IDC School of Design
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BIOMIMICRY IN DESIGN

SWARMS INSPIRED SHAPE SHIFTING MATERIAL

SPECIAL PROJECT

By Deepak Peddoju (156390001)
Guided by Prof. Nishant Sharma

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DECLARATION

I declare that this written report represents my own idea in my own words, and where others, ideas or words have been included, I have mentioned the original source. I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission. I understood that any violation of the above will be cause for disciplinary action by the institute and can also penal action from the source from which proper permission has not been taken, or improperly cited.

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APPROVAL SHEET

This Mobility and Vehicle Design project report entitled “Biomimicry in Nature: Swarms Inspired Shape Shifting Material”, by Deepak Peddoju is approved in partial fulfilment of the requirement for Master of Degree in Mobility and Vehicle Design.

Project Guide:

Date :

Place :

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1. INTRODUCTION

With its 3.8 billion years of experience nature has always been a great resource of inspiration and information. Nature has evolved with time adapting to various conditions taking shape for optimum adaption in a particular environment. Designers and engineers in search of new ideas always seek nature for inspiration. As we continue to observe and understand, nature continues to show us the best ways to handle various problems.

2. RESEARCH

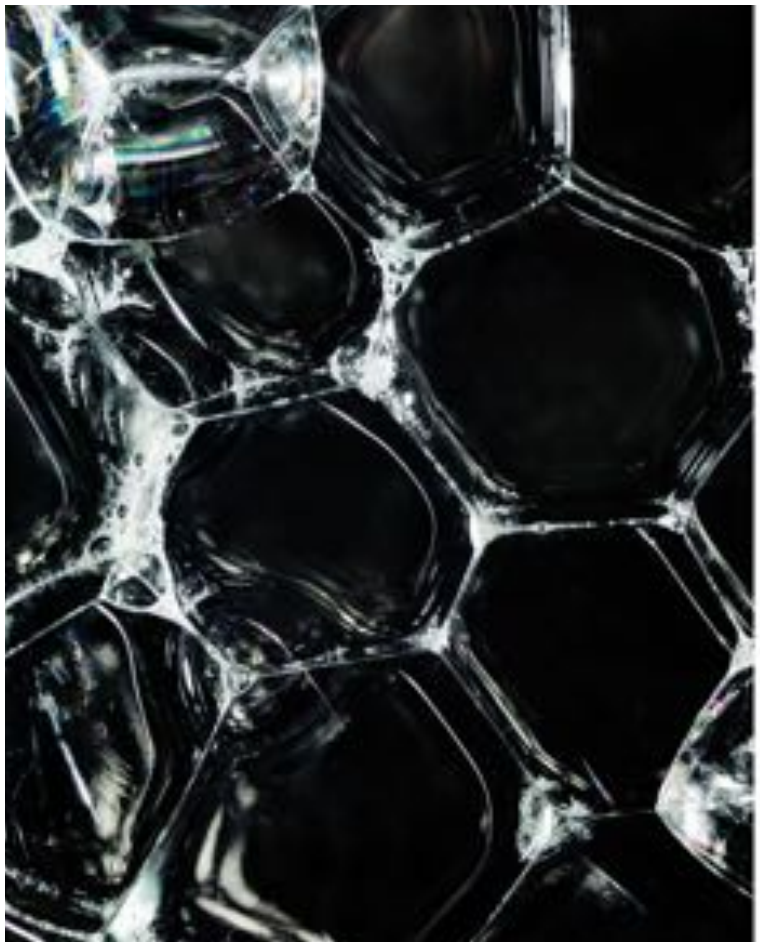
In this project before arriving at an inspiration, research was done on biomimicry and various examples of biomimicry in the field of design and engineering.

