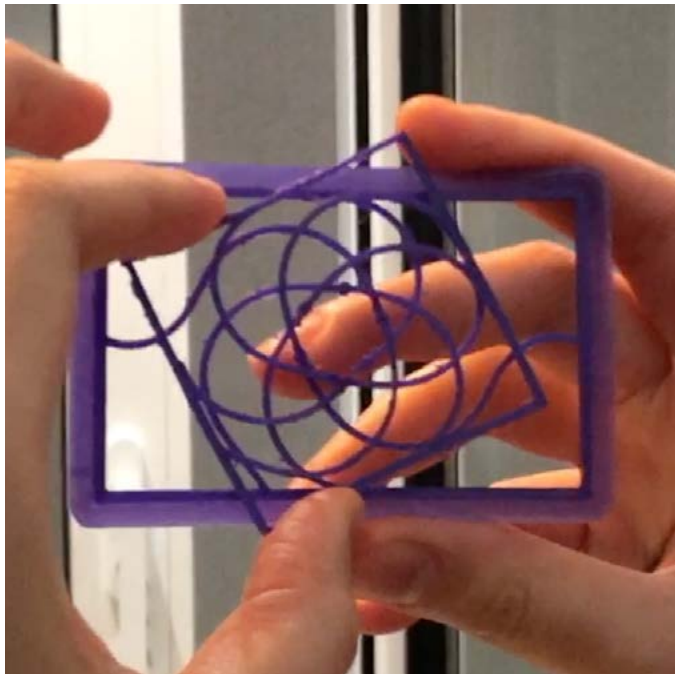
Merging the iris mechanism with compliant mechanism, the large amount of components can be trimmed to a single-bodied structure. However, depending on the 3D printer, the model is not very easy to print, which require specific print settings and printer adjustment.

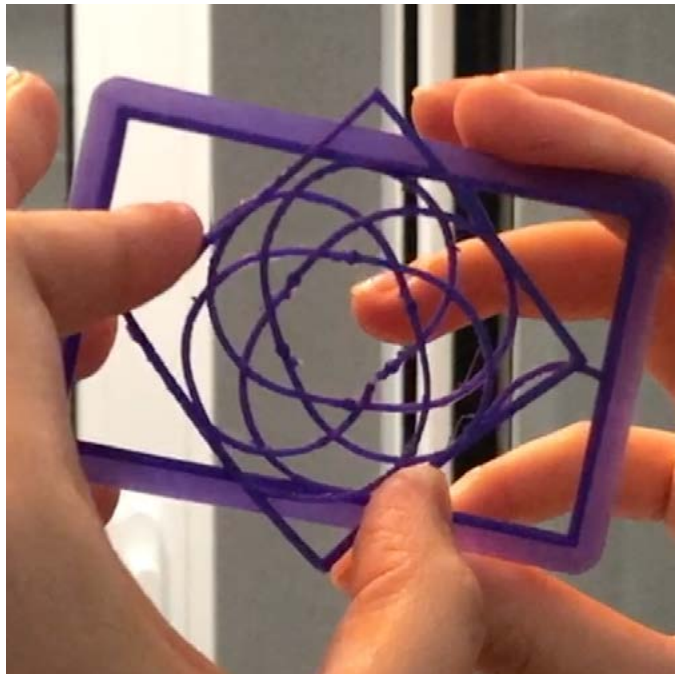
As a result, the thorough of understanding on designing a compliant mechanism would be needed, so the design can be more friendly for printing and merged with other variations (i.e. rectangular form).

MECHANISMS

Compliant Mechanism







Experiment:
Adapt Compliant Mechanism

Convert two layers of floral pattern with a square and rectangle to experiment the transformation.

However, the problem of this design is the perception of door. Users are familiar with a certain types of doors 1) Hinged Door, 2) Sliding Door, 3) Rotating Door, 4) Automatic Door, 5) Rebated Door.

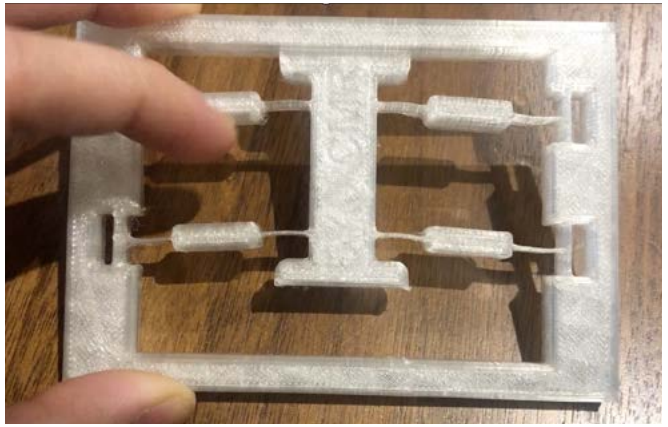
Therefore, a further development in perception should be investigated for the door design for different user groups.

MECHANISMS

Compliant Mechanism

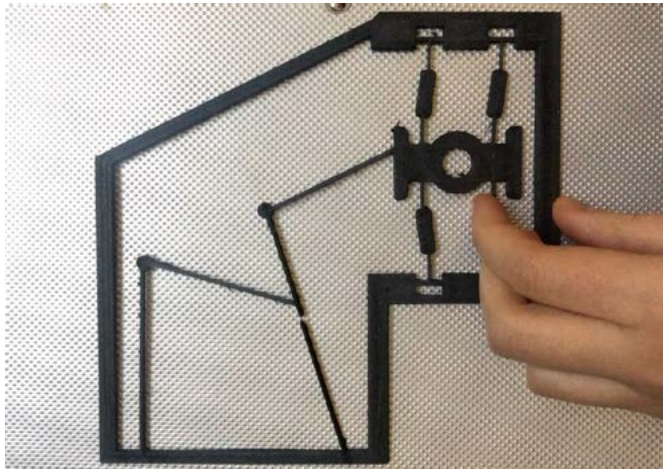
Bistable Switch by BYU

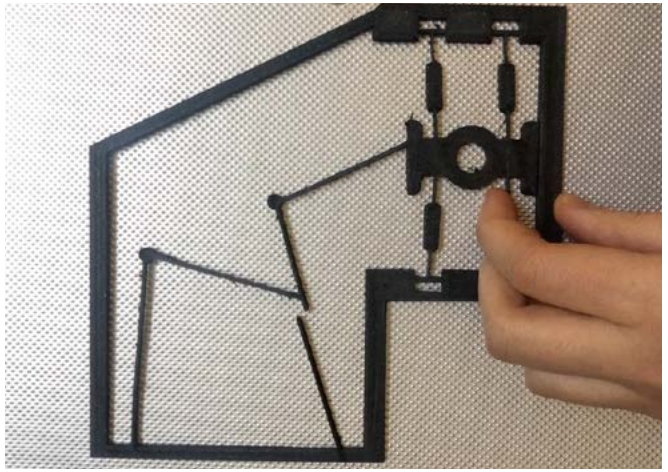
The feedback is given by the click sound, which gives a sense of security for locking system



Experiment:
Adapt Bistable Switch with Pattern

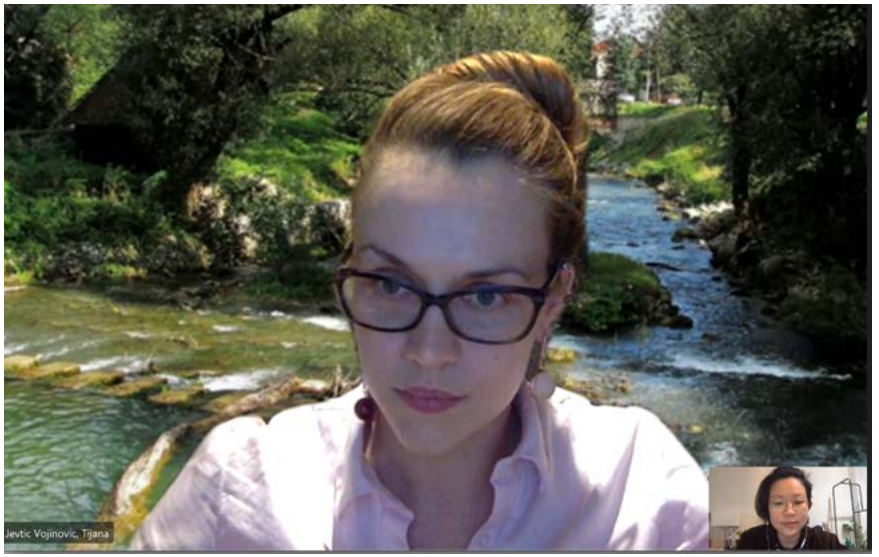
Design a transformable pattern changed by the locked and unlocked condition, so the condition could be visualised to enhance the sense of security directly





