3D PRINTING FOR CREATIVES

GRAP2756

Semester 1, 2021

Lecturers: Phoebe Richardson; Thom Luke

Design research Compendium

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MDIT - RMIT School of Design
March 19, 2021

I. RESEARCH

3D printing & Compliant Mechanism Design

1. RESEARCH FIELD

1.1 Field of Research

3D printing has contributed to the efficiency of time-consuming, idea brainstorming, and testing prototypes for the process of designing complexity.

For the field of research on complaint mechanism design from the past to the future, I want to explore the evolvement of tools and equipment that equips designers and professionals to come up with innovations and inventions.

1.2 Theo Jansen Linkage

I follow an example of a kinetic mechanism produced by Theo Jansen and tried to customize this structure based on my knowledge about 3D fabrication through Fusion360 and basic electronics prototyping in order to investigate the subject of the compliant mechanism design process.

Working on making a prototype based on this model, I can understand better how 3D printing can support the design process of building a mechanism, as well as, how this technology can help me be able to fabricate the complexity without the need of gaining full knowledge as a scientist, artist or an engineer.

During working on the digital modeling through Fusion360, I can learn more about the joint function and how the hinge structure works well with 3d printing technology thank to the digital simulation method. I expect through this example compliant mechanism, I can apply the knowledge of the kinetic system to the field of making responsive architectural facades, artistic performance for kinetic motions, mobile robotics, etc.

THEO JANSEN LINKAGE

a = 38
b = 41.5
c = 39.3
d = 40.1
e = 55.8
f= 39.4
g = 36.7
h = 65.7
i = 49
j = 50
k = 61.9
l = 7.8
m = 15

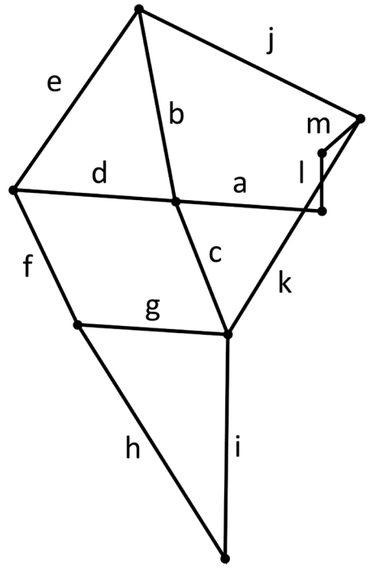
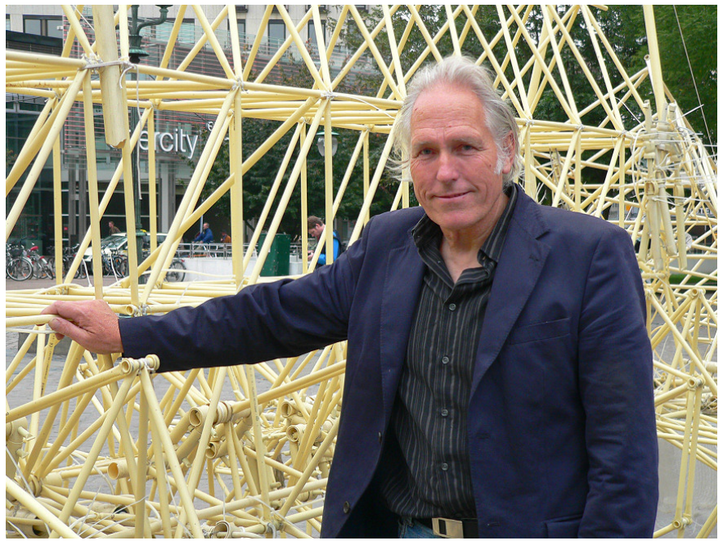


Diagram shows 11 numbers in Jansen's principle for creating the linkage

(Image by author)



Key information about Theo Jansen linkage

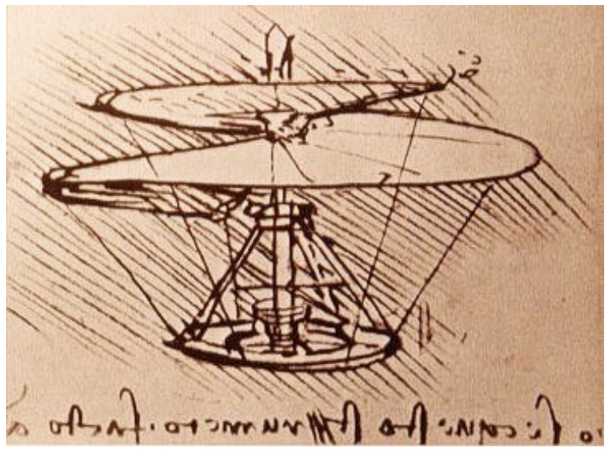
- Designer: Theo Jansen
- Leg-mechanism of organic walking motion for mobile robotics
- The work is driven by air movements from wind energy; or electric motor.
- It is an art form focusing on visualizing the act of walking as a living creature from machines.
- Other keywords: Jasen mechanism, Jansen linkage, kinetic sculptures

For this mechanism, the robotic movement which is driven from wind energy or electricity performs in an artistic sense as a living creature walking on a surface.

Reference
Wikimedia Foundation, Inc, 'Jansen's linkage', viewed May 01 2021, <https://en.wikipedia.org/wiki/Jansen%27s_linkage#:~:text=Jansen's%20linkage%20is%20a%20planar,for%20%22beach%20beasts%22).>

2. TRADITIONAL WAYS IN DESIGN PROCESS

2.1 Sketching



Leonardo da vinci, 1508–10

Image source: Wikipedia

Rembrandt, unknown

Image source: Wikipedia

Sketching is defined as the first act in the design process to produce preliminary drawings for quick visualizing ideas from the head.
Sketching helps designers to observe their logic of thinking, imaginations to improve their ideas for later processes. In addition, this form of design communication helps creators to introduce their ideation to others, especially in the art and design spectrum.

The sketching method has been used for a long time in human history and contributed to the process producing great innovations and inventions by many famous designers, architects, scientists, and artists, such as: Leonardo da Vinci, Carel Fabritius, Jean-Honoré Fragonard, ... [1]

During the modern age, in spite of the intervention of technology in the design process, this traditional technique remains its important role for practicing the skill of design thinking and observations for both intermediate design/art students and professionals.

Reference
[1] Wikimedia Foundation, Inc, 'Sketch (drawing)', viewed May 01 2021, <https://en.wikipedia.org/wiki/Sketch_(drawing)>

2.2 **Drafting**

Image source (Google, n.d.)

DRAFTING

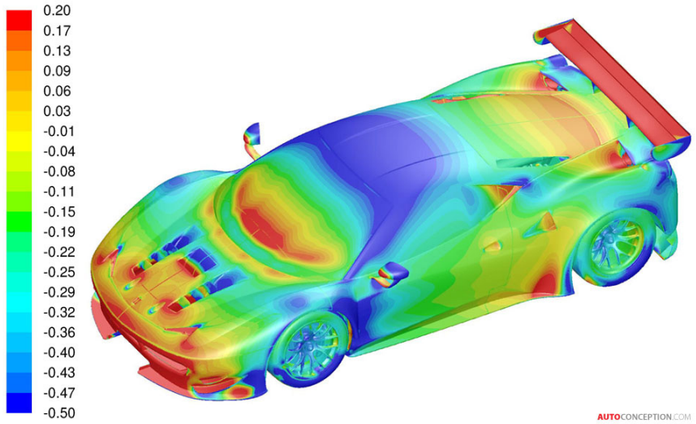
Another word for drafting is technical drawing. This method is to present the layout or plans in detail of construction before its execution. Drafting is mostly used by architects, urban planners, landscape designers, engineers for design presentation from a large scale of cities to smaller scale of interior design as furniture.