2.1.Gecko Climbing Feet

The secret of geckos climbing up vertical walls or surfaces without falling lies within tiny little hairs covering their toes. Researchers have managed to mimic the biomechanics of gecko feet in a pair of climbing pads capable of supporting a human's weight. Each pad is covered with adhesive tiles bearing sawtooth-shaped polymer structures about the width of a human hair that create an adhesion force when they're pulled on.

2.2.Water Cube

The Watercube's design is based on the structure of soap bubbles, giving it a natural feel and earthquake resistance. The walls of the rectangular facility are made of large bubbles, both in form and function. Each bubble is a pillow of rugged plastic. The bubbles, which are just 0.008 inch thick, trap hot air from the sun that's then circulated to heat the pools. The plastic is resistant to damage from sunlight, weather and even dust. It's also easy to clean. When it rains, grime from Beijing's thick smog is swept away.



2.3.Cephalopod camouflage

Squids are capable of glowing as well as changing their skin colour. This camouflaging capacity enables them to hide from predators while the bioluminescence allows them to communicate with and/or attract a mate. This complex behaviour is produced by a network specialised skin cells and muscles.

Researchers at the University of Houston have developed a similar device capable of detecting its surrounds and matching this environment in mere seconds. This early prototype uses a flexible, pixelated grid utilising actuators, light sensors, and reflectors. As the light sensors detect a a change in the surroundings, a signal is sent to the corresponding diode. This creates heat in the area and the thermochromatic grid then changes colour. This artificial “skin” could have both military and commercial applications down the road.

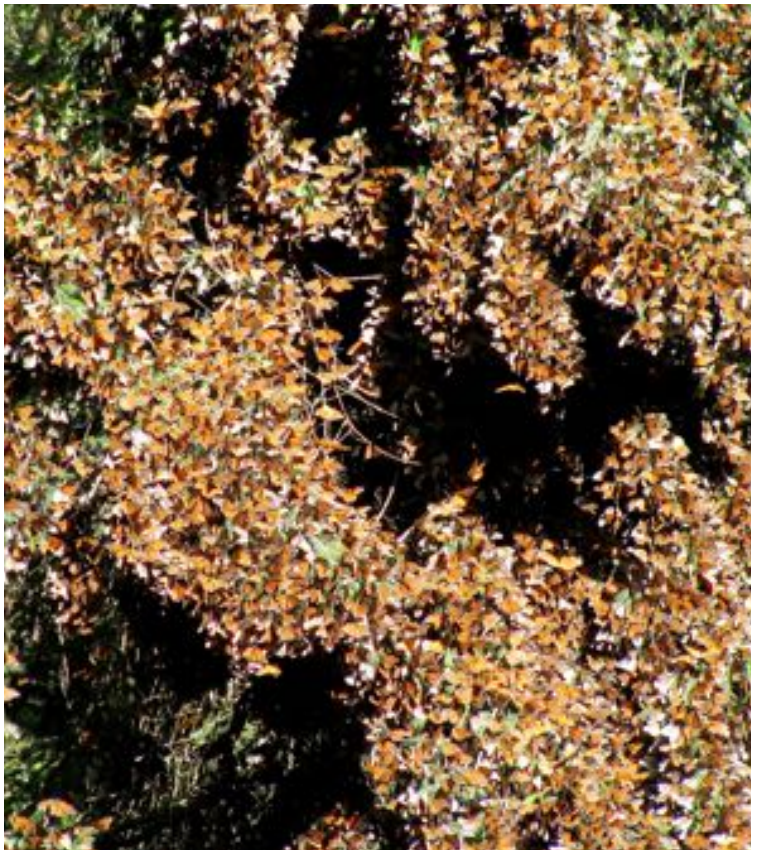
3. INSPIRATION

3.1.Swarms

During research, I found swarm behaviour of animals to be interesting and inspiring because of their interesting and unexpected formations. Swarms are basically large gatherings of entities like animals. Swarm behaviour is the collective motion of a large number of self-propelled entities. This behaviour is well observed with insects, birds during their flight, fish trying to defend underwater and other animals during migration.

