# プロアクティブリサーチコモンズ
# PROACTIVE RESEARCH COMMONS

枝垂

Team B - Nature
2021 | 12 | 07

# IDEA

**周囲の環境に応じて構造物が変化し、それに応じて人の流れがかわる**

# Method

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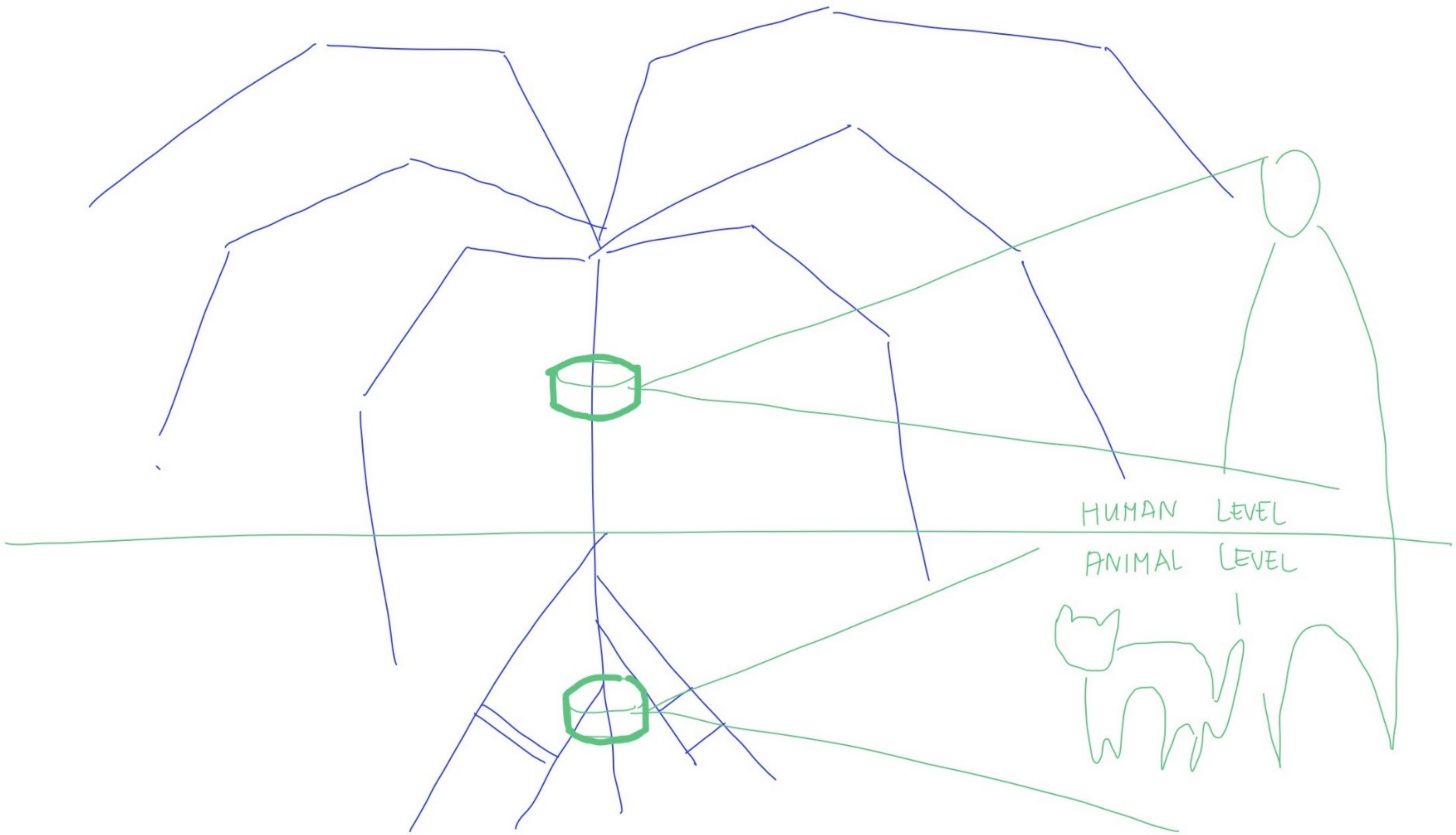
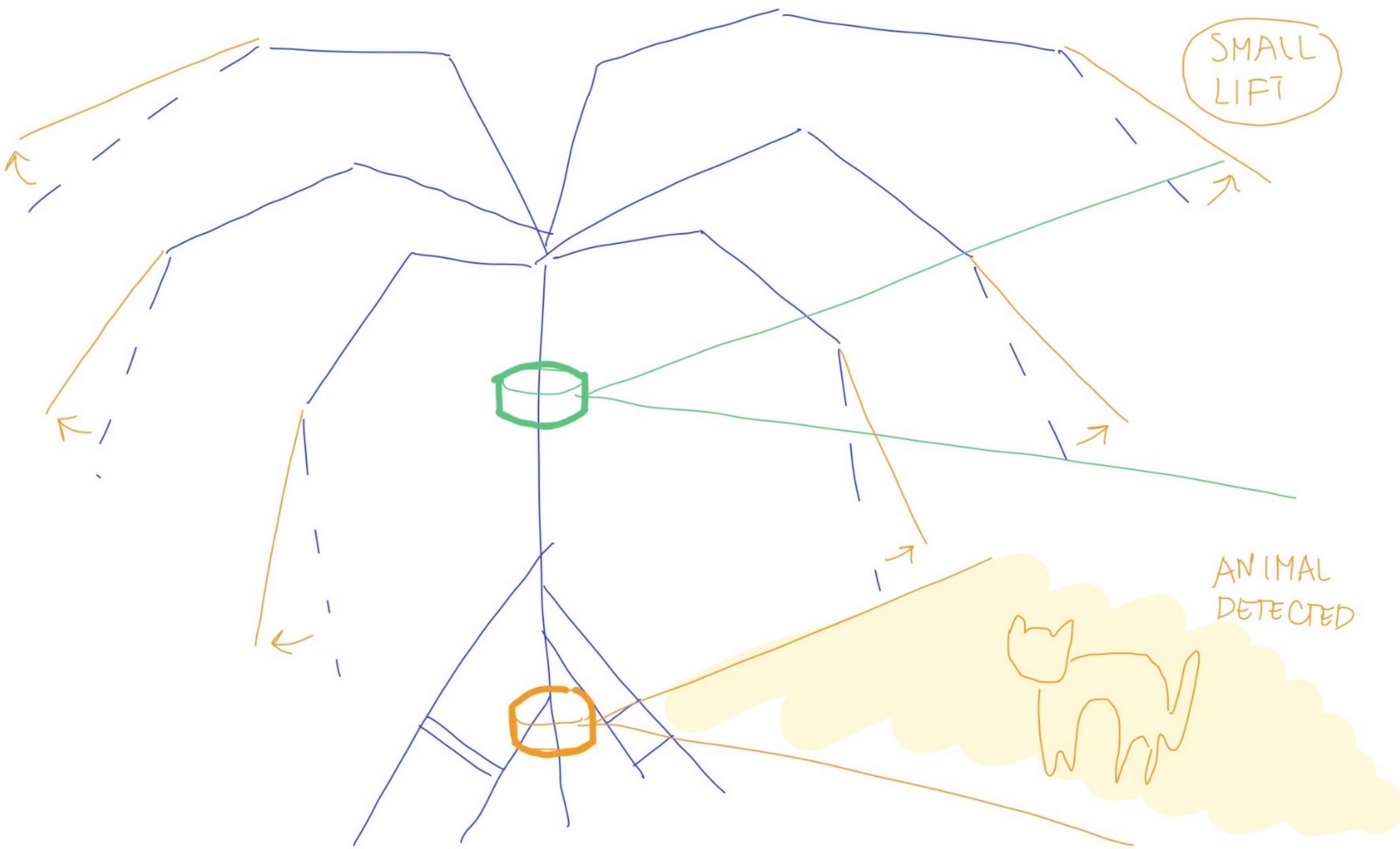
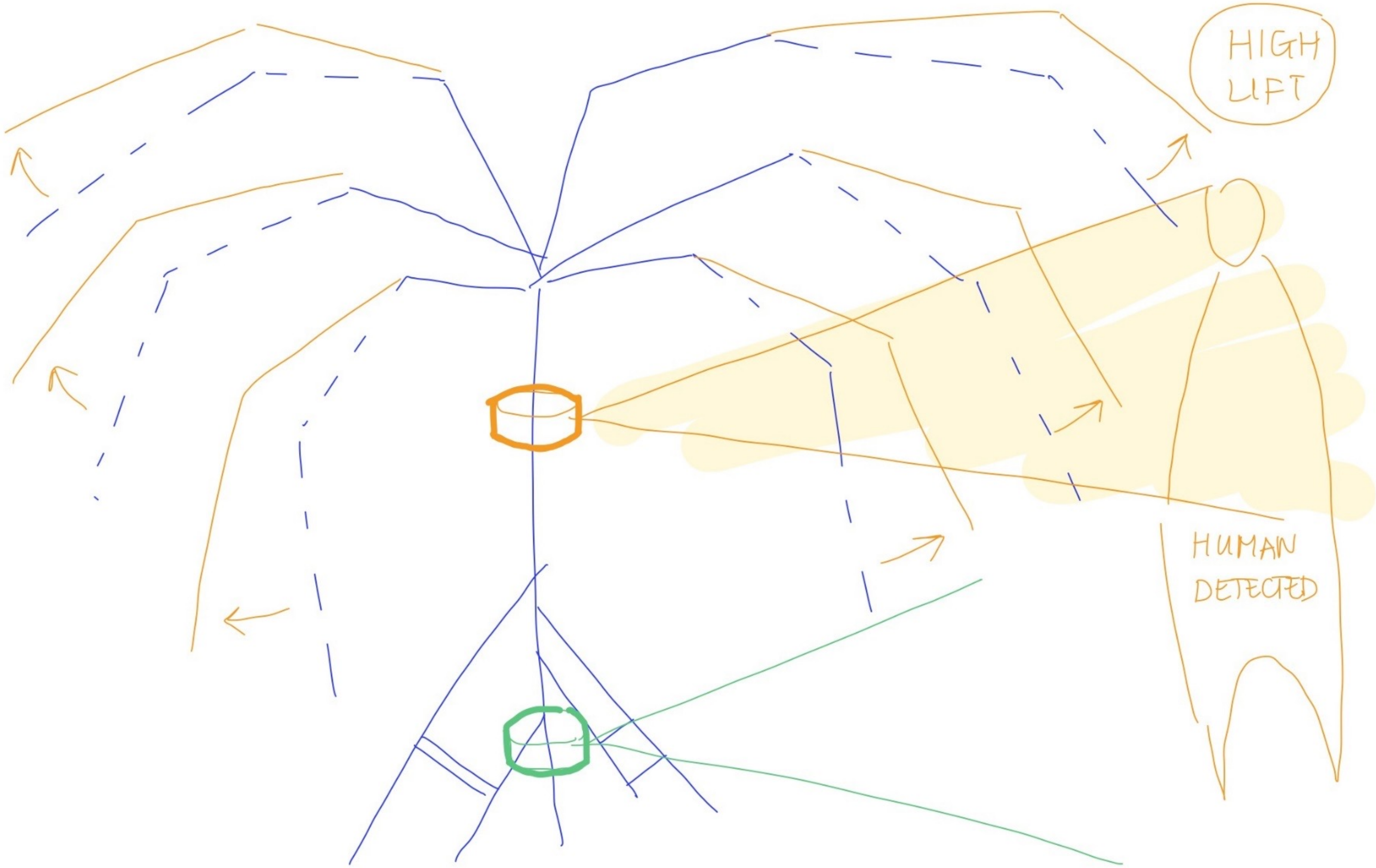