Drafting used to be drawn by hand with a pencil on paper. This work was standardized with the strict requirement of the same style in hand drawing letters, frame, unit, scale, the layout of content with different views and sections of construction.

Thank to the invention of CAD software (Computer-Aided Design), hand-drawing- drafting is replaced by 2D-CAD digital drawings with a higher quality of standards and easier to cooperate with many workers at the same time.

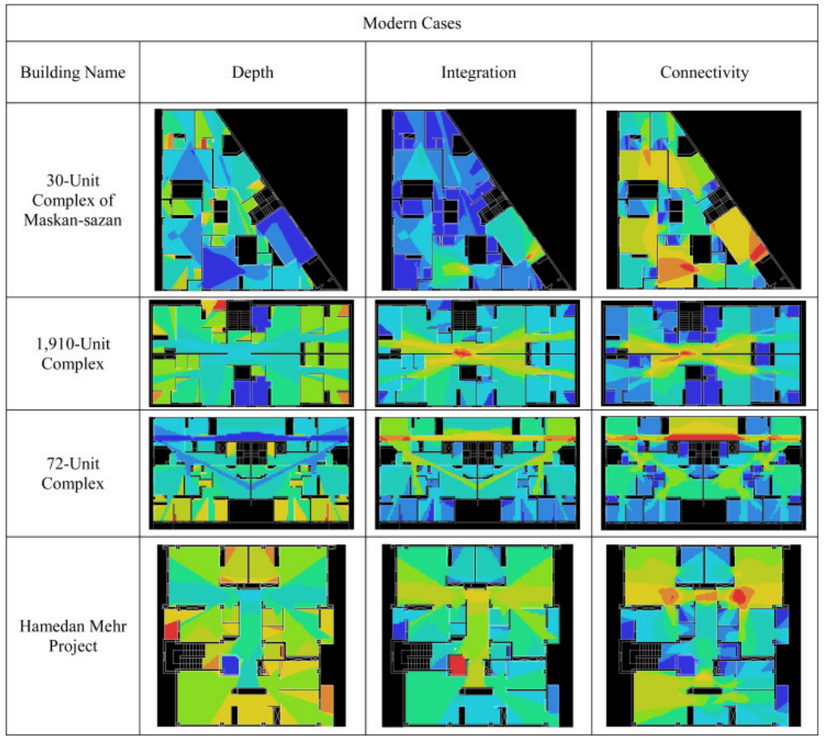
Today, the common use of digital 2D drawings among various disciplines has turned this method into a new-traditional way for the drafting process.

2.3 Digital simulation



Digital simluation helps to improve the aerodynamic performance of its car designs

(Image source: autoconception.com)



Urban planner using digital simluation for analyzining the complexity in cities (air movement, transportation, heat...)

(AlitajerGhazalehMolavi, S & Nojoumi, G 2016)

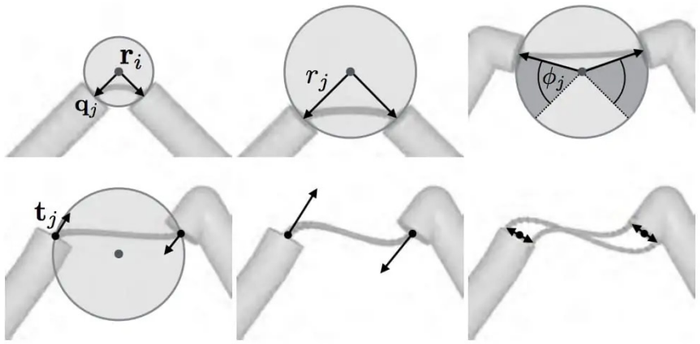
Digital simulation is a method using mathematical models assisted by a computer to investigate real-world phenomena, systems, devices, processes...

For designing complex mechanisms or systems, digital simulation is a great tool for designers to have a comprehensive understanding of the concept by applying computing algorithm to manipulate various possibilities which can be produced from a digital model from a computer for testing, observing the real potential outcome of designed product before fabricating it.

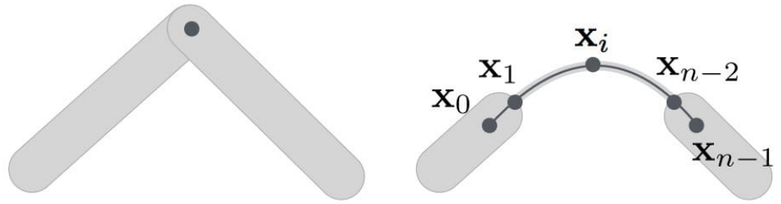
Urban planner uses digital simulation method to investigate the conditions of natural phenomena within cities to have a better plan for designing allocation of buildings.
The artist Theo Jasen has applied this method to come up with a theory for his idea about a kinetic linkage mechanism that can mimic the walking behaviour for mobile robotics design.

3. EXAMPLES OF COMPLIANT MECHANISM (OR KINETIC MECHANISM) DESIGN

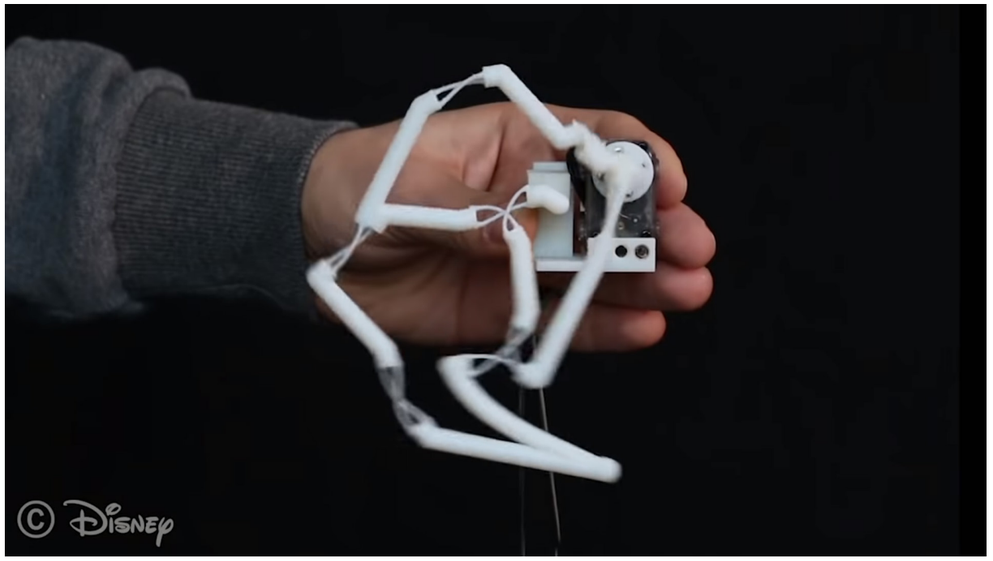
3.1 Disney's Compliant Mechanism Study

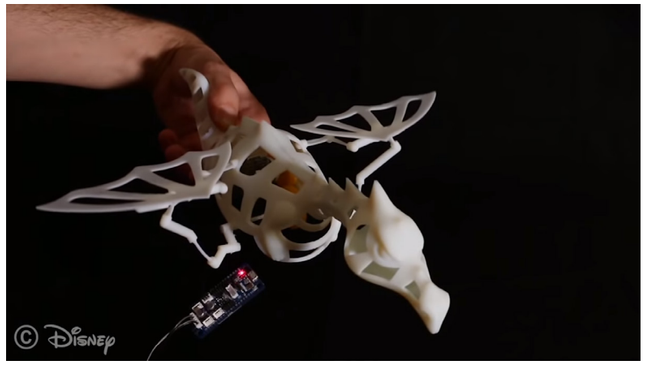


Defining parameters for compliant system



Designing a joint





Wing and leg structures

Disney Research labs investigate a new approach of using a digital fabricating tool to come up with better ideas for more innovative mechanical toys mimicking elegant and efficient structures in nature such as tendon and cartilage structure.