EXPERT

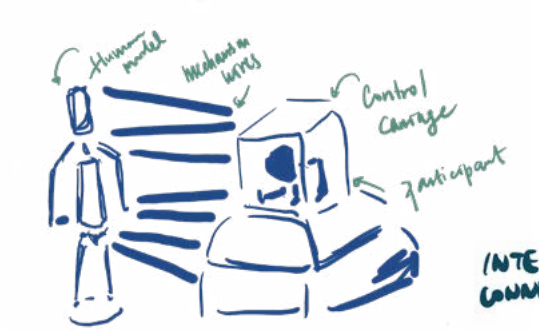
Design Engineering
- Rehabilitation and Assistive Technologies

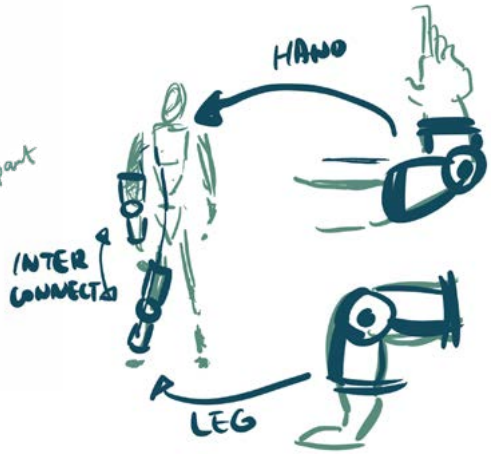


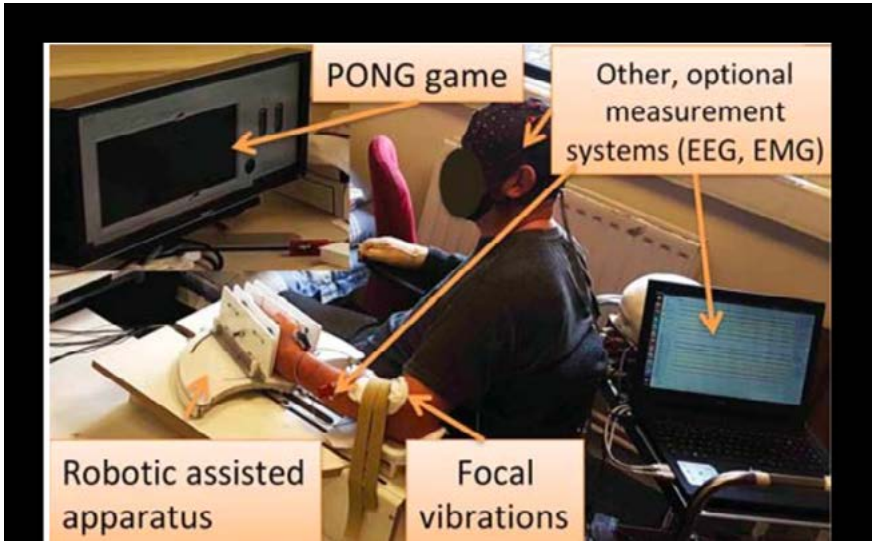
Dr. Tijana Vojinovic

Post-Doctoral Research Fellow,
Royal National Orthopaedic Hospital, London, UK

. Relationship between designer and engineer
. Design process of patient rehabilitation project
. How a design thinking process of designer and engineer can be better communicated to smoothen the UX and UI design
. Possibility of collaboration: Door for Parkinson's disease patients







https://discovery.ucl.ac.uk/id/eprint/1554761/1/ICORR17_0306_FI.pdf

EXPERT

Transformable Architecture

Dr. Negar Kalantar

Associate Professor, Interior Design Program
California College of the Arts

. Discuss how transformable design is applying or could be applied to architecture
. Understand the design process for the transformable design: geometry pattern to moving parts

https://transtudio2019.wordpress.com/category/design-project-i/

EXPERT

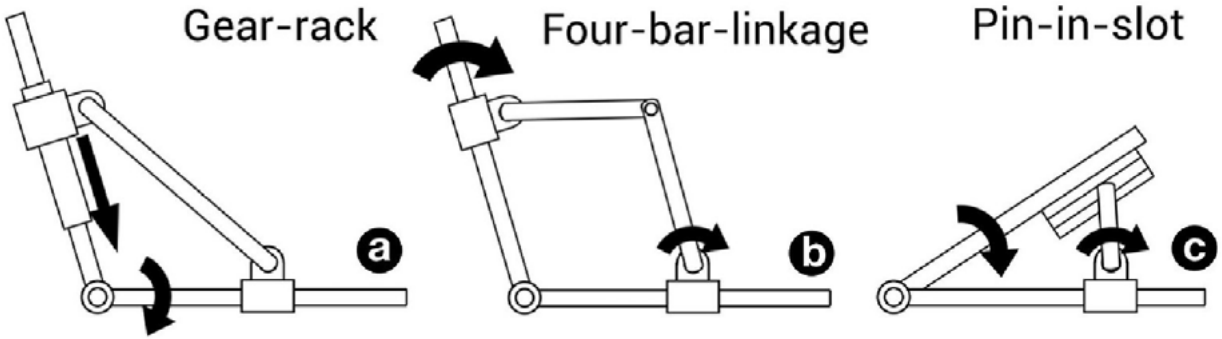
Mechanical Engineering
(Waiting for the coming discussion)

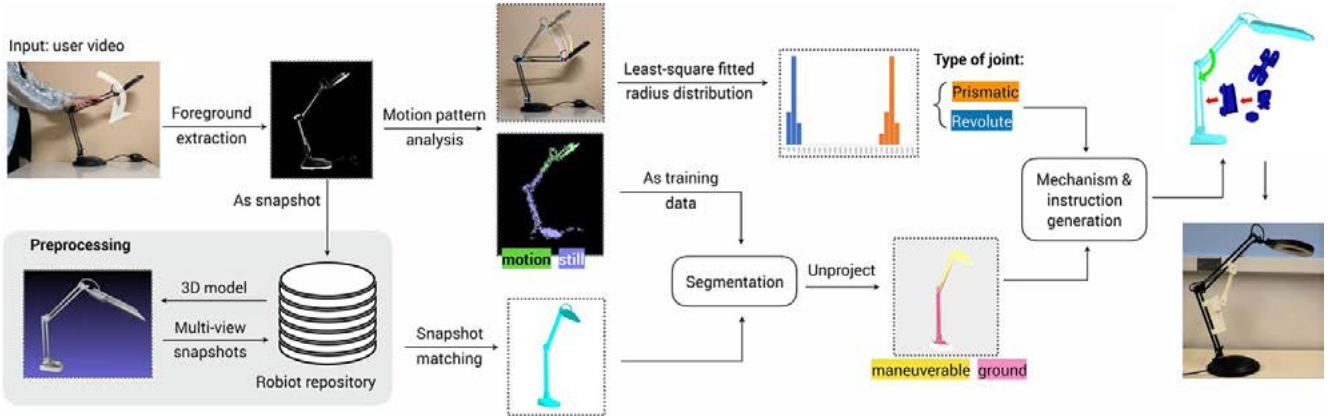
Nick Li

PhD Student, HCI Research, UCLA

His project creates a design tool for generating mechanisms for automating a physical objects, such as lamp and water tap, controlled through iOT devices.