## Method



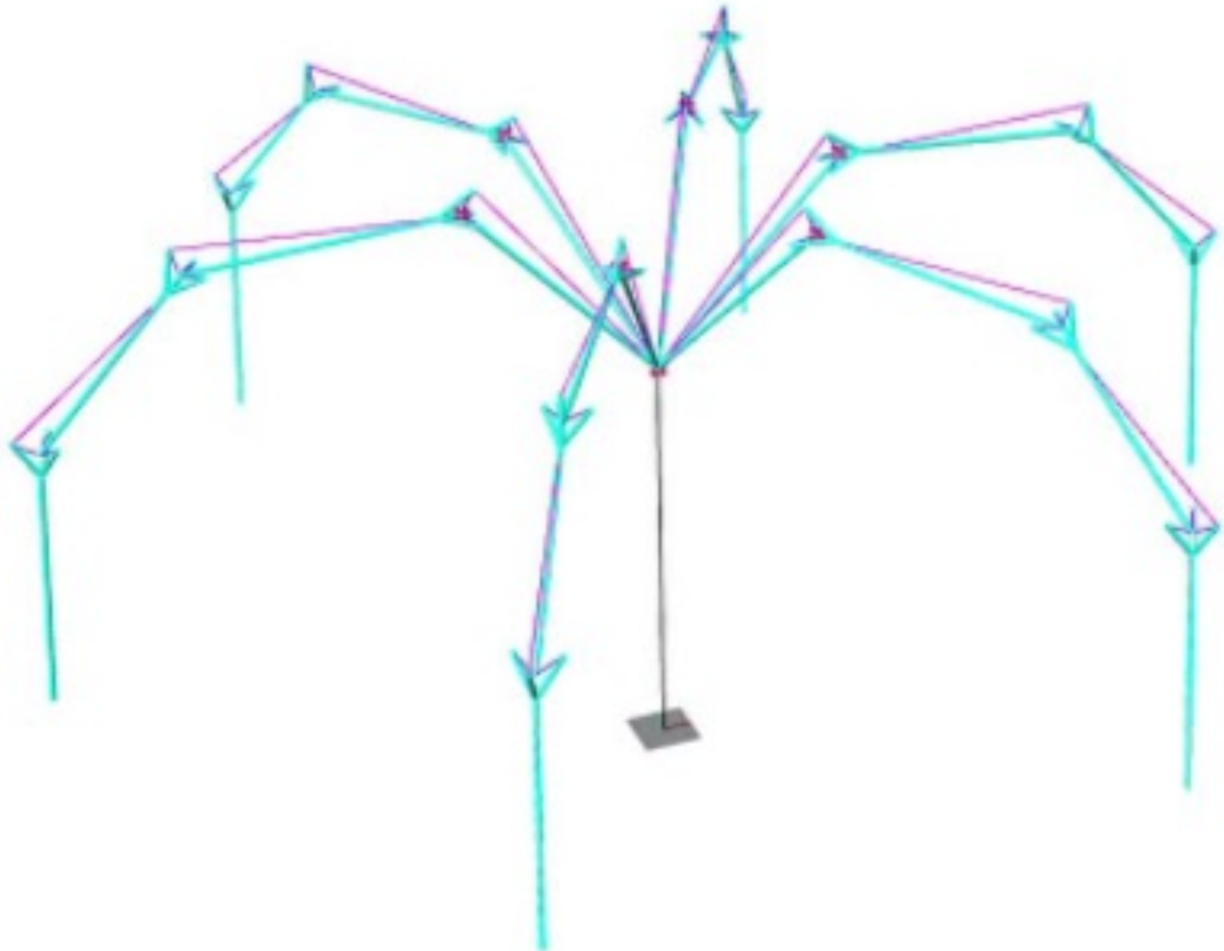
## Method



# STRUCTURE

# Structure

バイオテンセグリティ機構を応用し、ヒンジに使用している。

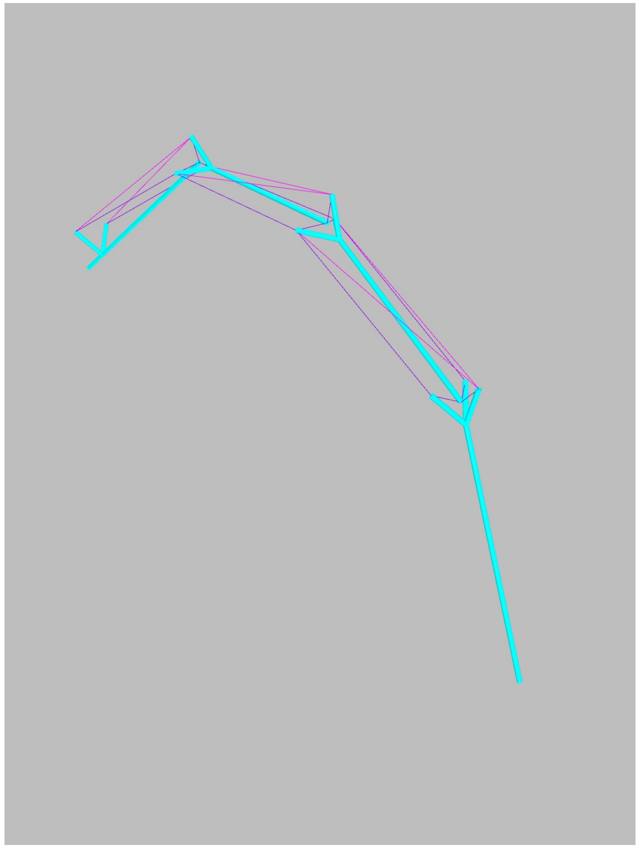


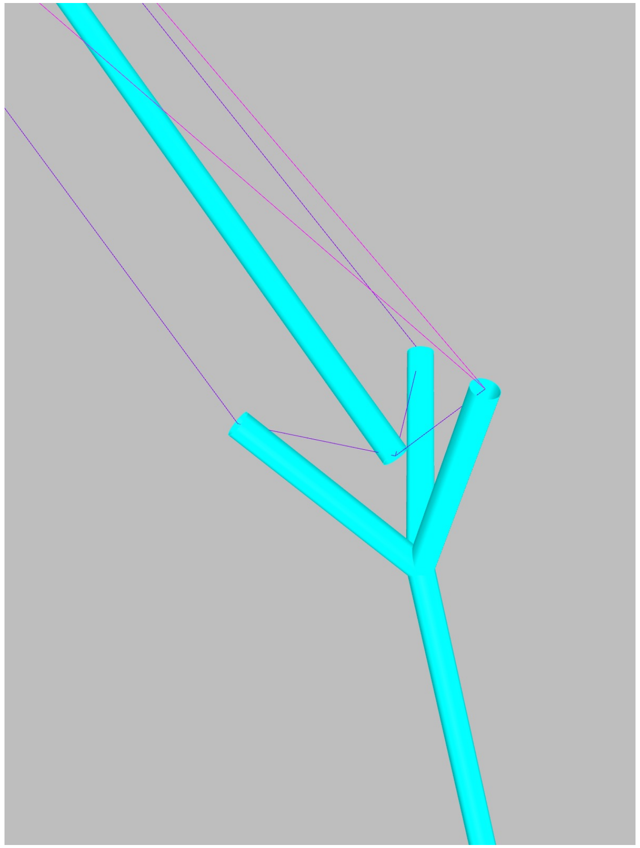
## Structure

バイオテンセグリティ機構を応用し、ヒンジに使用している。

テンセグリティとは圧縮材と引張材で構成されており、圧縮材同士が接触しないで成り立つ構造システム。

幾何学的な変形の解析はkangarooで行い、変形後の解析はHoganで行った。