Researchers have used the 3D printing technique to prototype parts of compliant mechanisms: an animatronic eye, a bionic hand, etc for a physical demonstration of the principles. For using 3D printing technique to come up with physical artifacts, the complexity in compliant mechanisms is easy to be explained and exchanged ideations through multi-disciplinary designers.

Therefore, they can develop their intuition of using a compliant mechanism for designing elegant and fictional mobile robotic as well as mechanical toys for children.

More specify in the project, they investigate the hinge system of organic machines, studying the flexibility in motions with complex geometries inspired by organic systems in nature. They digitally simulate the model on a computer and generate multiple iterations of linkages and equations and test out the best option for the ideation through physical artifacts.

The following applications throughout this project include topological speculation in "animatronics" (animal-like robotics) - improving toy and robotics design with the sense of novelty and efficiency in motions, etc.

Key innovator:

3D printing

Digital simulation

Reference

SolidSmack 2020, "Disney’s Compliant Mechanism System for 3D Design", viewed June 09 2020, <https://www.solidsmack.com/fabrication/disney-compliant-mechanism-system/>

3.2 Hazza Bin Zayed Stadium / Pattern Design

This is a design of facade using a kinetic mechanism to manipulate windows to react to the outside environment through the changing of sun movements. The building locates in Bad Gleichenberg, Austria, designed by architect Ernst Giselbrecht in 2007.

The idea is to create a responsive facade taking benefit of principle on shading angles from sun movements in day to reduce the necessity of air conditioning inside the office. Technology implemented in electro-mechanical technology using sensors to detect light signals and motors to run the sequence of movements of aluminum panels.

This kinetic facade is also considered as a "dynamic sculpture" that proposes an active-designed system for the sustainable energy-consuming strategy.

Key innovation:

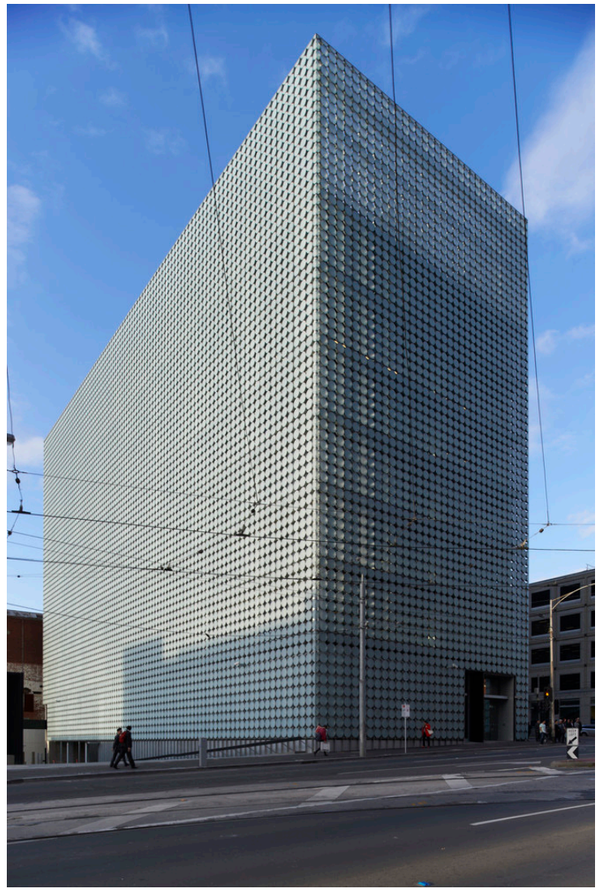
Parametric design using kinetic mechanism & sensing technology

Reference

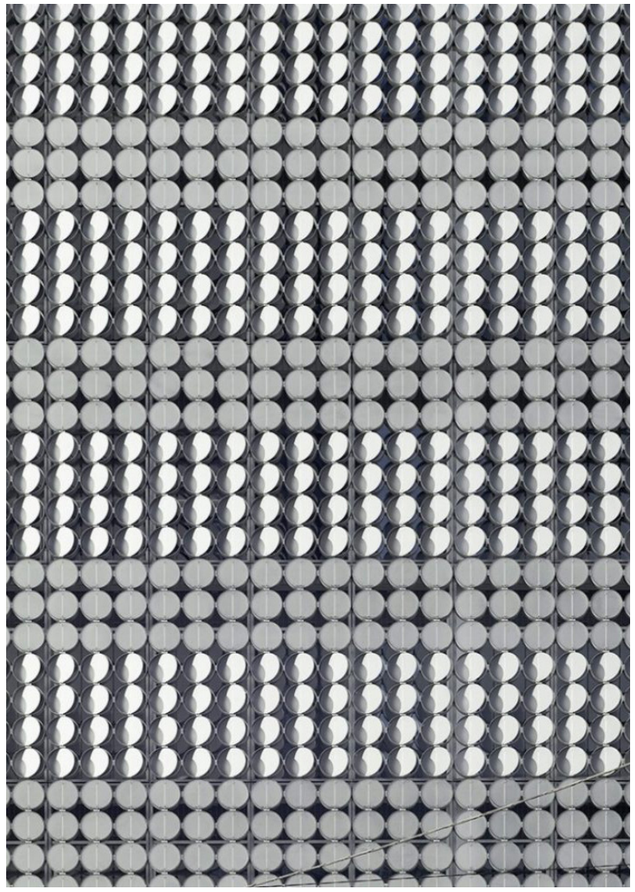
Design Indaba 2021, "The dynamic solar shading of Kiefer Technic Showroom", viewed June 09 2020, <https://www.designindaba.com/articles/creative-work/dynamic-solar-shading-kiefer-technic-showroom>

Nora Schmidt, 2010, "Dynamic façade – Kiefer technic showroom by Ernst Giselbrecht + Partner (AT)", Daily Tonic, viewed June 09 2020, <https://www.dailytonic.com/dynamic-facade-kiefer-technic-showroom-by-ernst-giselbrecht-partner-at/>

3.3 Rmit Design Hub Facade - by Sean Godsell Architects



Source: ArchDaily



Source: PeterClark Photography

Another example of using the kinetic mechanism in architectural design is a design by Sean Godsell in 2012 for RMIT Design Hub.

The facade generated by high technology helps to preserve the inner climate from the harsh solar conditions of Melbourne (Australia) climate. It is expected using solar power for running electricity for the whole building.

This is a dynamic facade built up with 17000 glass discs. The idea is using light sensors to detech the sun movements and transfer to the discs' rotations for preventing direct sunlight from outside coming into building.

Another aesthetic perspective for this idea is to illustrate the gesture of "waking up and greeting day" poetically performed by the facade as an artwork among city.

Other information:

Technology: Electro-Mechanical; Central control
Program based in Weather: Light sensors
Materials: Sandblasted glass; aluminum; steel

Key innovation:

Parametric design using kinetic mechanism & sensing technology

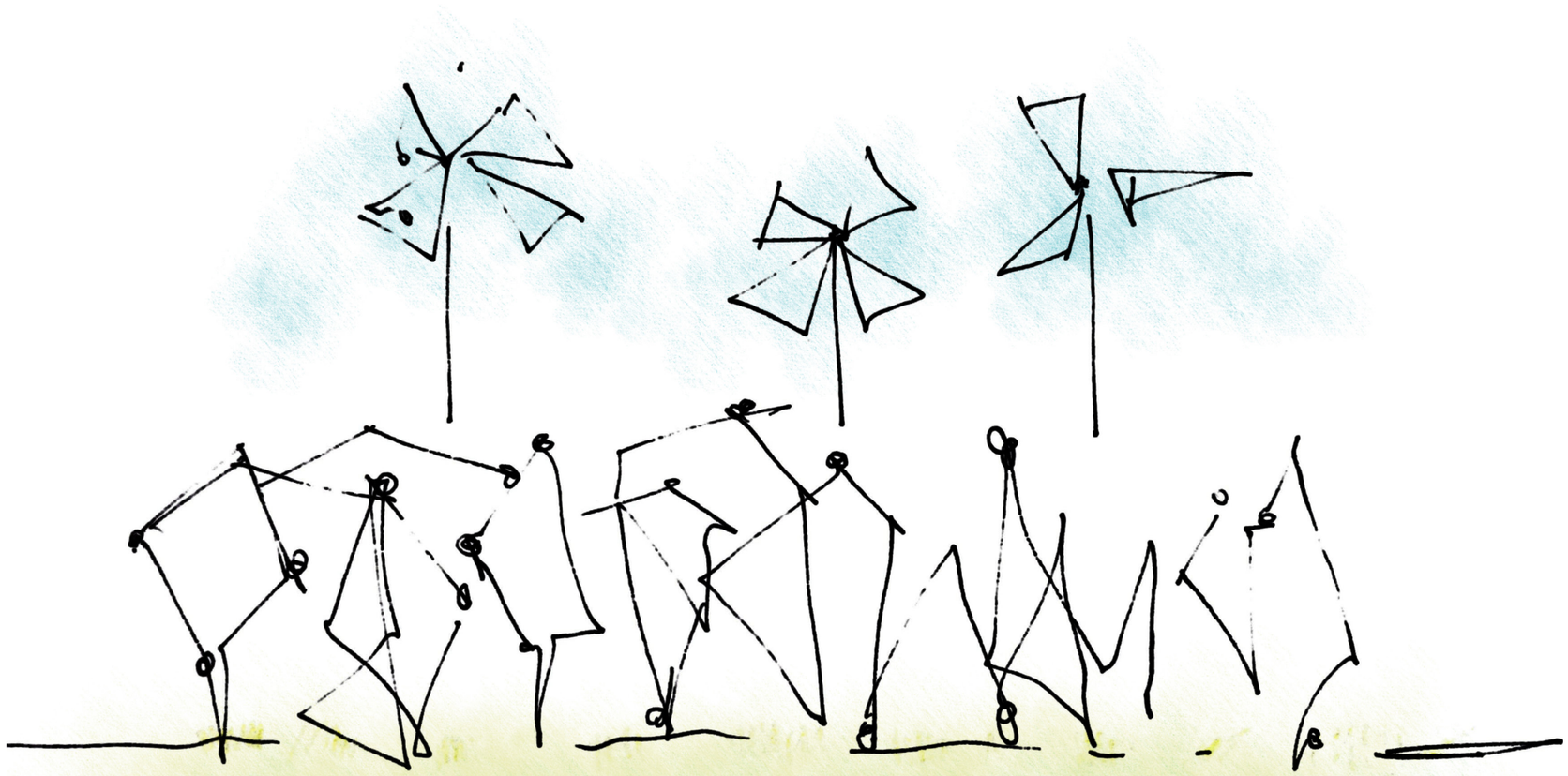
Reference

IAAC, 2017, " Parametic Facade Decoding", viewed June 09 2020, <http://www.iaacblog.com/programs/parametric-facade-decoding-2/>

ArchDaily 2013, "RMIT Design Hub / Sean Godsell", viewed Jun 09 2021. <https://www.archdaily.com/335620/rmit-design-hub-sean-godsell> ISSN 0719-8884

4. FUTURE SPECULATIVE VISION

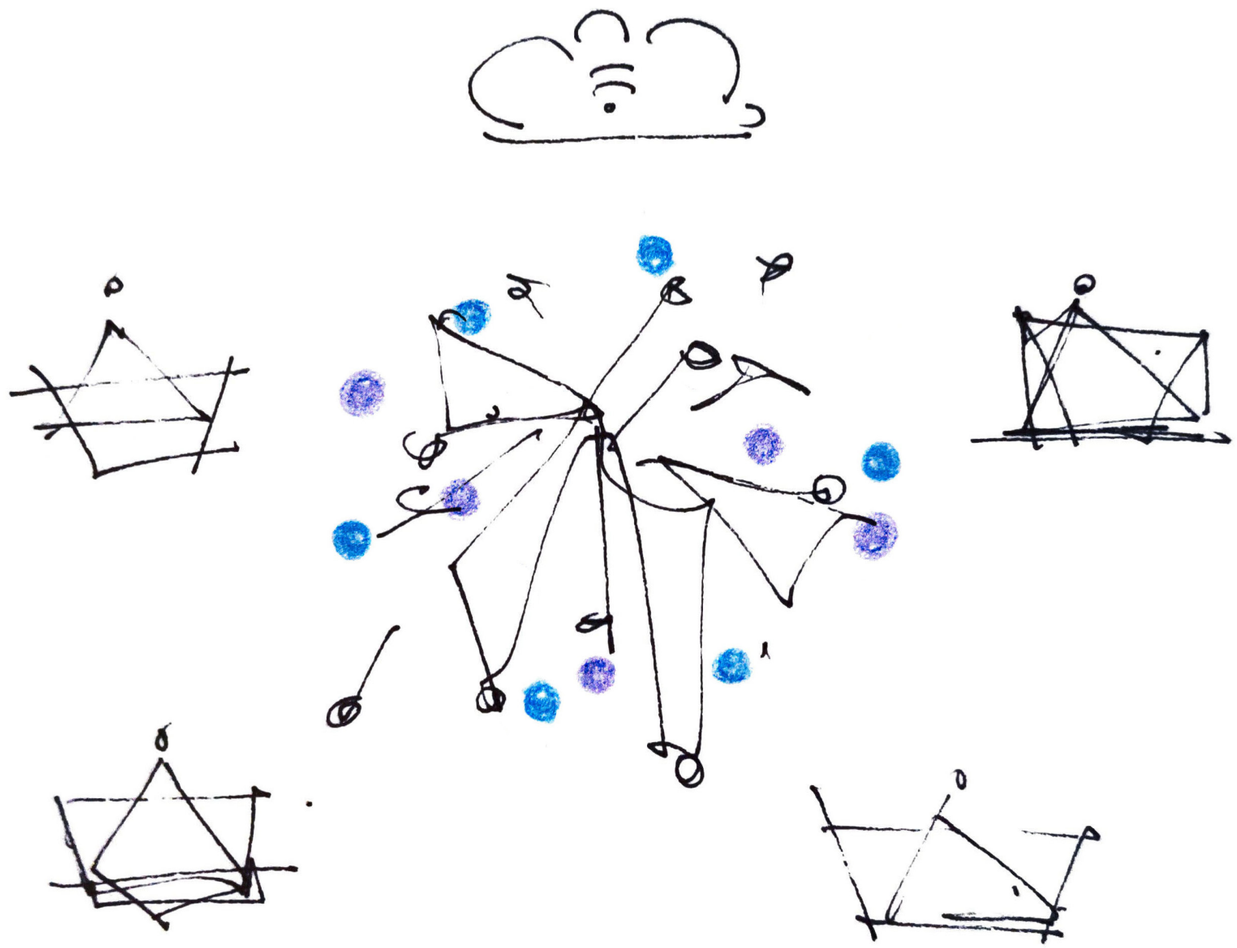
4.1 POSSIBILITY 1 : ROBOTICS FARM USING SUSTAINABLE ENERGY



For a fictional future farming vision, humans return to the old-fashioned- organic way of farming with a higher technology using mobile robotics.

The animal-like mobile robotics powered by solar and wind energy can become a new kind of "predator" to protect crops from insects, mice... without using pesticides. They can also monitor soil and water for plants with flexibility in motions under the guidance of humans from distance.