3.2. Monarch butterflies

Monarch butterflies, congregating in the millions, is an inspiring sight. Monarchs are the only butterflies that migrate like birds, but they do not survive the trip. They begin flying south into Mexico from up to 4,000 kilometres away in Canada, and the females lay their eggs on the way. They die, the eggs hatch, and the new butterflies complete the trip. They are inexplicably born with the knowledge of how to do this. The monarchs confine themselves every year to about 11.6 acres within this forest. They congregate on the trees, lighting on the leaves, needles, bark, ground, and one another like bushy orange vines. When they all take flight at once, they sound like rain. But, how do they find the path overtime is still a mystery.

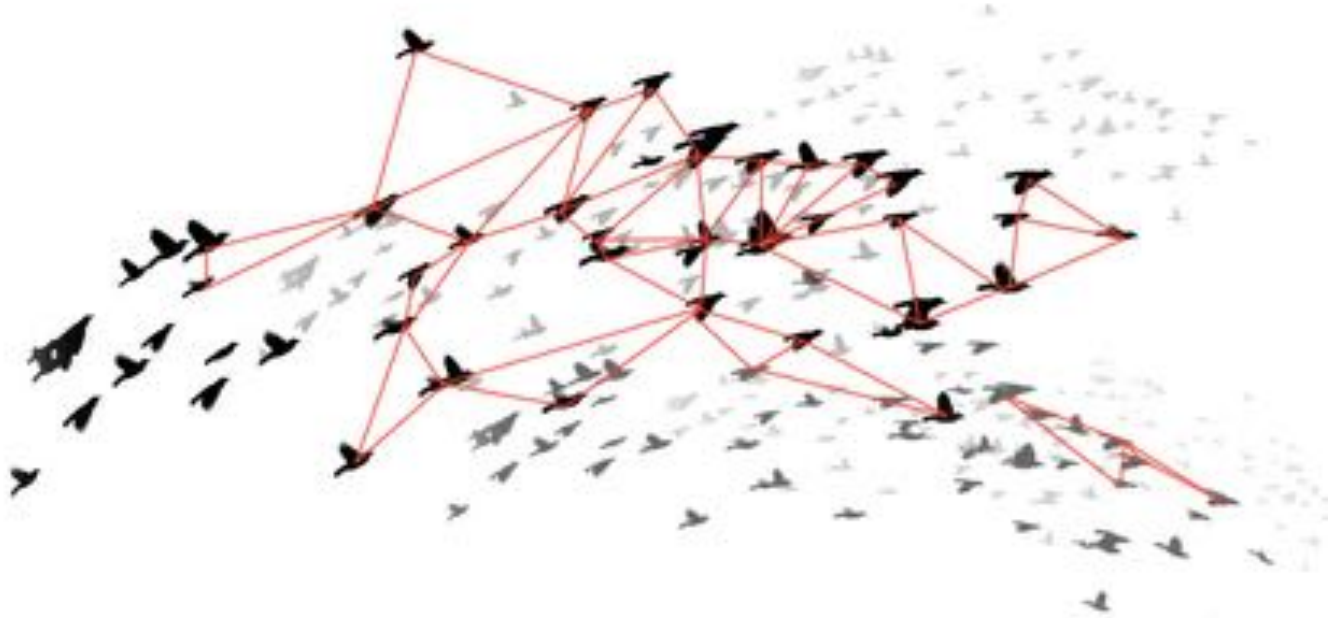


4. STUDY

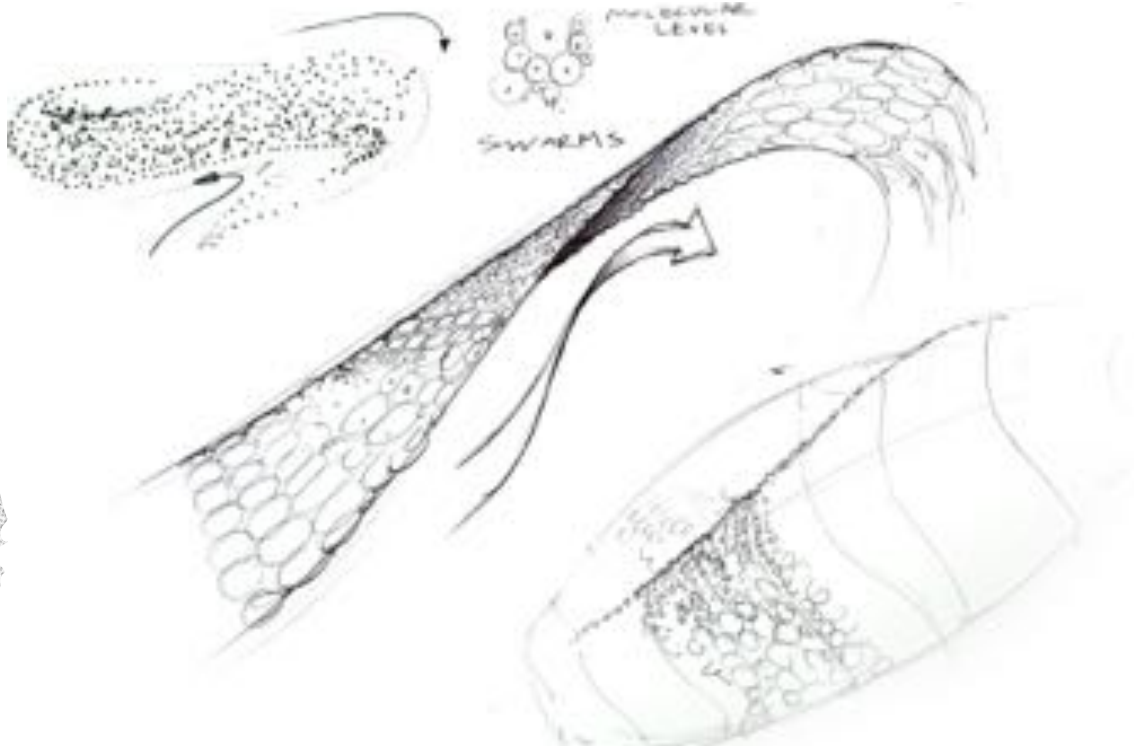
4.1. How do They Coordinate?

Flying at speeds of up to 40 miles per hour, an entire flock of birds can make hairpin turns in an instant. How do they do it?. Many observations were made till now. But, there is no single answer for this question yet. Birds like pelicans and geese form lines and V's for aerodynamic efficiency. But the bird flocks that form irregular shapes are the most impressive. The density of these flocks is high and may be they fly with a gap that is bit more than their body length. Yet they do quick manoeuvres.

It was described that each bird follow the one next to it as a leader and so on. According to Wayne Potts, a zoologist who published in the journal Nature in 1984, birds in flocks are able to change direction quickly not just because they are following a leader, or their neighbours, but because they see a movement far down the line and anticipate what to do next. Potts called this the chorus-line hypothesis for bird movement.