Potential Questions:
. Discuss how to empower designers to design with engineering
. Question on the improvement of mechanisms on the kindergarten entranace project
. Communicate on how to integrate both design and engineering knowledge to enhance the user experience, rather than solely the technological advancement





https://hci.ucla.edu/#projects-robiot

TUTORIAL

User Research

Mike Thompson

Co-founder, Thought Collider

. brainstorm the idea from the users' perspective, rather than the engineering side
. find out the aim of the design
. understand the existing experience
. Convey why the design is needed with a story -telling strategy
. connect with the user group for further research
. put down the workability of idea in the early stage

SCENARIO

Kindergarten Entrance

SCENARIO 01

Kindergarten Entrance

Kids
Kindergarten
Playful

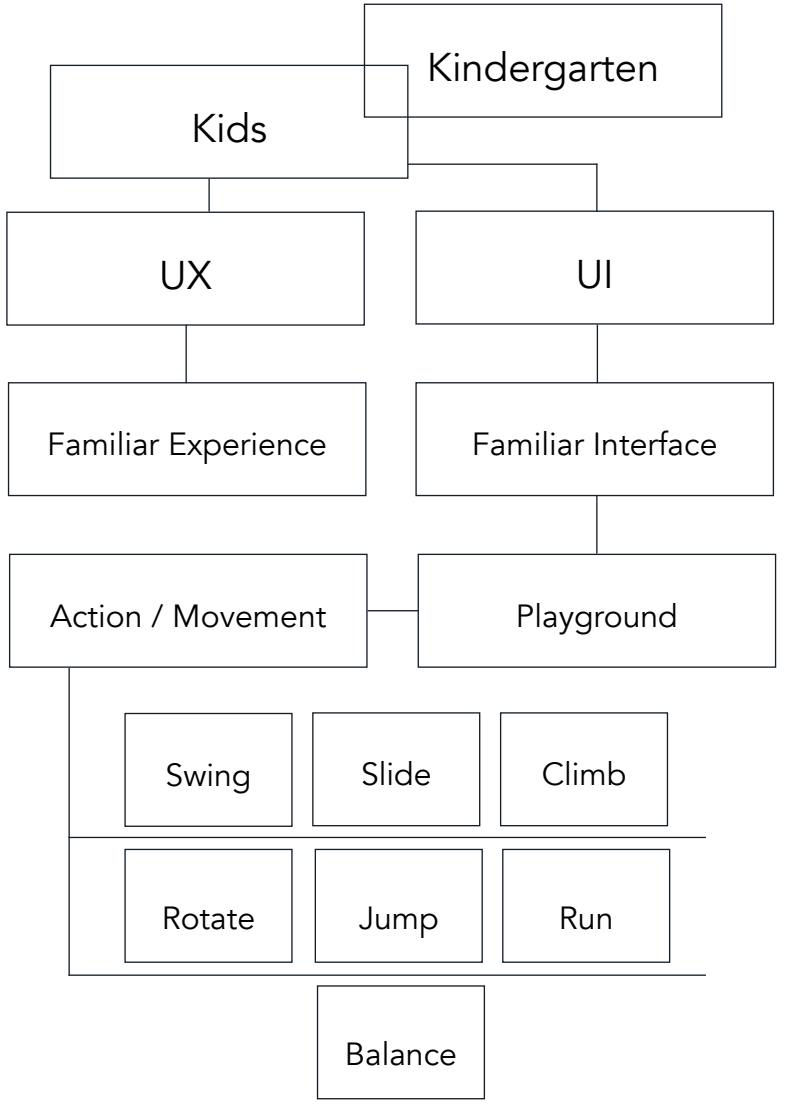
How will kids go to school?

Entrance for children

Journey to the school

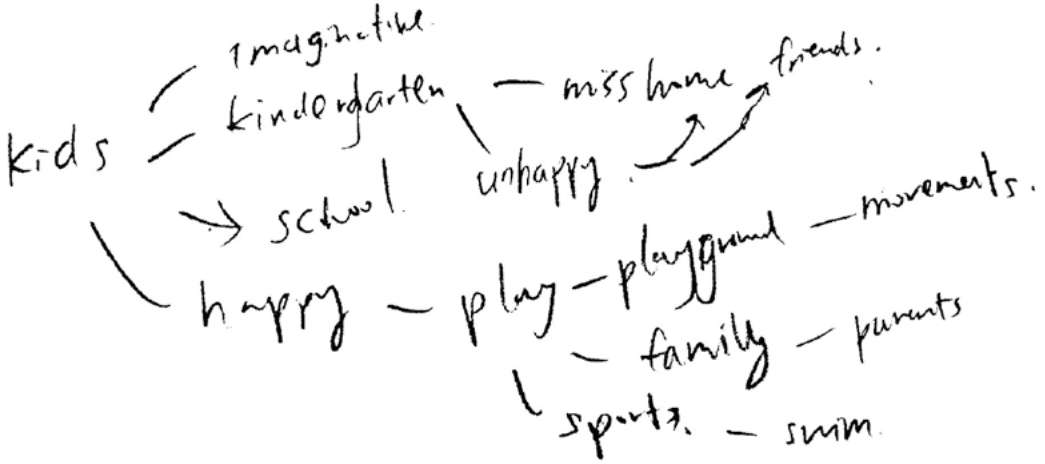
Happiness & Exploration

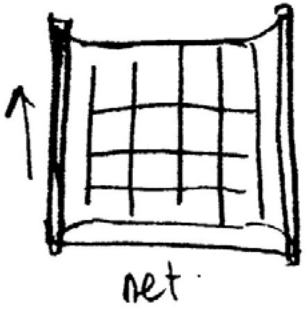
Playground

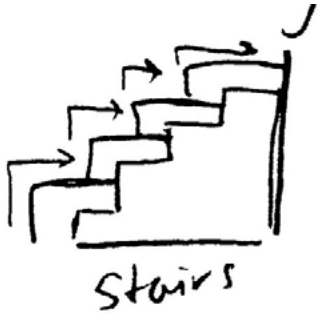


DESIGNS

Sketches and Idea Development







Experience for Kids

Familiar User Interface
Designing user interface for children, what should be take into consideration is the ease of using the interface. Therefore, familiar UI is carefully chosen from the objects in playgrounds.

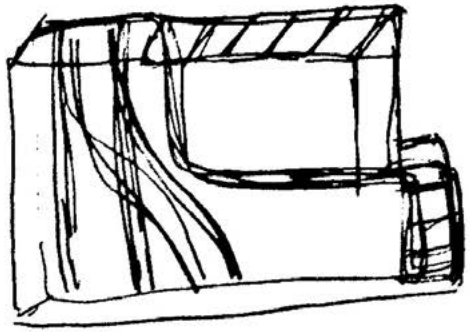
Familiar User Experience
Referring to playgrounds, investigating how children play and what are their actions and movements while they are interacting with the playground.

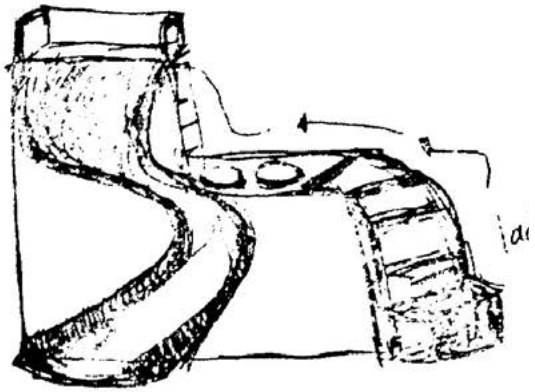
DESIGNS v1.0

Sketches and Idea Development

Packed Playground

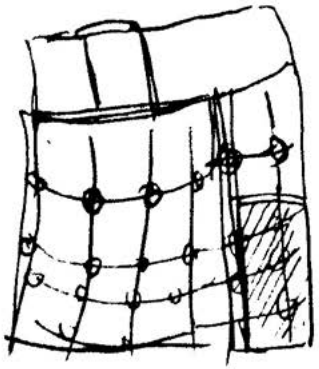
Children will go through the pathway to explore the door, which transformed from a 1D/2D space to a 3D/4D space.

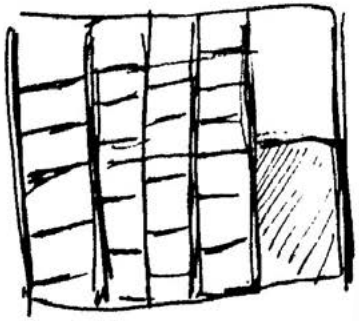


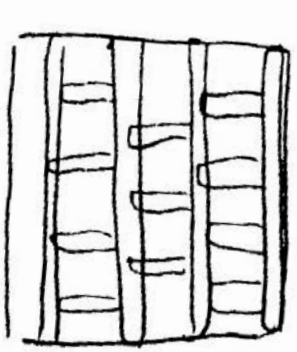


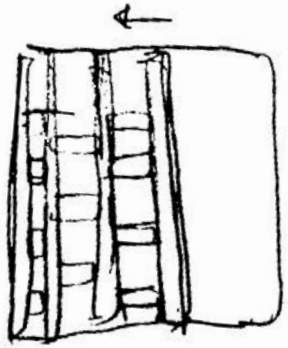
Extended Playfulness

Exploring the interaction that children are familiar with - climb, spin, jump, swing, slide and so on, the door could be transformed to an interactive one for them to play as part of the journey to the school.