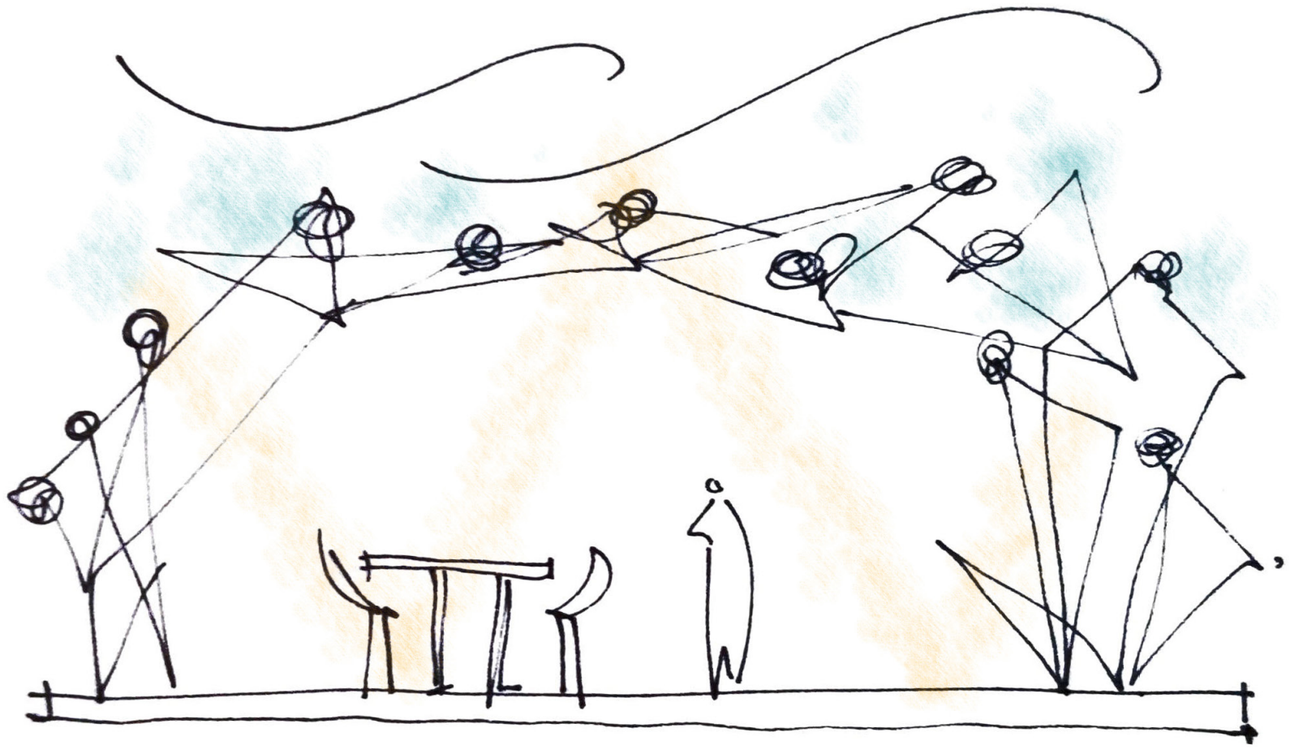
4.2 POSSIBILITY 2: USING COMPLIANT MECHANISM FOR COLLABORATIVE FABRICATION IN ONLINE LEARNING



Regardless of online lectures, the new trend of cloud 3D printing with a high capacity for real-time collaboration using CAD software can propose a better online learning experience by giving students the ability to cooperatively fabricate things with other classmates using the Internet.

In addition, they can access and manipulate equipment from distance by using the linkage mechanism. This mechanism provides an ideal solution to manipulate physical objects/ equipment and keep people safe from dangerous situations. For that, people can explore and learn things in extreme conditions. This way of learning can bring a new perspective on a global scale for the quality of online education in general.

4.3 POSSIBILITY 3: PERSONAL FABRICATION



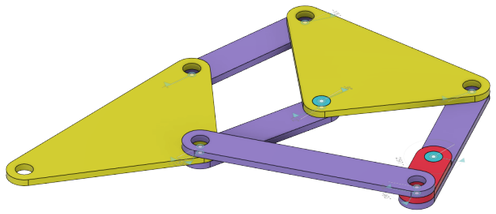
3D printing fabrication for compliant mechanisms can bring opportunities for users with a non-expertise background to come up with robotic ideas for their personal needs.

The linkage machis can be customized for the use of domestic responsive facades, canopies... Users can download the blueprints from open-source and print assemblies to create their aesthetic design to fit with their demands.

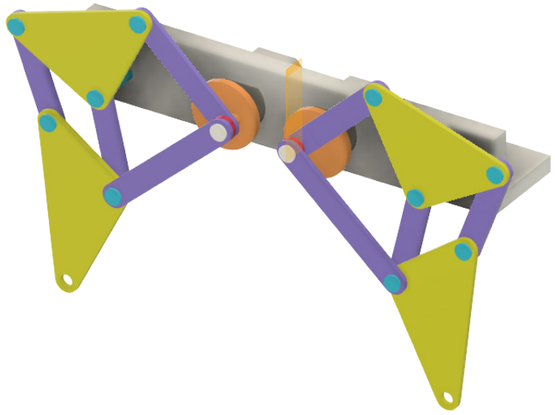
II. ARTFACT

Making process and physical model

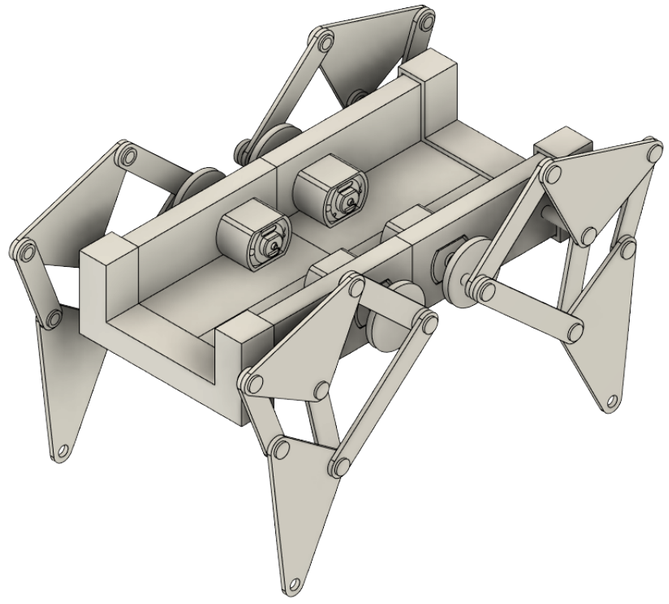
1. MAKING PROCESS



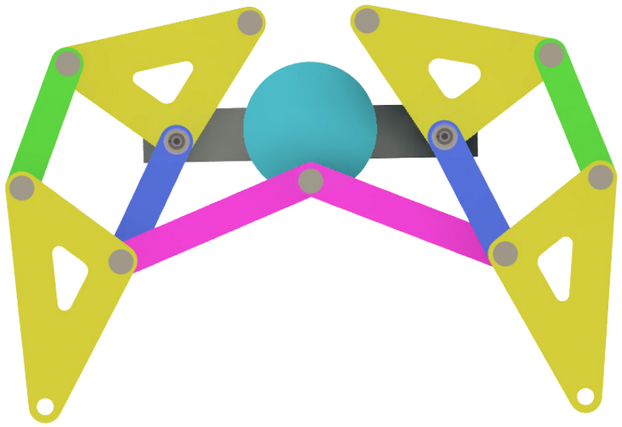
Phase 1: Making one leg structure



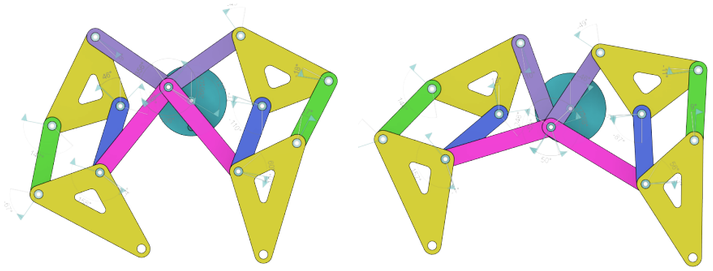
Phase 2: Making two leg structure using 2 motors as motion drivers