**人体の構造では**

Cable=muscle
cartilage

BMF=muscle

Strut=born

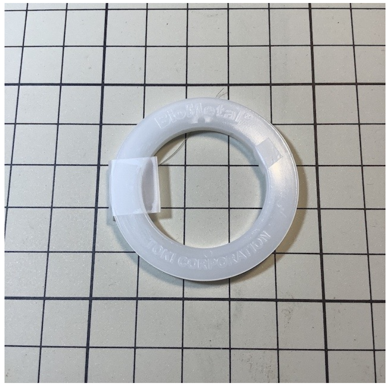
# Structure

## Material

### BMF

電流を流すと筋肉のように動く繊維状の駆動装置
Ti-Ni系形状記憶合金

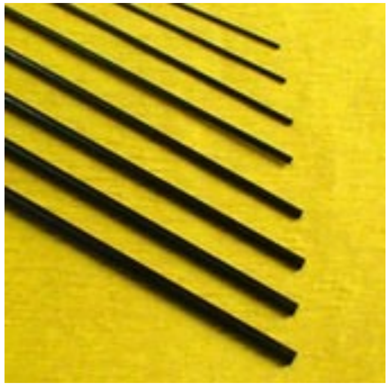
| | BMF150 |
|---|---|
| 標準直径(ϕmm) | 0.15 |
| 実用発生力(gf) | 150 |
| 実用運動ひずみ(%) | 4.0 |
| 駆動電圧(V/m) | 20.7 |
| 引張強度(Kgf) | 1.8 |