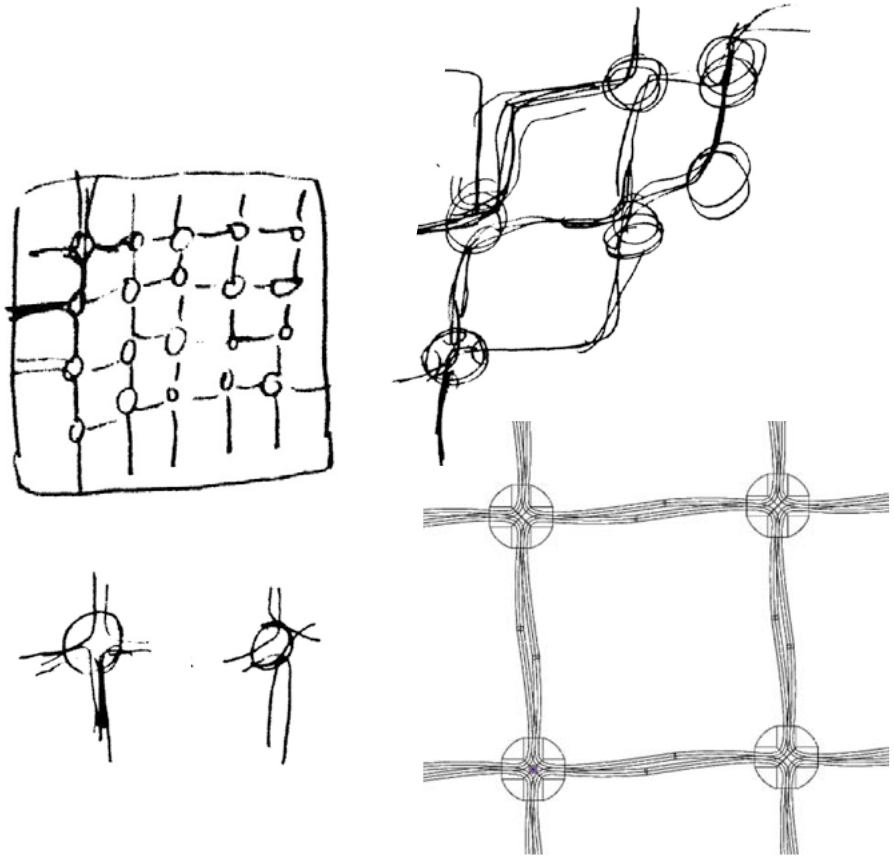


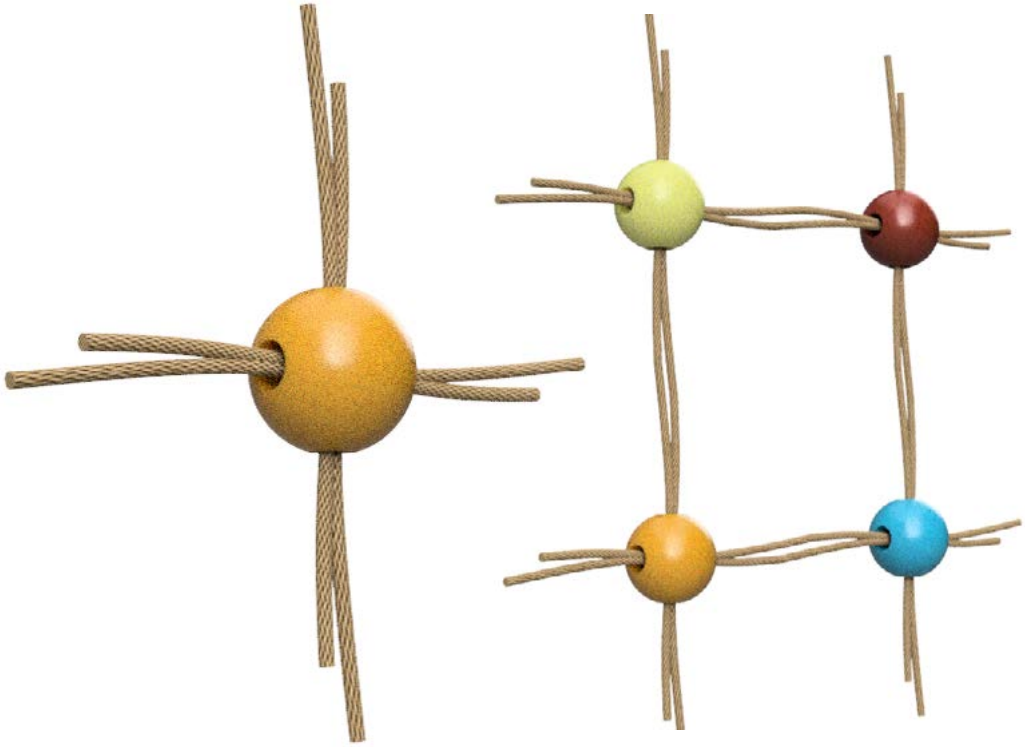




EXPERIMENTS v1.0

Climbing Frame



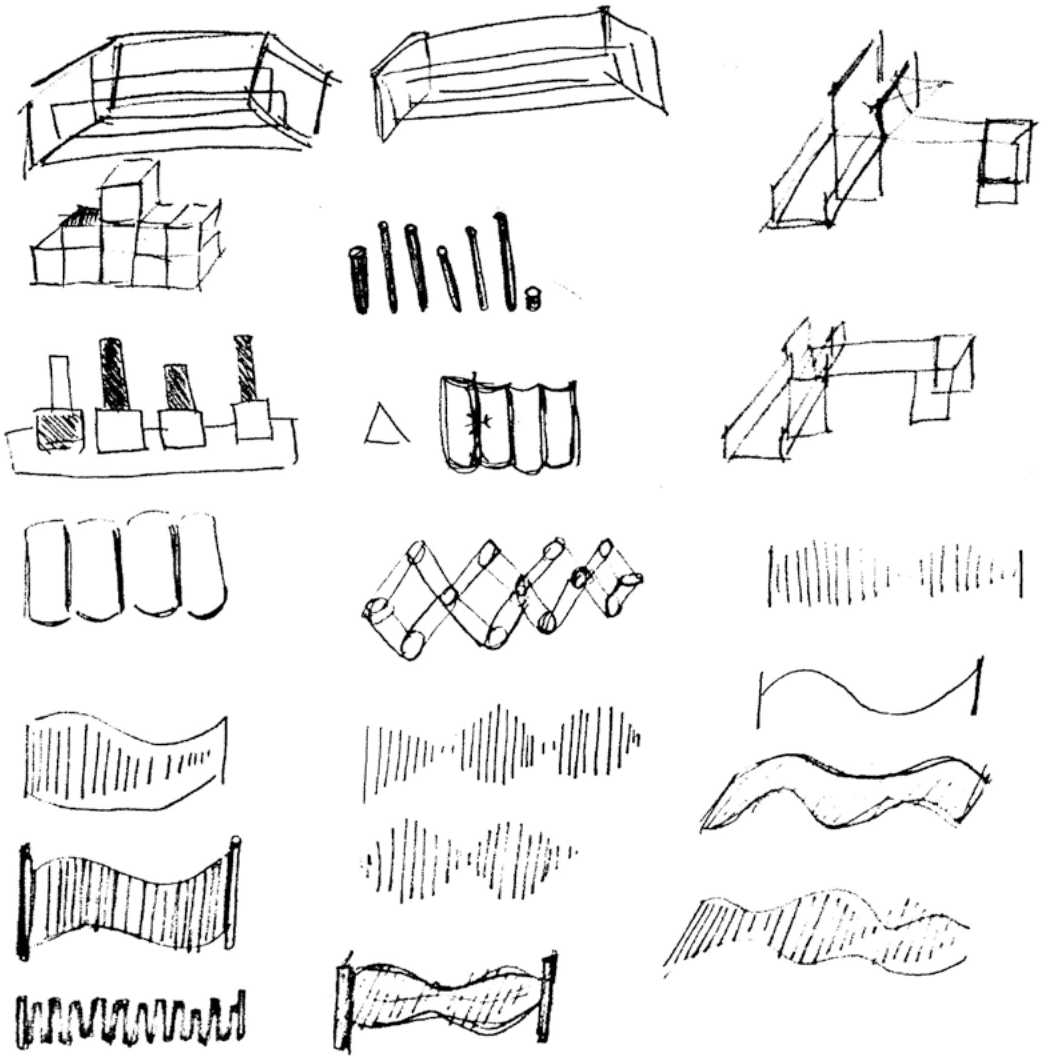


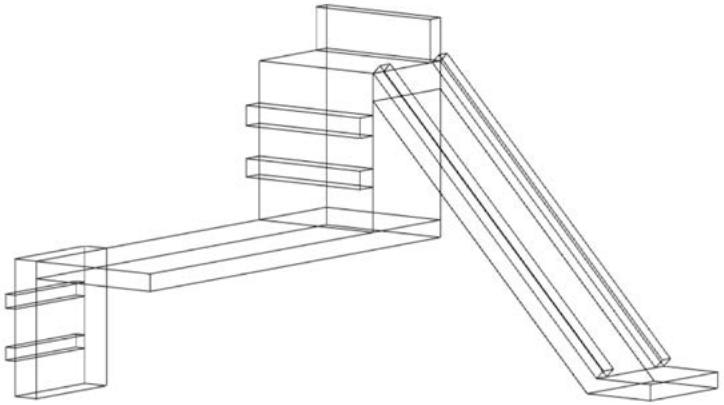
Rope and Movable Loop

Using ropes as the connectors, the door became a climbing frame. However, considering the experience, it doesn't enhance a playfulness for the kids with this adaptation on the school entrance.