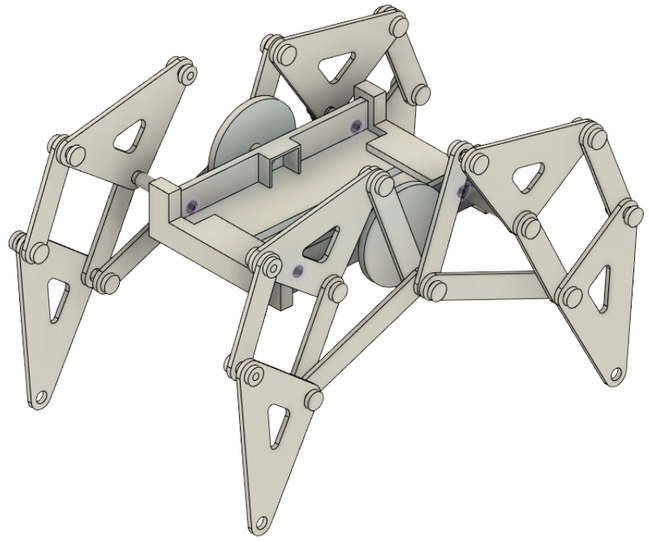
Phase 2b: Combine 2 two-leg structues for a simple form of robotic