INDIVIDUAL
CO-ORDINATION
PATTERN

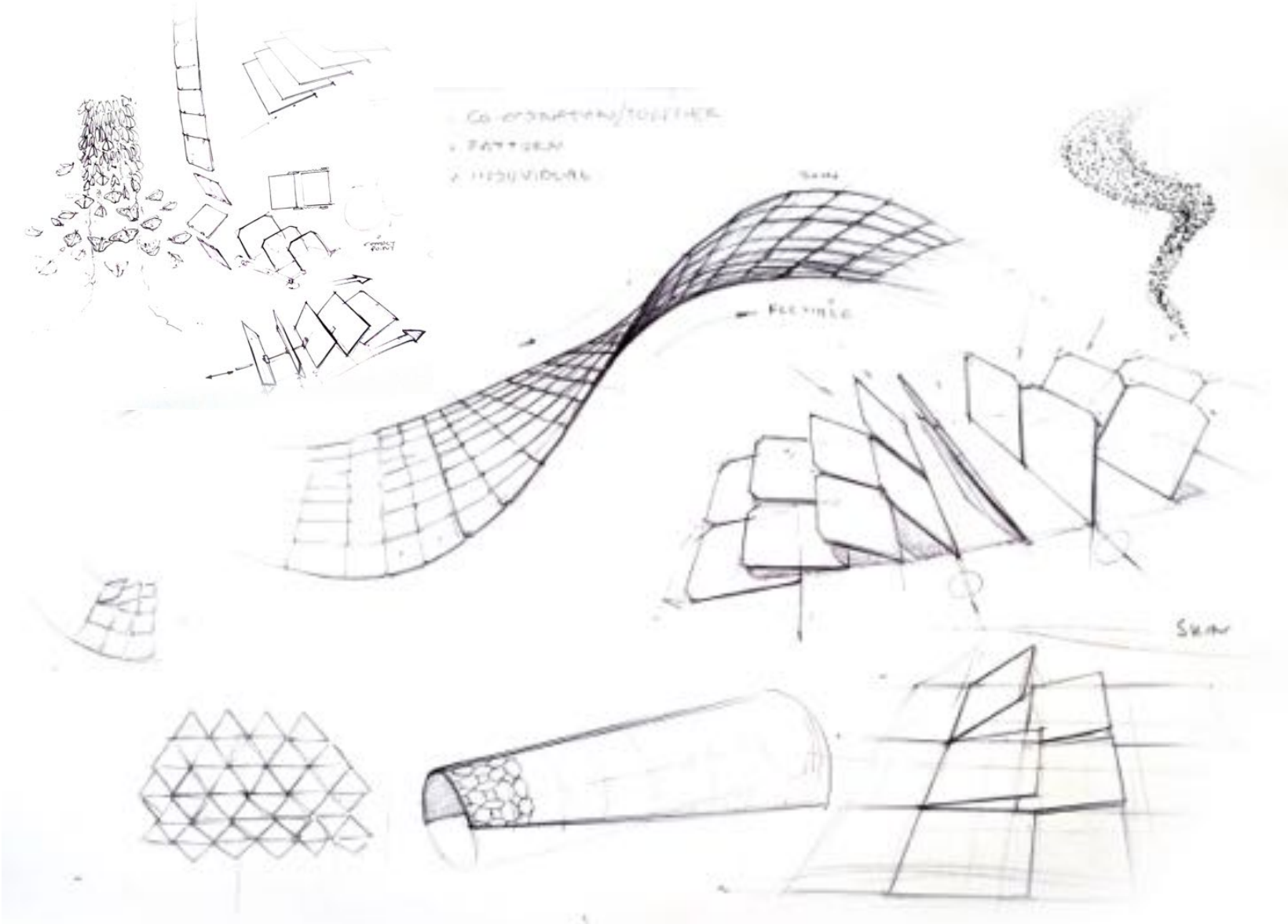

SWARMS

4.2. Monarch Butterflies

The way monarch butterflies attach and move on to an existing form(tree, branches, etc.) is shown below.