DESIGNS v1.1

Sketches - Modular Forms

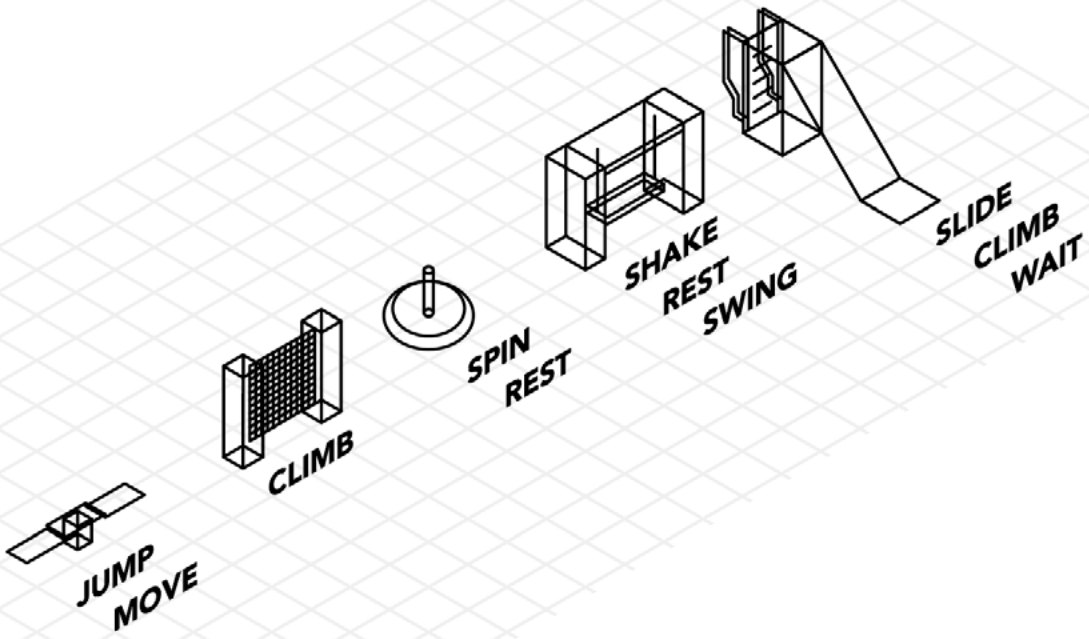


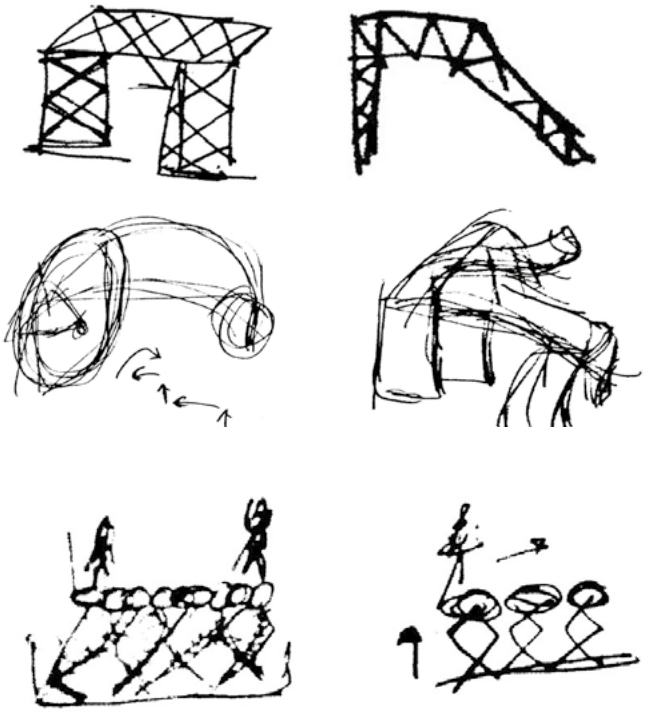


Inflatable and Deployable Structures
Modular structures can allow the flexibility and mobility of transformation, so this is one of the directions that can allow more exploration on integrating both functionality and aesthetics.

DESIGNS v1.1

Sketches - From Moment to Journey



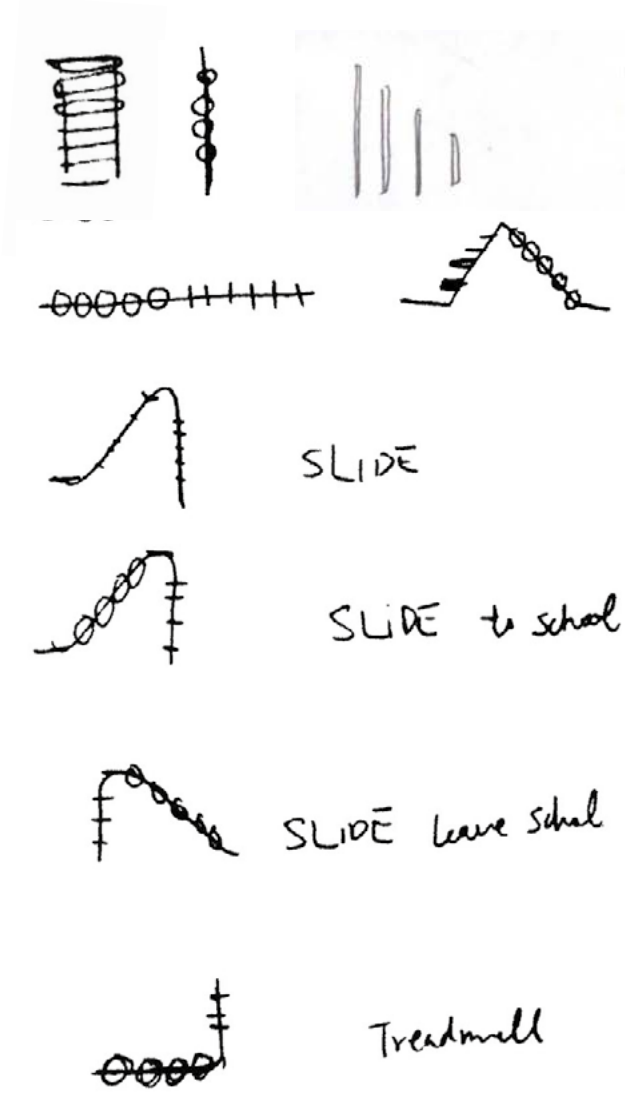


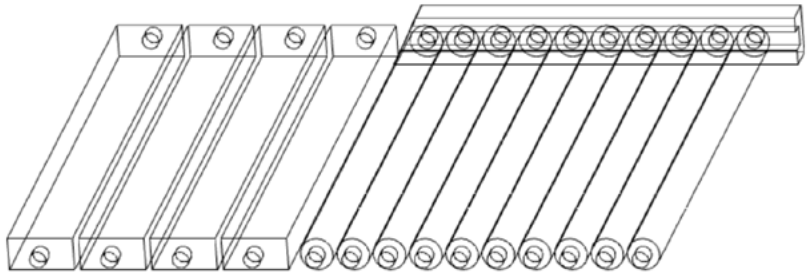
Create a User Path

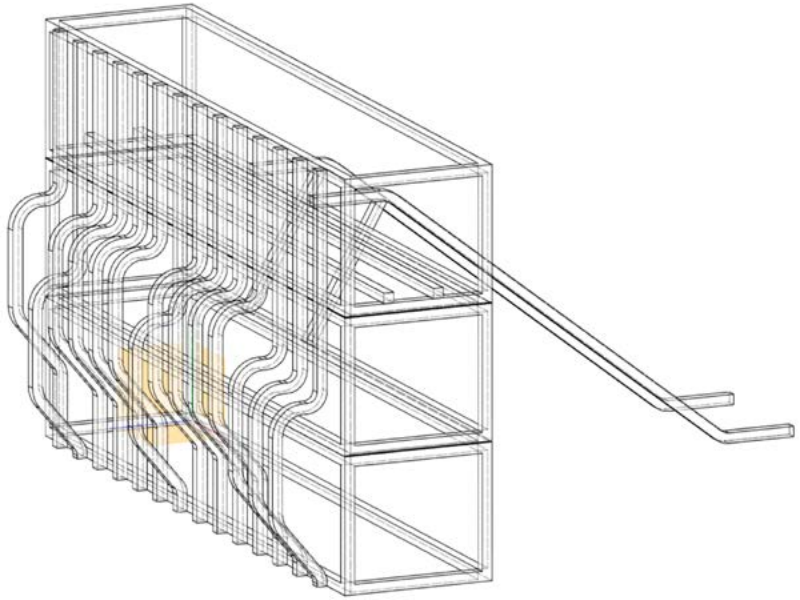
Door is a barrier that allow people to walk in/out, but in the concept of timeline, a journey is created for the user to have a different experience walking through the door. Playground is the main studies for enhancing the playfulness of the door design.