Phase 3: Making two leg structure using 1 motor as motion driver

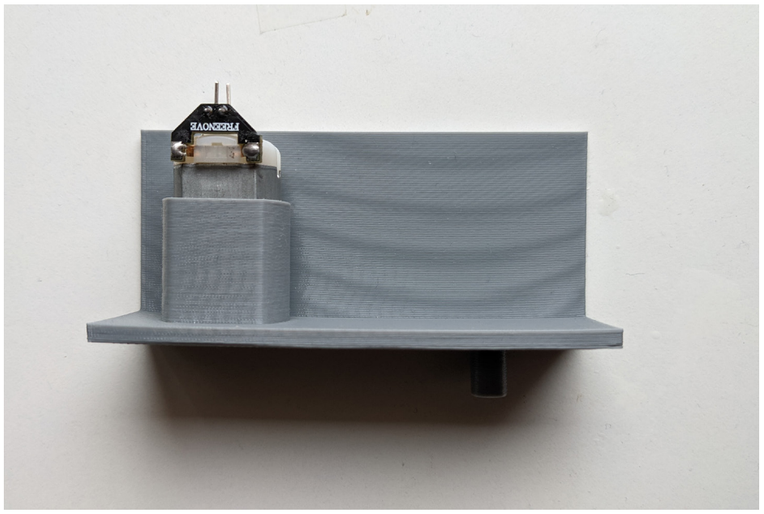


Phase 4: Using digital simluation for testing motions

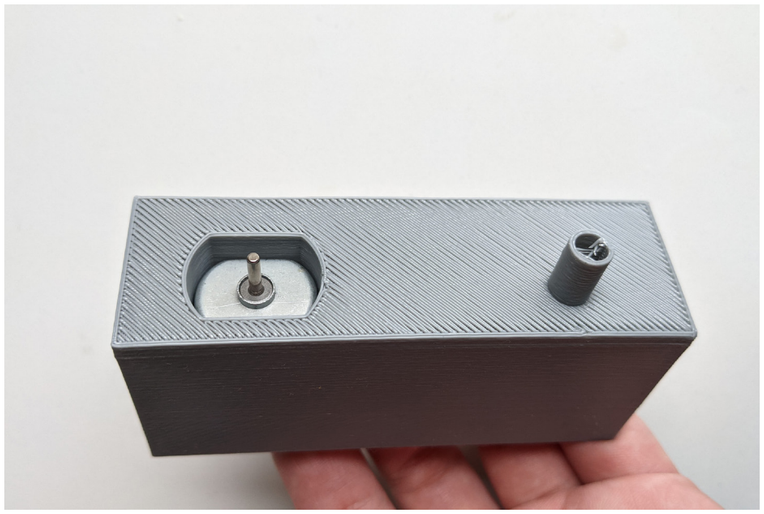


Phase 5: Finalize a simple form of robotic with 4 legs

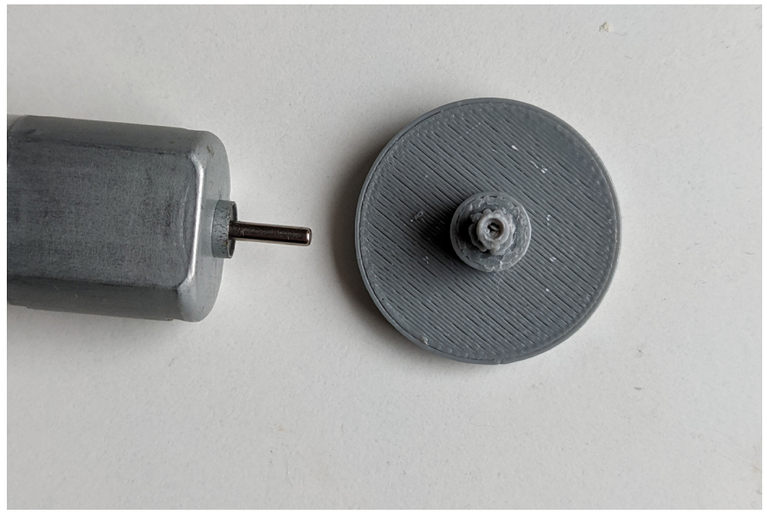
2. PROTOTYPING

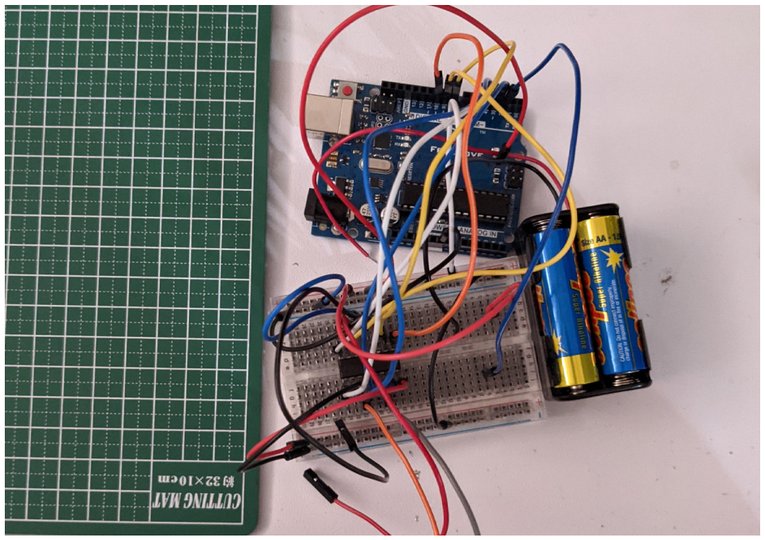


Making 3D prototype

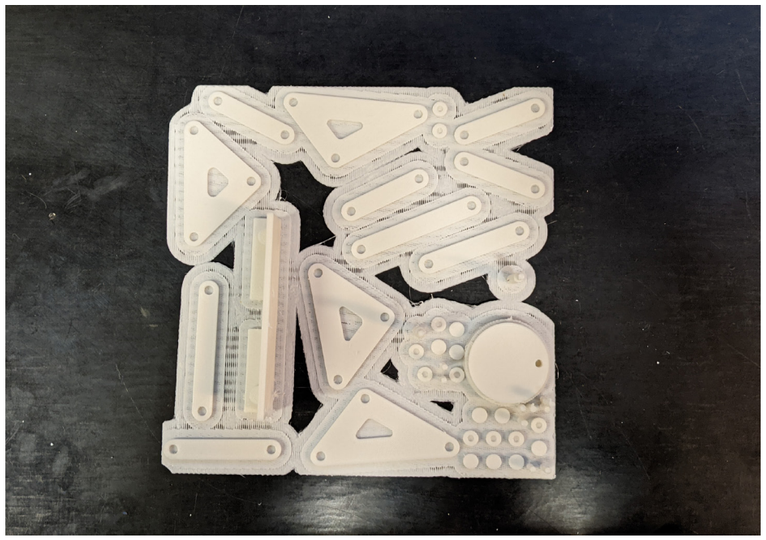


Some problems with hinges, and tolerant gaps

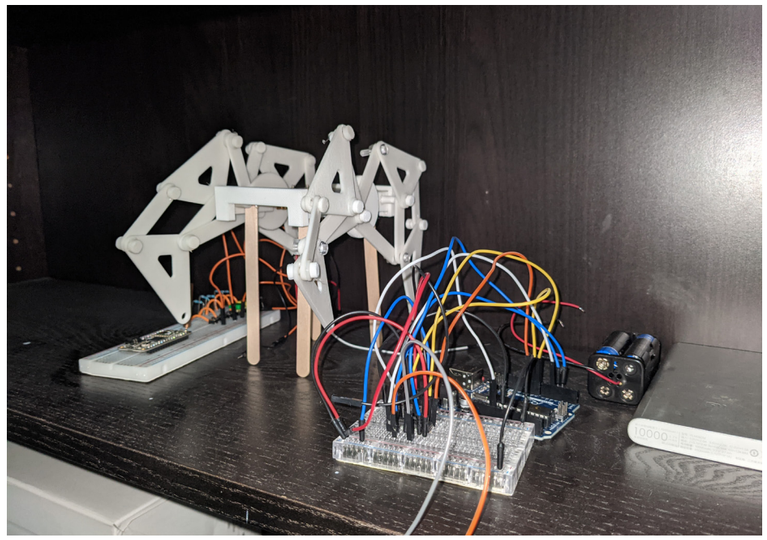




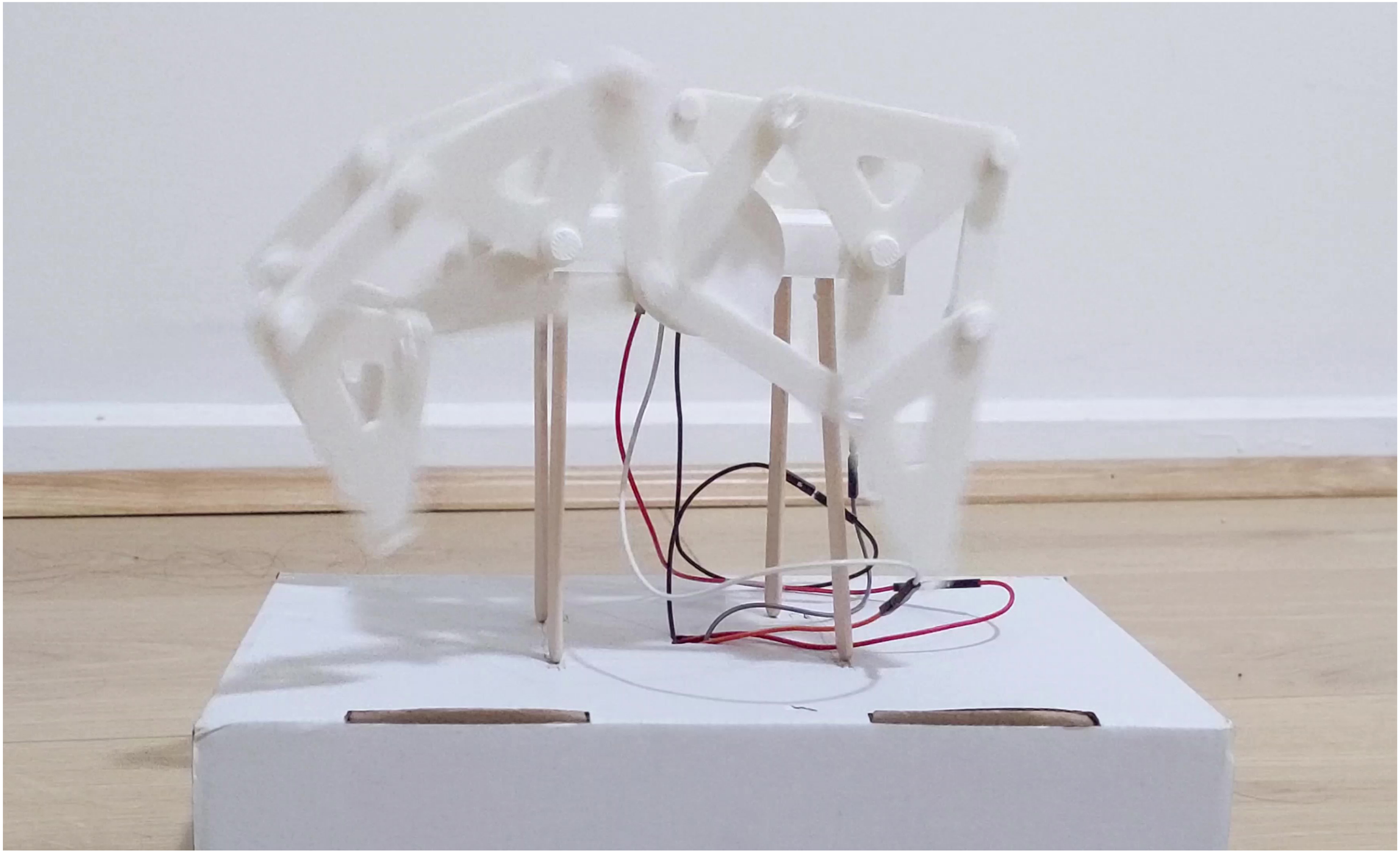
Making electronic prototype with 2 motors and Arduino



Making 3D prototype version 2



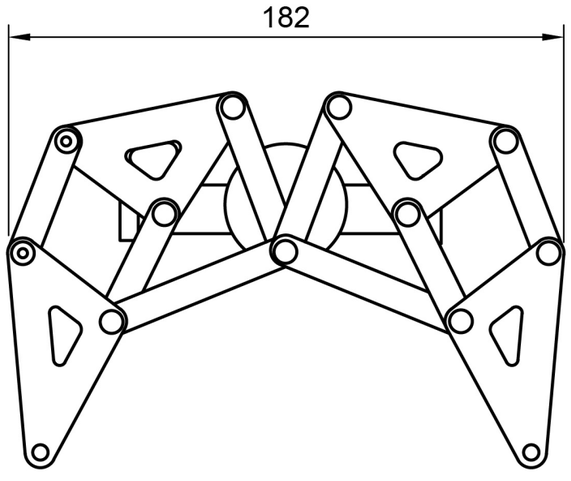
Combine 3D model with electronic prototype

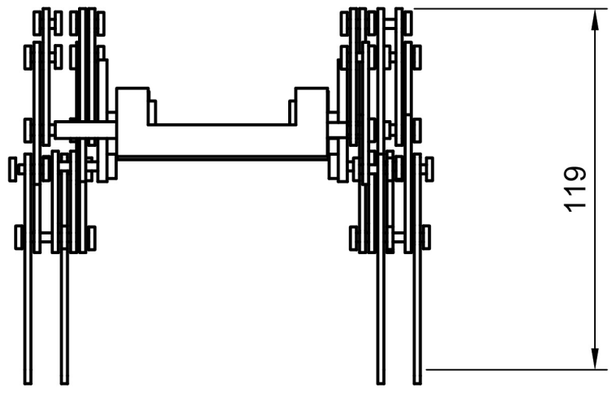


Video demonstration

Online Link: https://youtu.be/qanmk54HrGc

3. TECHNIQUAL DRAWINGS





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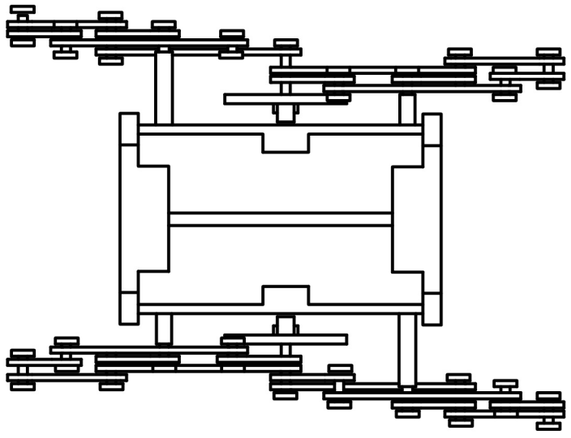