### CFRP

軽くて剛性が高い

アームに1mm、2mm、3mmのCFRPを使用



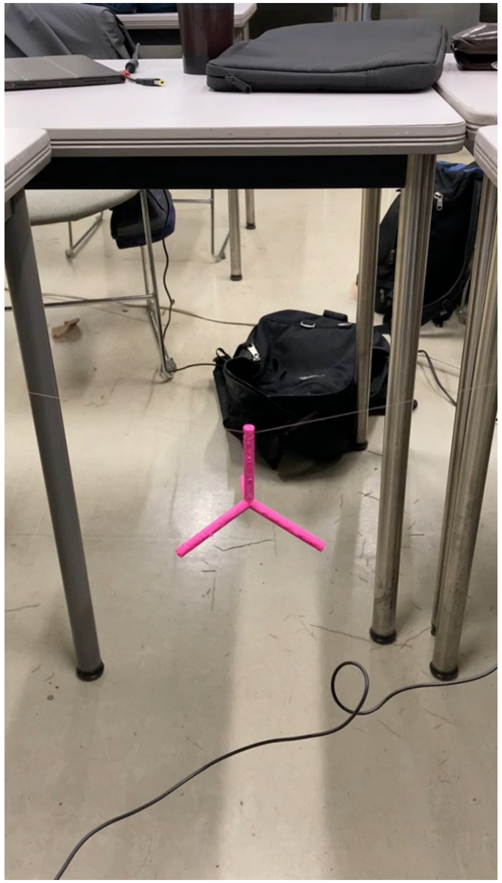
BMF（バイオメタルファイバー）

動作実験
・長さ40cmのBMFに150gの錘をぶら下げた
→5%(2cm)ほどの伸縮が見られた

BMF（バイオメタルファイバー）

動作実験
動き幅を大きくする

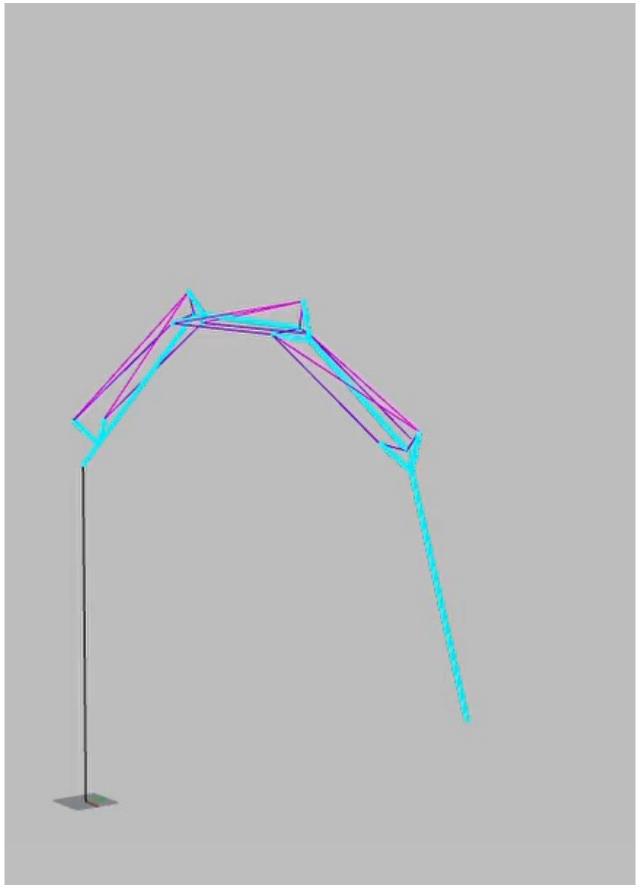
他にもテコを使ったりして可動域の幅を増やす
→構造物の動きの多様性

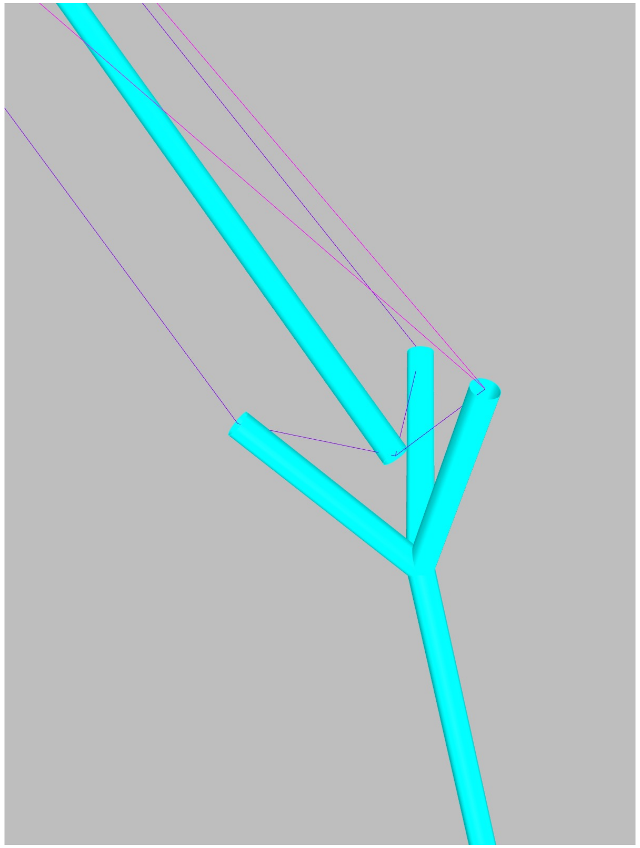


# Structure

Kangarooによる幾何学的解析

先に近いヒンジを動かすと、微細な変化をし、中央に近いものを動かすと大きな変形をする。





## Cable

・ジョイントとしてプレテンションをかけたもの