4.2.1. Attach

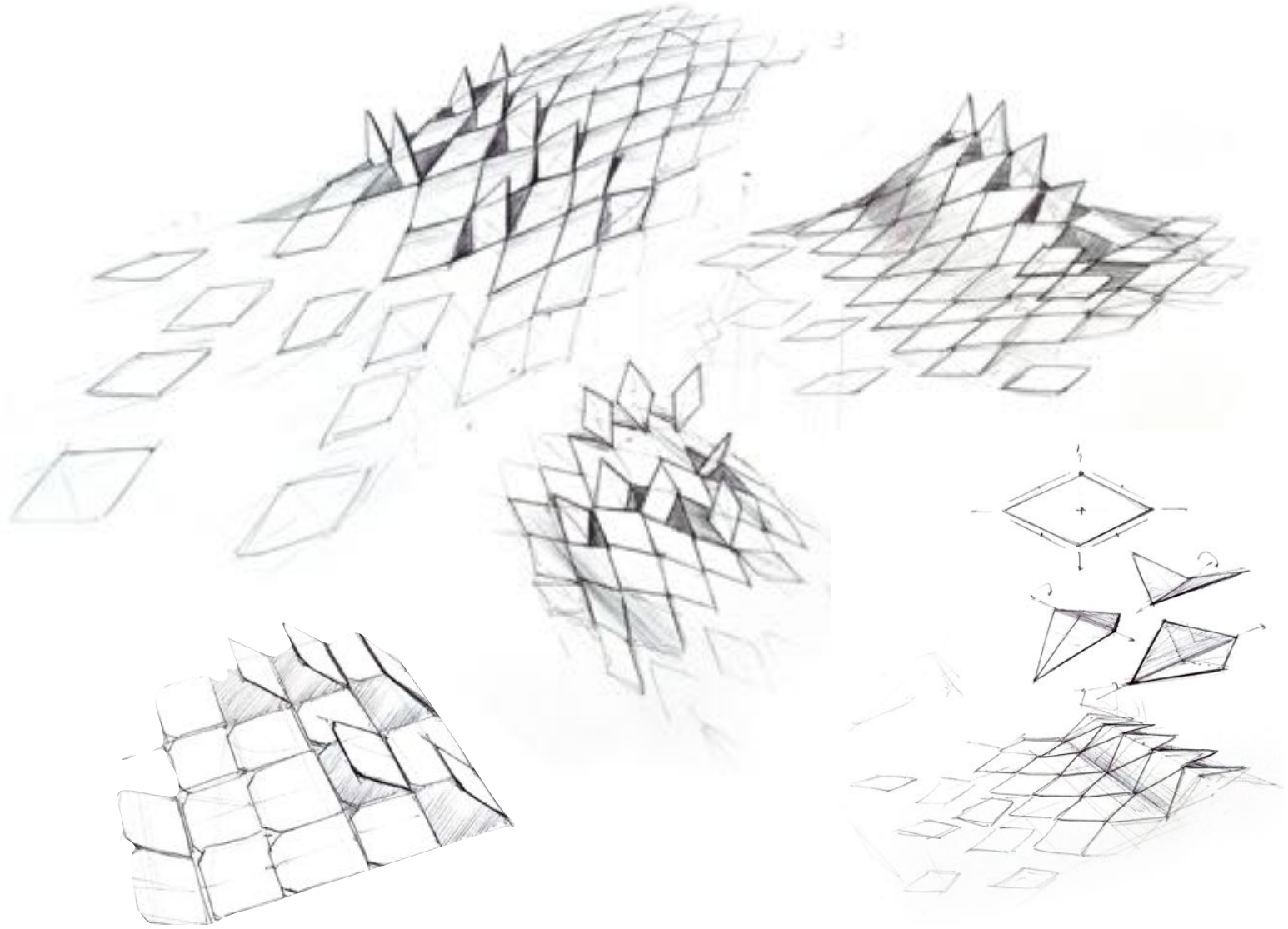
4.2.2. Detach

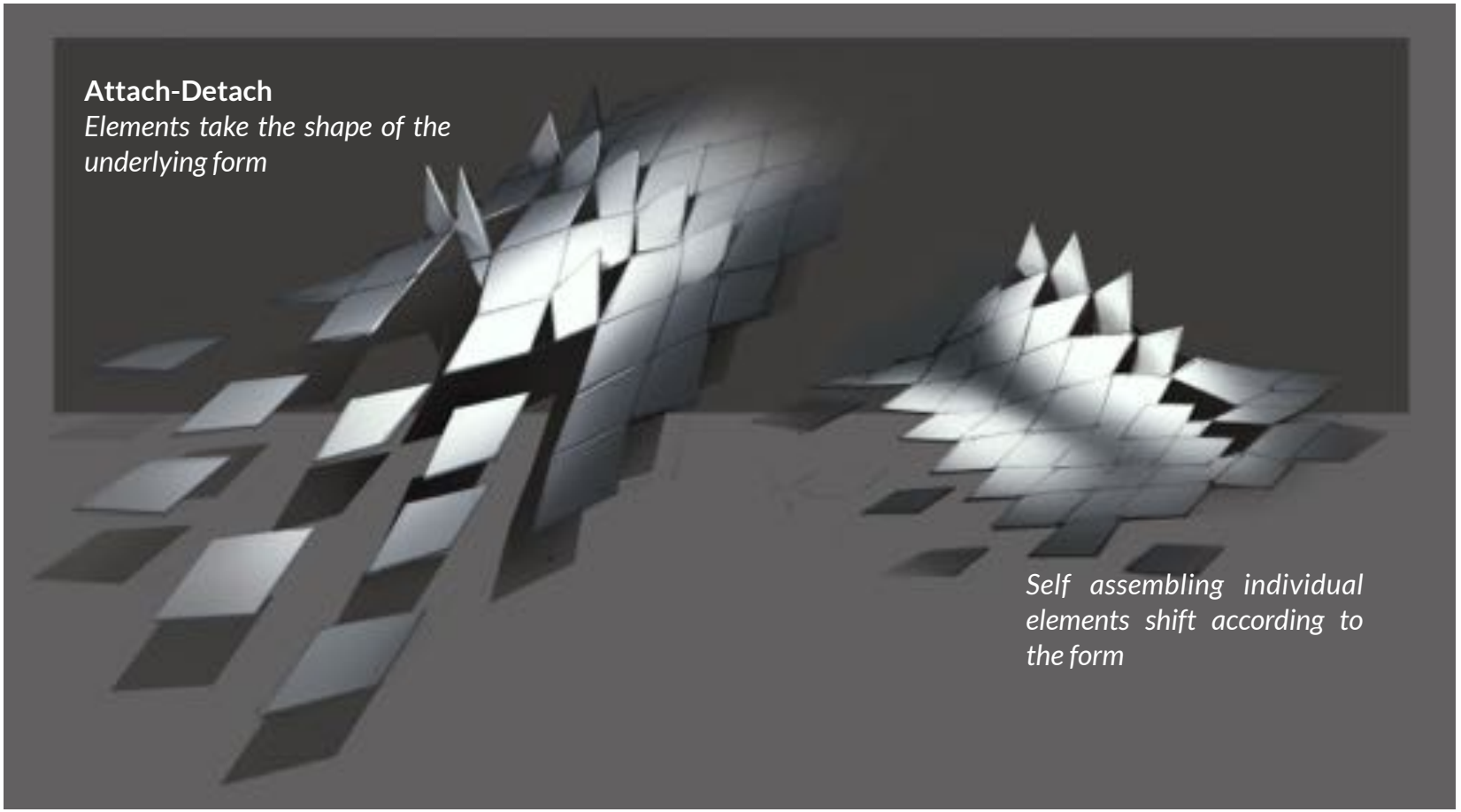


4.2.3. Possibilities - Self Assembling Bots

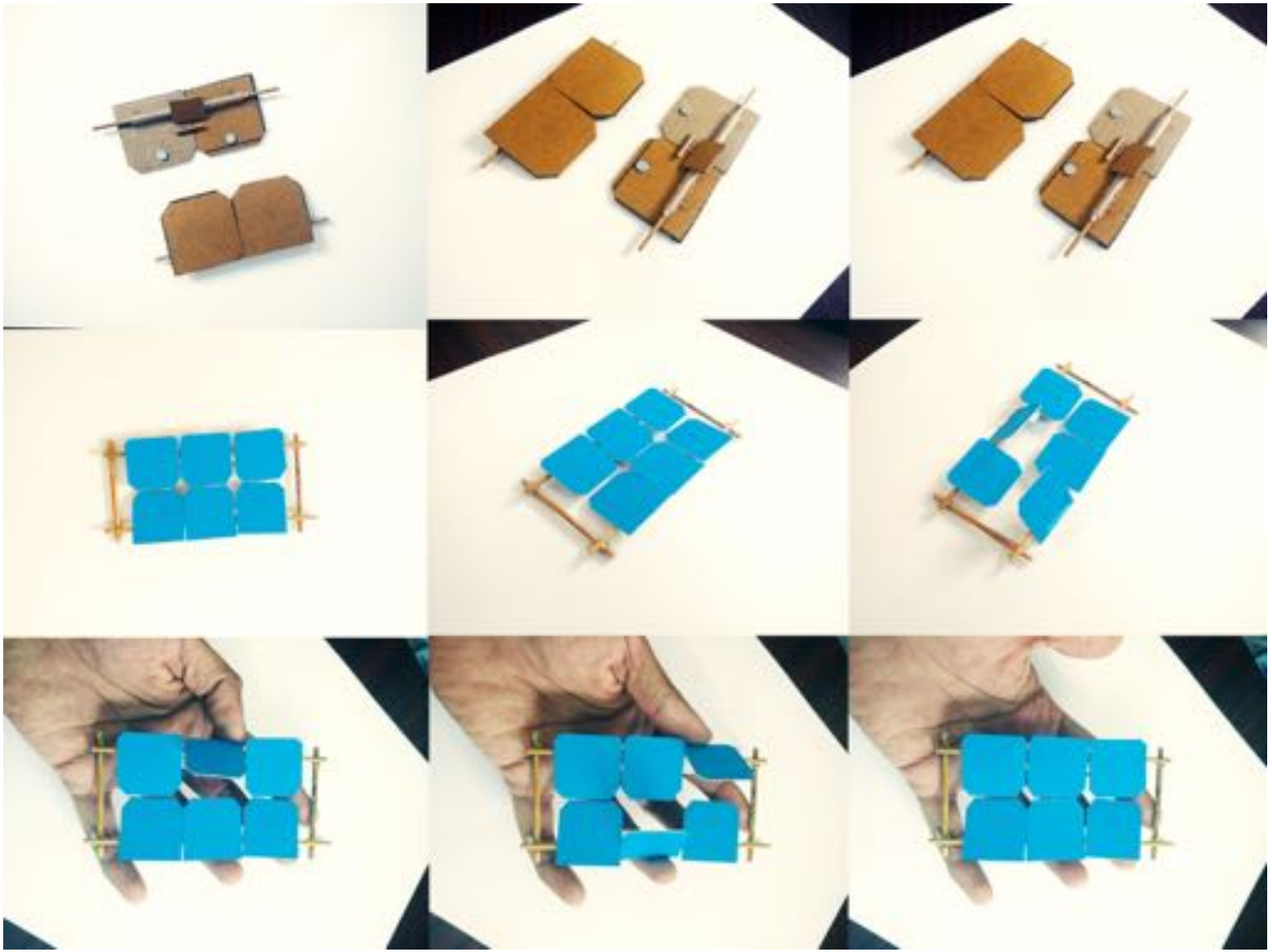
Possibilities of performing these manoeuvres is possible today. As shown below, these small bots can assemble them according to the instructions given to them. These take the help of gyro's and accelerometers to move around. Where magnets present outside help them stay in contact.

5. CONCEPT




Attach-Detach
Elements take the shape of the underlying form
Self assembling individual elements shift according to the form

5. MOCK UP



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