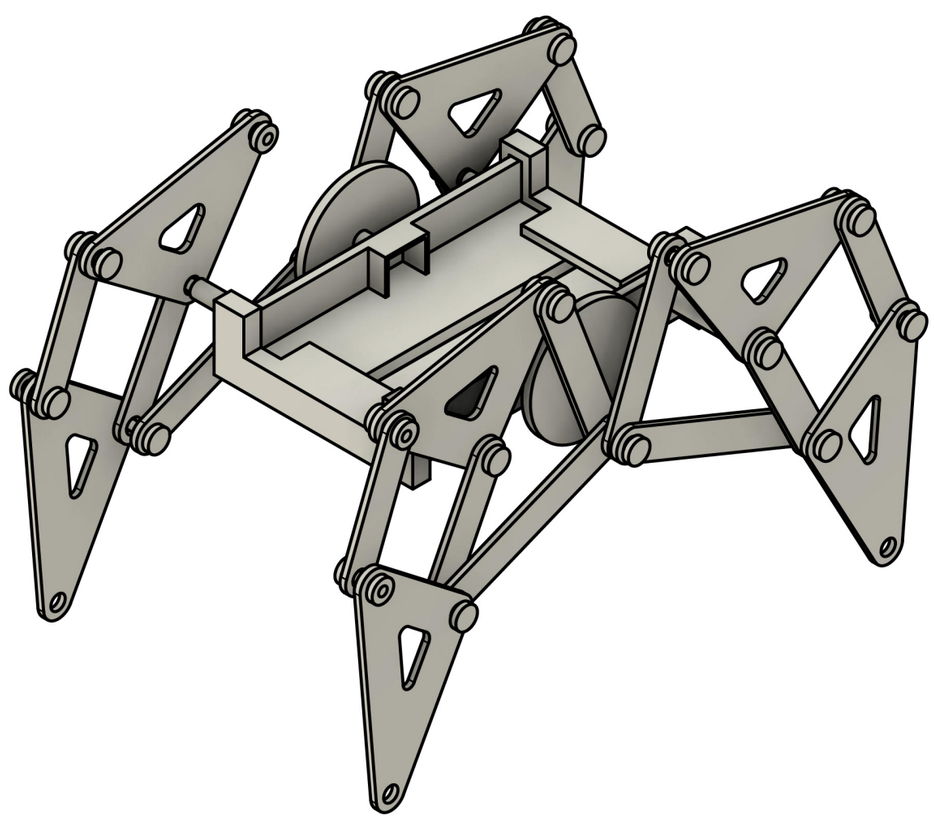

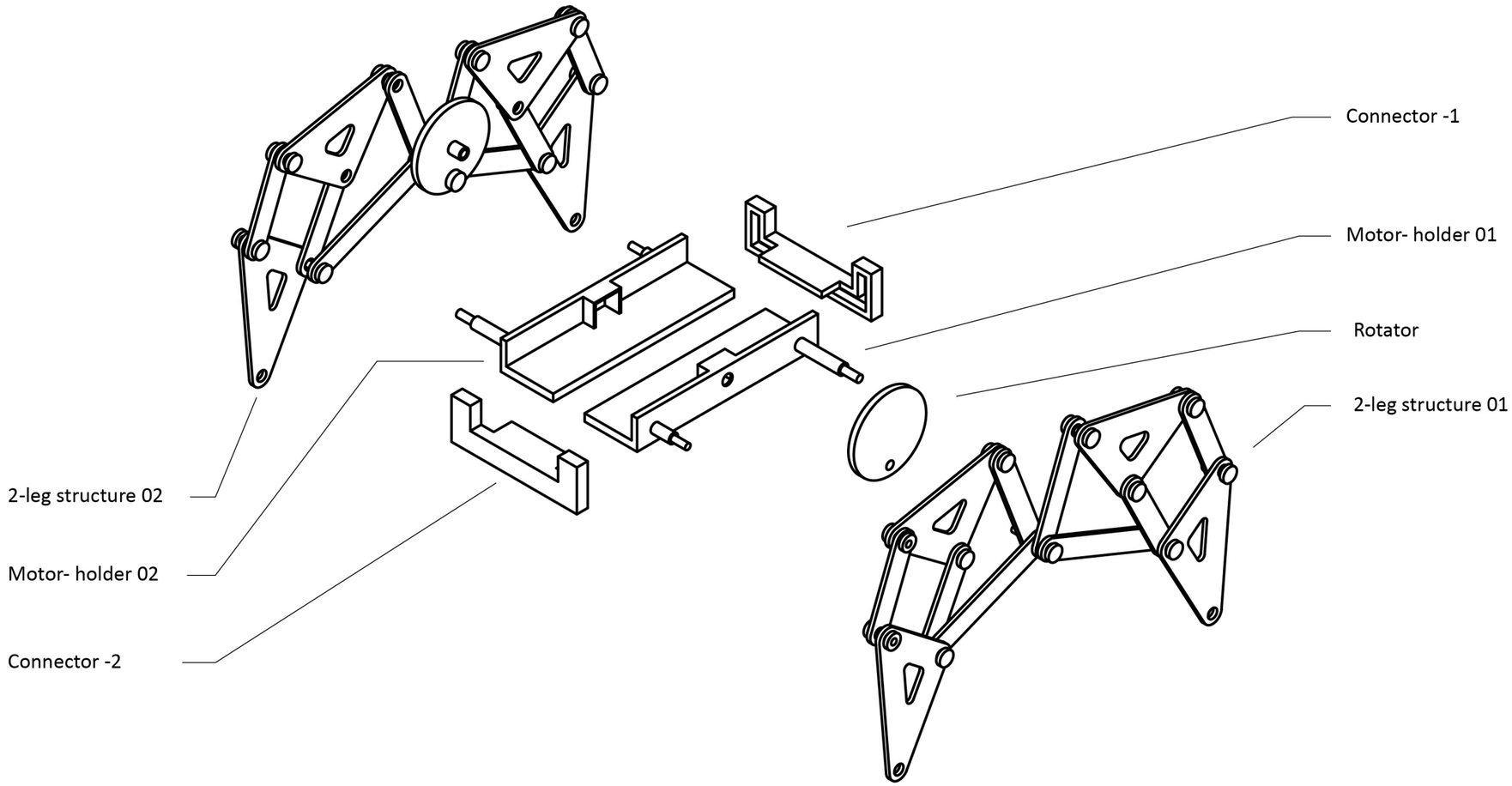

PART NUMBER	PART NAME	DESCRIPTION	MANUFACTURING TECHNIQUE
P-01	2-leg structure 01	2-leg front structure assembly	Manufacturing Technique
P-02	2-leg structure 02	2-leg back structure assembly	Manufacturing Technique
P-03	Motor- holder 01	Place for holder motors	Manufacturing Technique
P-04	Motor- holder 02	Place for holder motors	Manufacturing Technique
S-01	Rotator	Part to trigger motions from structures	Manufacturing Technique
S-02	Connector -1	Part to connect motor-holders	Manufacturing Technique
S-03	Connector -2	Part to connect motor-holders	Manufacturing Technique