・横ブレ防止用のケーブル

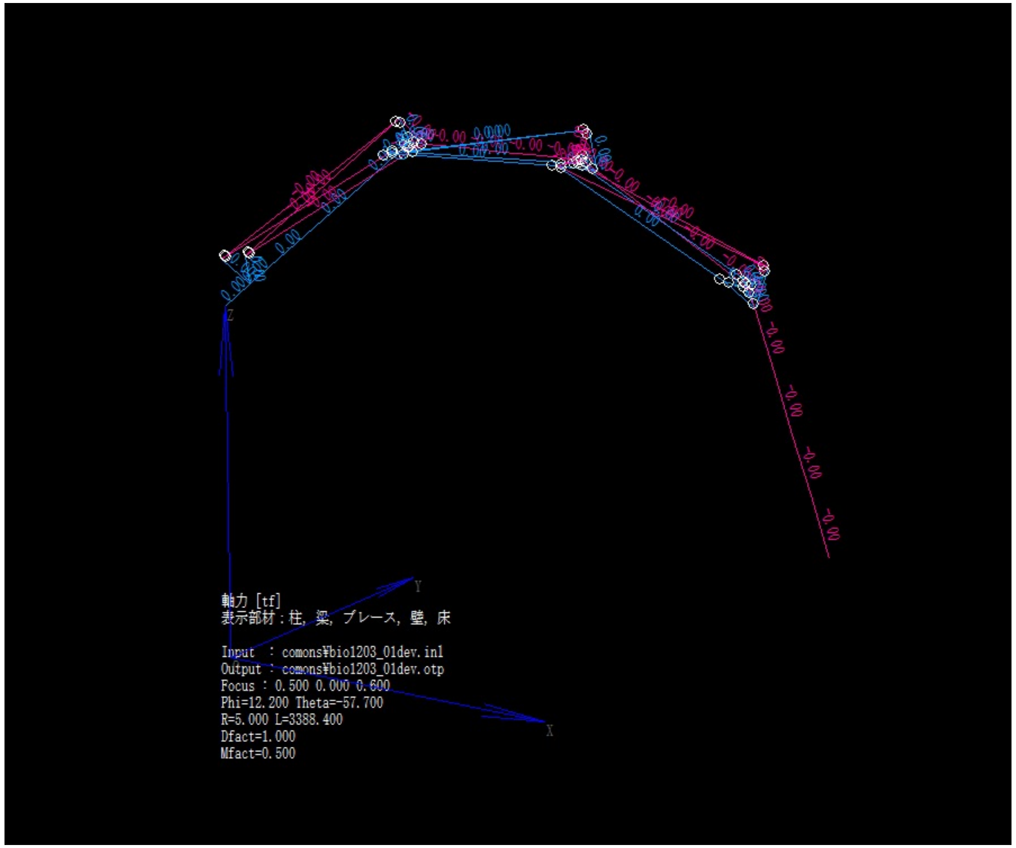
## BMF

## Strut

・先端に近いものほど細くする

# Structure

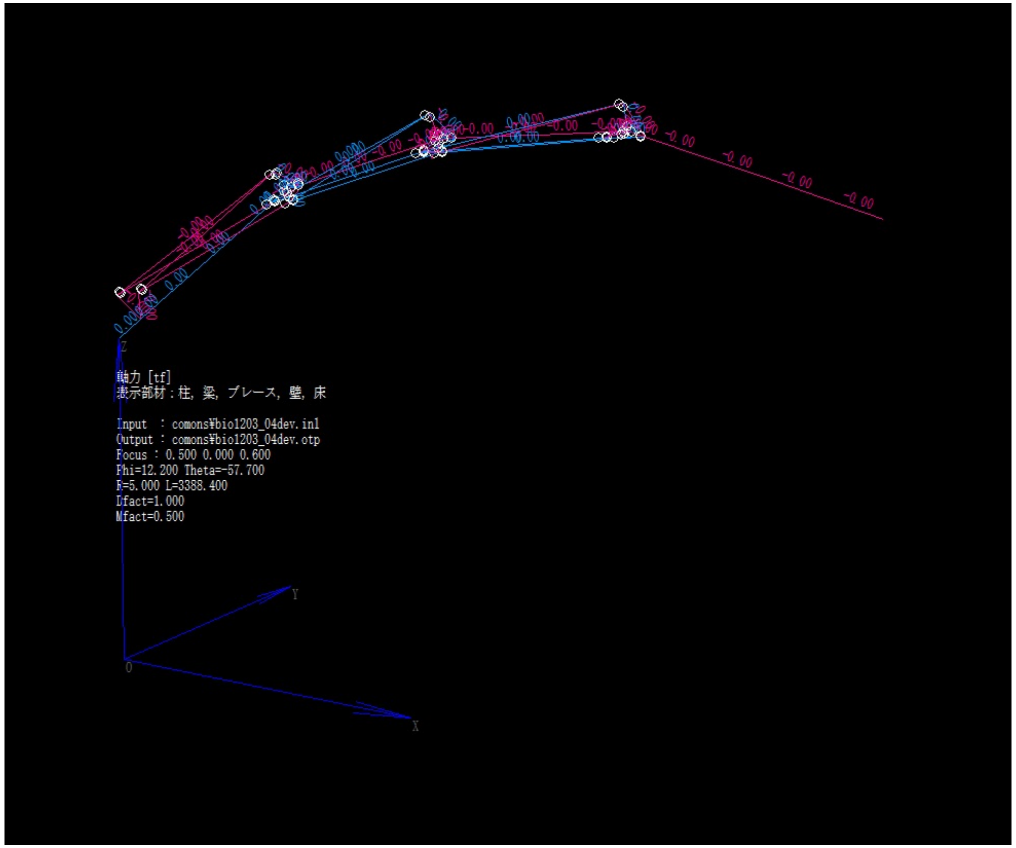
Before transformation




BMFにかかる最大張力　36.1gf

＜ BMFの実用発生力　144gf

After transformation



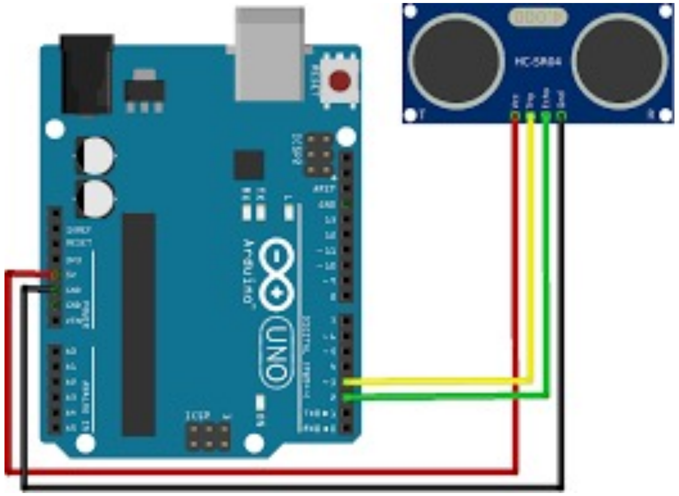

BMFにかかる最大張力　43.5gf

＜ BMFの実用発生力　144gf

# SENSING

# Sensing

By using ultrasonic sensor we can detect obstacles for the structure in the environment.