EXPERIMENTS v1.2

Combination of Modules and Playfulness





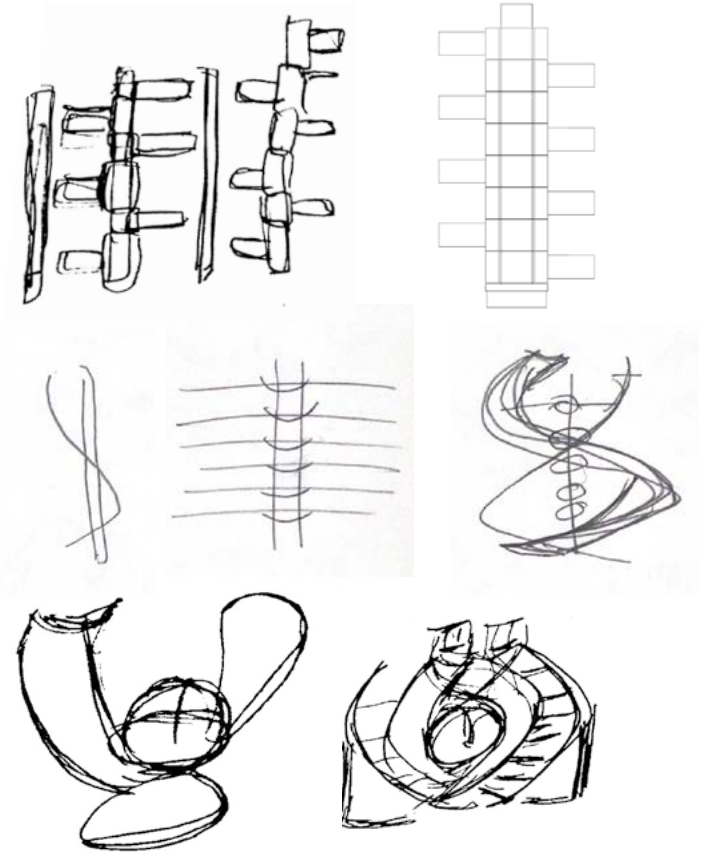


Test with Modules

Transform with modular design, a door, slide and treadmill can be possibly transformed from motions. However, this design still stick closely to the existing door design with flat and retractable, like a garage door. Another main problem is that it requires a lot of component to control the mechanism.

EXPERIMENTS v1.2

Transformable Modules

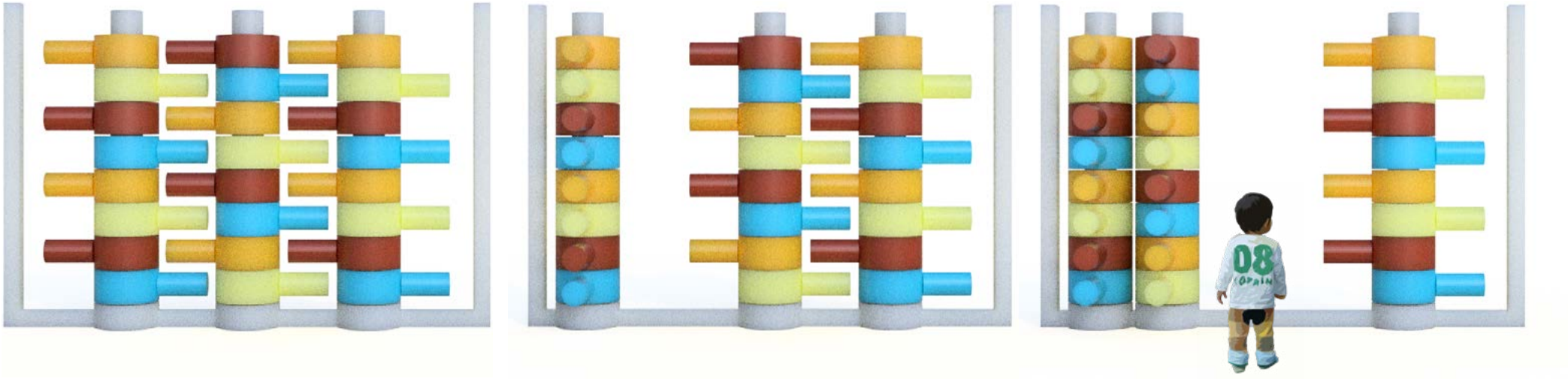


Spin the climbing module

Kids can climb up to enter the school

EXPERIMENTS v1.2

Climbing Frames



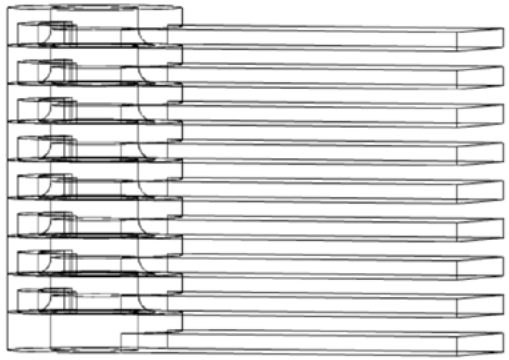
Modular Climbing Pillars

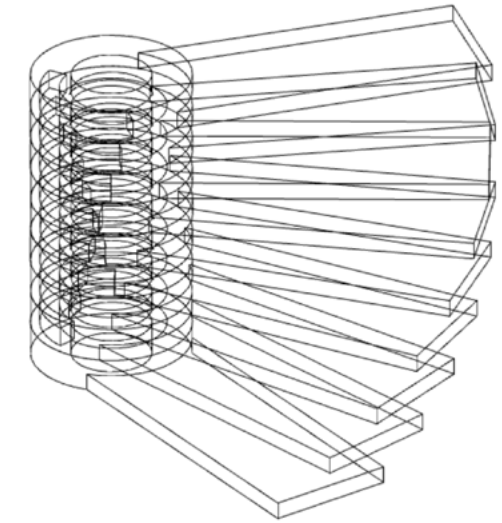
Rotate the modules and slide the pillars, It can become an entrance for people to walk through. However, this is not intuitive enough for users, especially children, to understand the use of the modular pillar as a climbing frame.

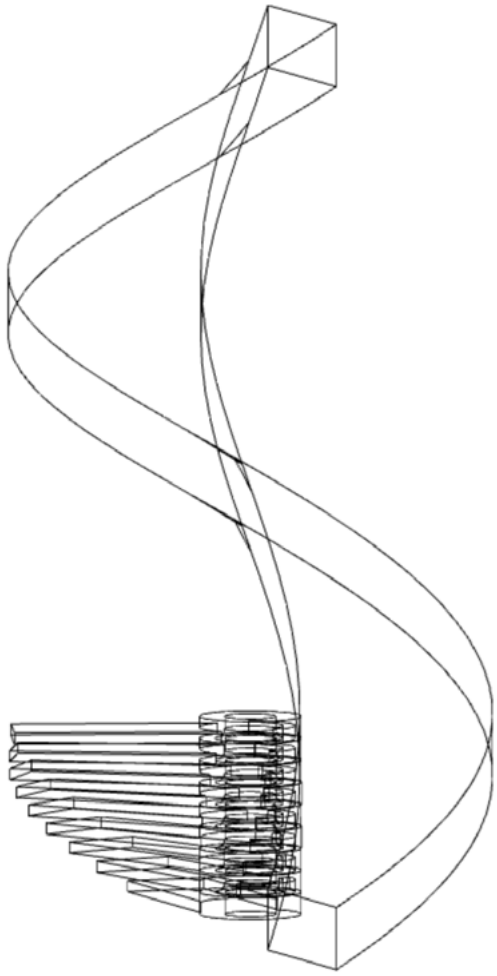
Therefore, the transition between transformable design with functionality and aesthetics should be developed from not only the functions or forms, but experiment together with the understanding of mechanisms.