Arduino circuit with ultrasonic sensor

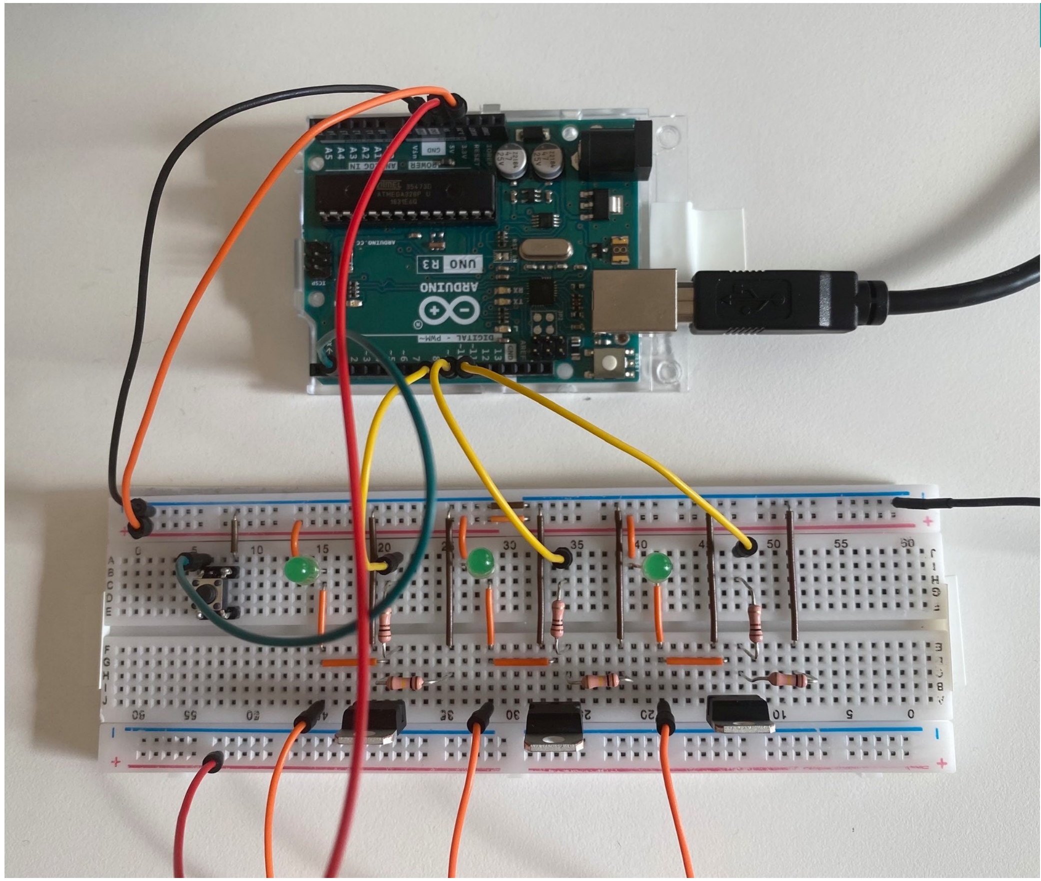
Verify

PRC_211108_ultasonic_sensor

```
const int pingPin = 7; // Trigger Pin of Ultrasonic Sensor
const int echoPin = 6; // Echo Pin of Ultrasonic Sensor

void setup() {
   Serial.begin(9600); // Starting Serial Terminal
}

void loop() {
   long duration, inches, cm;
   pinMode(pingPin, OUTPUT);
   digitalWrite(pingPin, LOW);
   delayMicroseconds(2);
   digitalWrite(pingPin, HIGH);
   delayMicroseconds(10);
   digitalWrite(pingPin, LOW);
   pinMode(echoPin, INPUT);
   duration = pulseIn(echoPin, HIGH);
   inches = microsecondsToInches(duration);
   cm = microsecondsToCentimeters(duration);
   Serial.print(inches);
   Serial.print("in, ");
   Serial.print(cm);
   Serial.print("cm");
   Serial.println();
   delay(100);
}

long microsecondsToInches(long microseconds) {
   return microseconds / 74 / 2;
}

long microsecondsToCentimeters(long microseconds) {
   return microseconds / 29 / 2;
}
```

# Reacting

By controlling the heating element using Arduino, we can set different states of activation. Using several states of energy flow we can enable motion of the structure based on environmental stimuli.



Arduino circuit for controlling electricity flow (1 arm)

PRC_211108_heat_3pins §

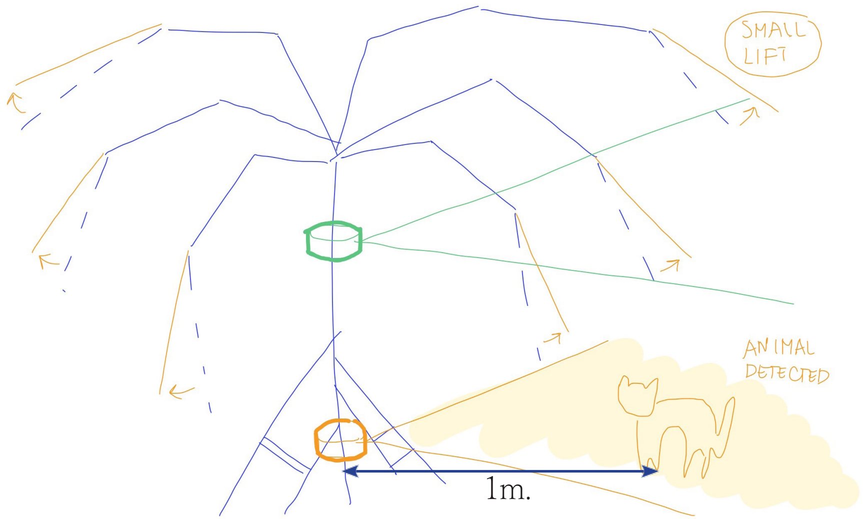
```
// constants won't change. They're used here to
// set pin numbers:
const int buttonPin = 2;     // the number of the pushbutton pin
const int heatPin1 =  9;      // the number of the LED pin
const int heatPin2 =  10;      // the number of the LED pin
const int heatPin3 =  11;      // the number of the LED pin

// variables will change:
int buttonState = 0;         // variable for reading the pushbutton status

void setup() {
  // initialize the LED pin as an output:
  pinMode(heatPin1, OUTPUT);
  pinMode(heatPin2, OUTPUT);
  pinMode(heatPin3, OUTPUT);
  // initialize the pushbutton pin as an input:
  pinMode(buttonPin, INPUT);
}

void loop(){
  // read the state of the pushbutton value:
  buttonState = digitalRead(buttonPin);

  // check if the pushbutton is pressed.
  // if it is, the buttonState is HIGH:
  if (buttonState == HIGH) {
    // start the heat sequence. as it is using delay, while the sequence is going, it does no
    digitalWrite(heatPin1, HIGH);
    delay(3000); // you can change the timing as you like, 1sec=1000
    digitalWrite(heatPin1, LOW);
    digitalWrite(heatPin2, HIGH);
    delay(3000); // you can change the timing as you like, 1sec=1000
    digitalWrite(heatPin2, LOW);
    digitalWrite(heatPin3, HIGH);
    delay(3000); // you can change the timing as you like, 1sec=1000
    digitalWrite(heatPin3, LOW);
  }
  else {
    // turn the heating off
    digitalWrite(heatPin1, LOW);
    digitalWrite(heatPin2, LOW);
    digitalWrite(heatPin3, LOW);
  }
}
```