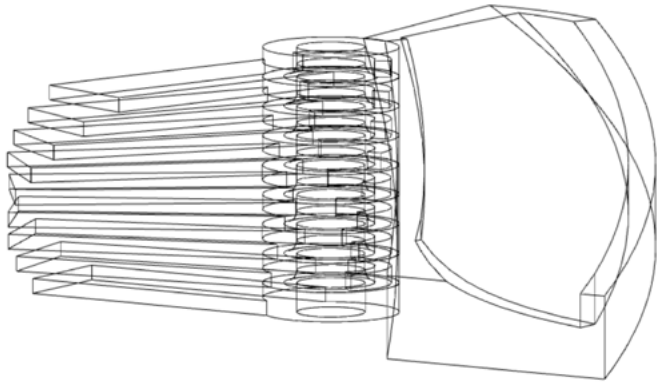
EXPERIMENTS v1.3

Repetition of Modules







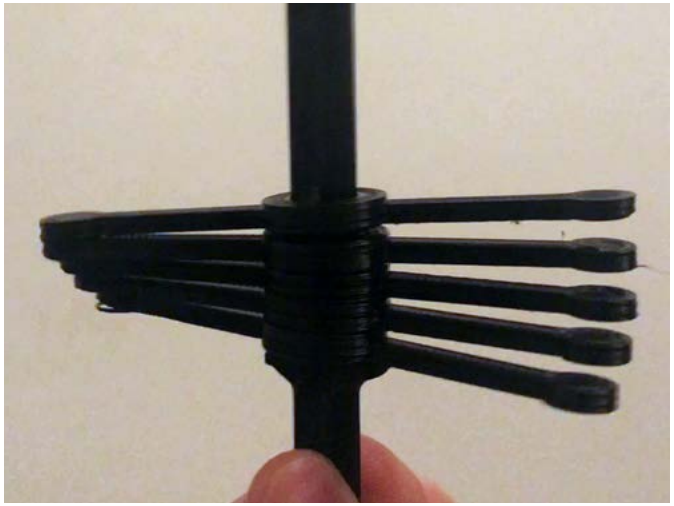


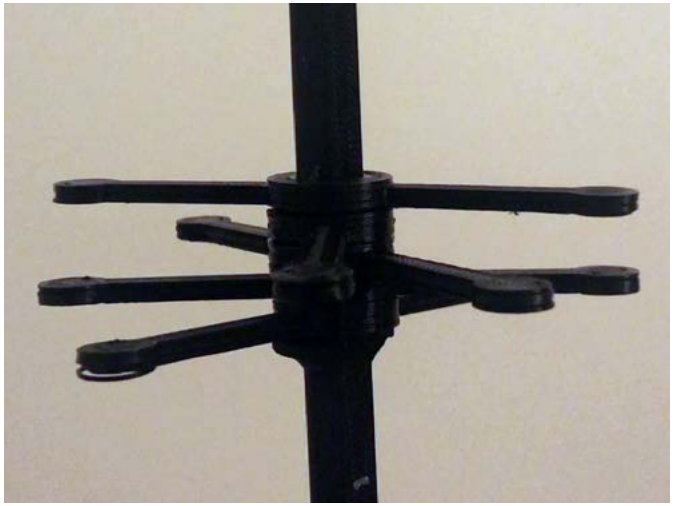
Transformed by Rotation

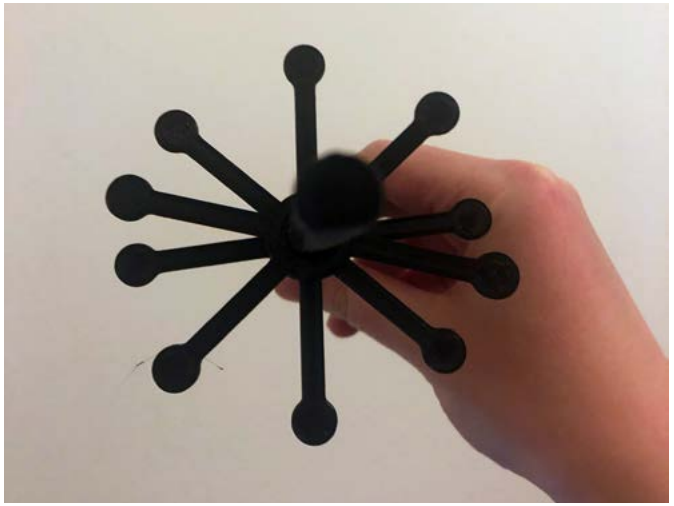
When experimenting with the form of the modules, I was inspired by John Edmark's Helicone, which rotates according to the golden ratio and changes the forms. The design is simplified to focus on less elements of playfulness.

EXPERIMENTS v1.3

Test Print







Rotation Mechanisms - Spin & Rotate

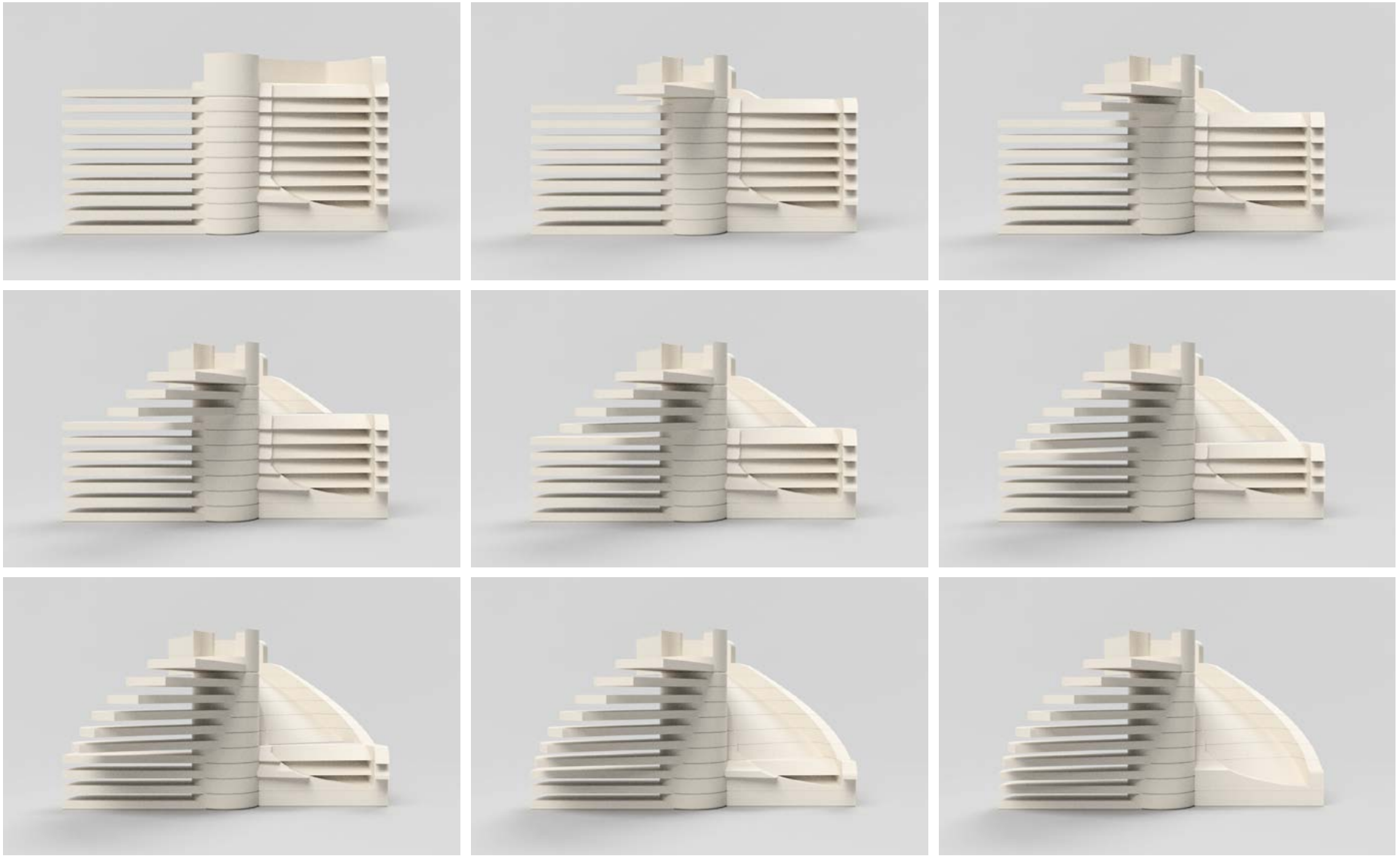
In the original design of Helicone, the form is transformed by a rotation from the center. However, as an architecture, I will further develop the design and mechanism in order to transform with a simple action (i.e. pull/push).


SPIN
SLIDE

DELIVERABLES

Transformation Experiment

SECURITY

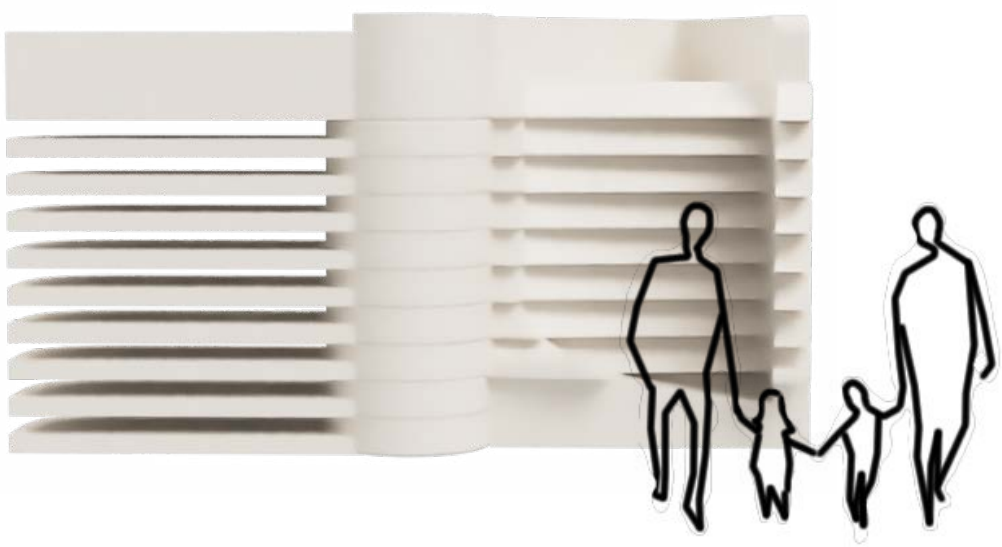


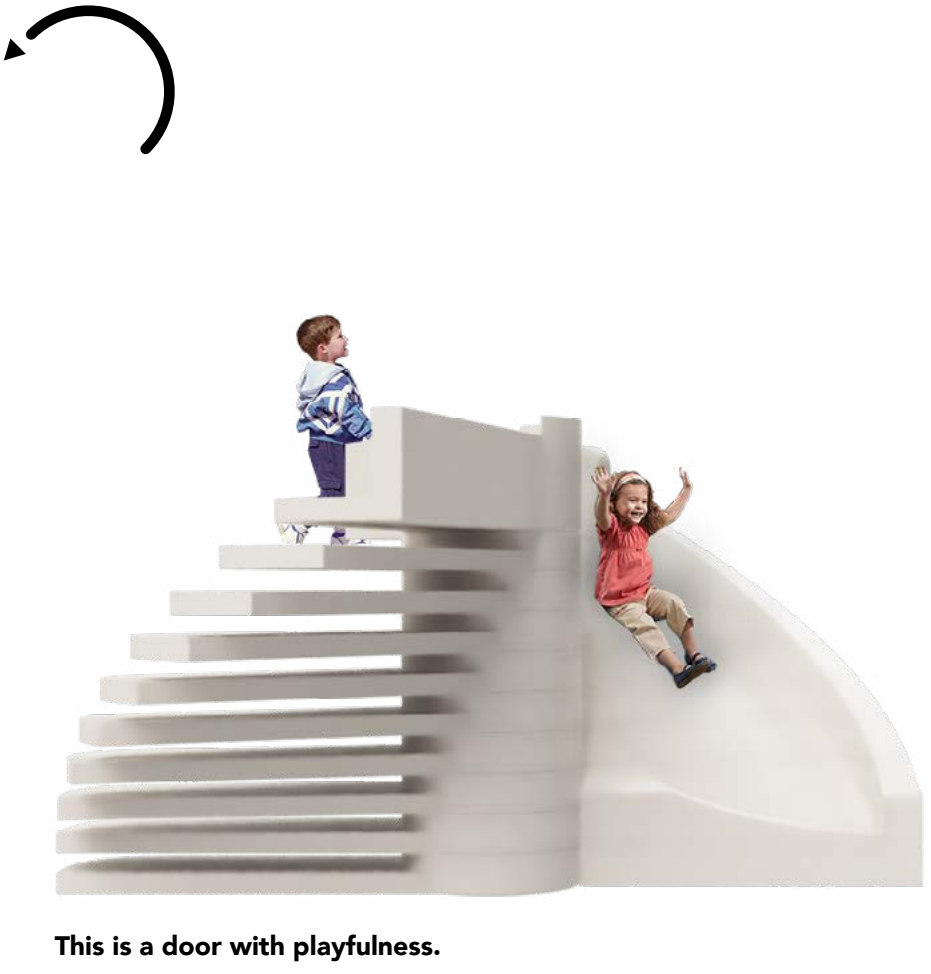
PLAYFULNESS

DELIVERABLES

From Security to Playfulness

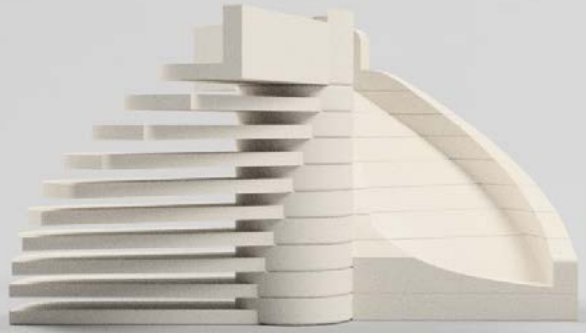
This is a slide with security.





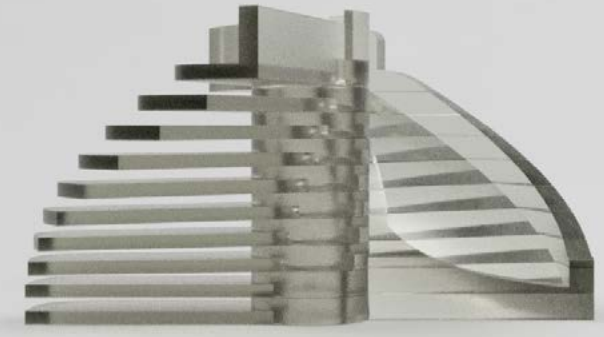
This is a door with playfulness.

MATERIAL

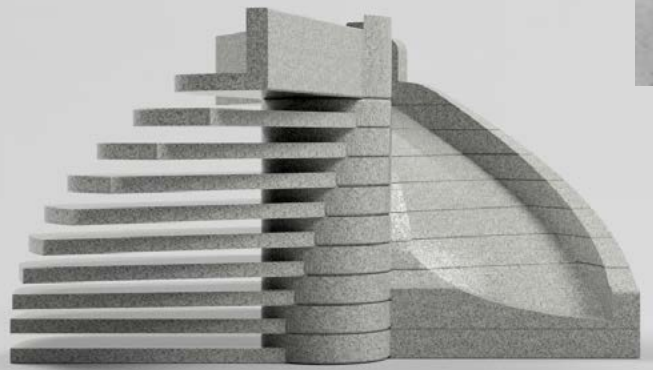


3D PRINT - CONCRETE & Rice Production Wastes

BAMBOO



TRANSPARENT WOOD



CONCRETE

FURTHER DEVELOPMENT

Materials

In order to simplify production and ease the recycling process, the project is designed to use a single material. Considering the production, 3D print technologies and modular construction method are proposed for manufacturing and installation, which aims to improve the installation and recycling problem.

Mechanisms

As this is an architectural project, the heavy duty movements would require different experiments to test with the mechanism, rather than a prototype in small scale. Experts in mechanical engineering and architecture will be consulted for the improvement.

Design System

The interdependency between design and engineering causes the difficulties in applying transformable design for designers. Therefore, a more comprehensive design thinking system should be developed for designers who do not have background in engineering and engineers who do not have background in design to communicate more effectively. This may be solved by new design tools in product design software.

Scenarios

In order to express the diversity of doors, I have decided another 2 scenarios: door for people with lower strength (i.e. Parkinson's Disease Patients and Elderly) and home front door for general public.