# Interaction

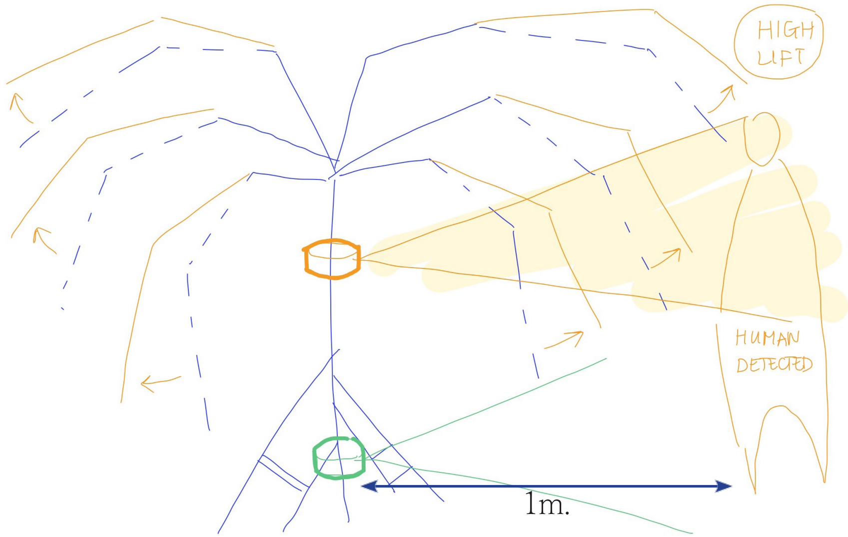
Between sensing and reacting a connection has been established by setting ground rules.

If something smaller than a human approaches the structure - first muscle of the arm contracts lifting the structure just above the ground for animal to pass.

If something larger than / or a human approaches the structure - first and second muscles of the arm contract lifting the structure to its highest position allowing passage



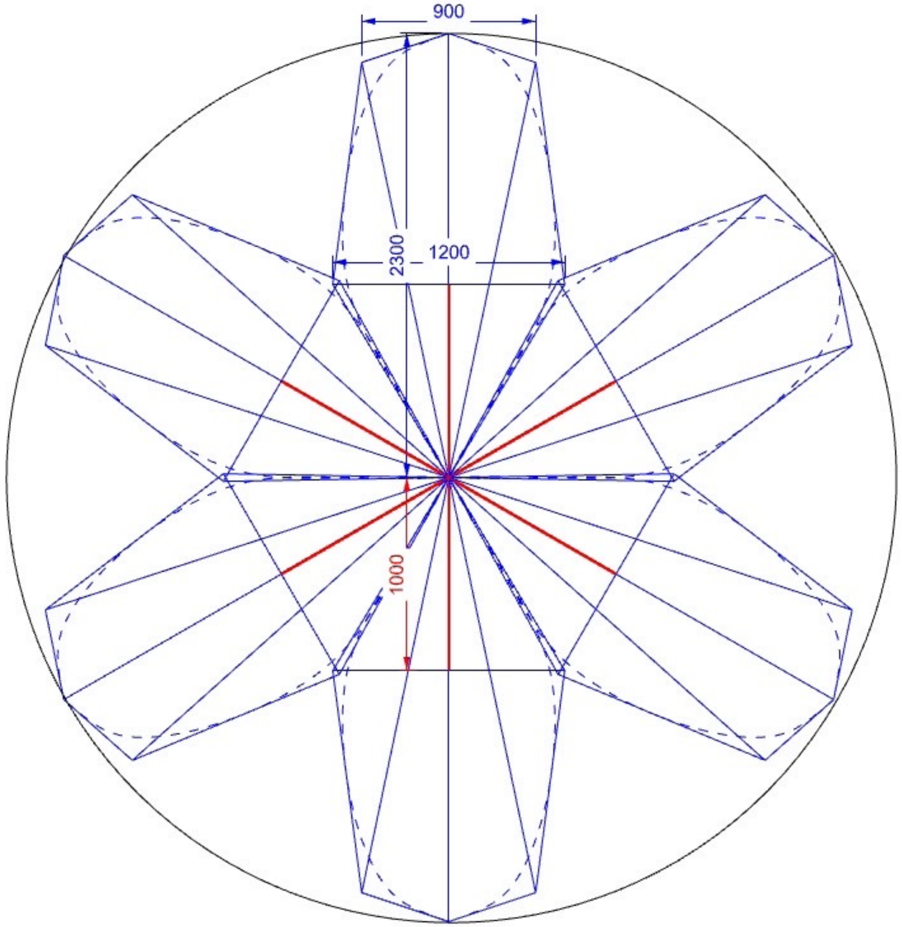

Case : SMALL LIFT



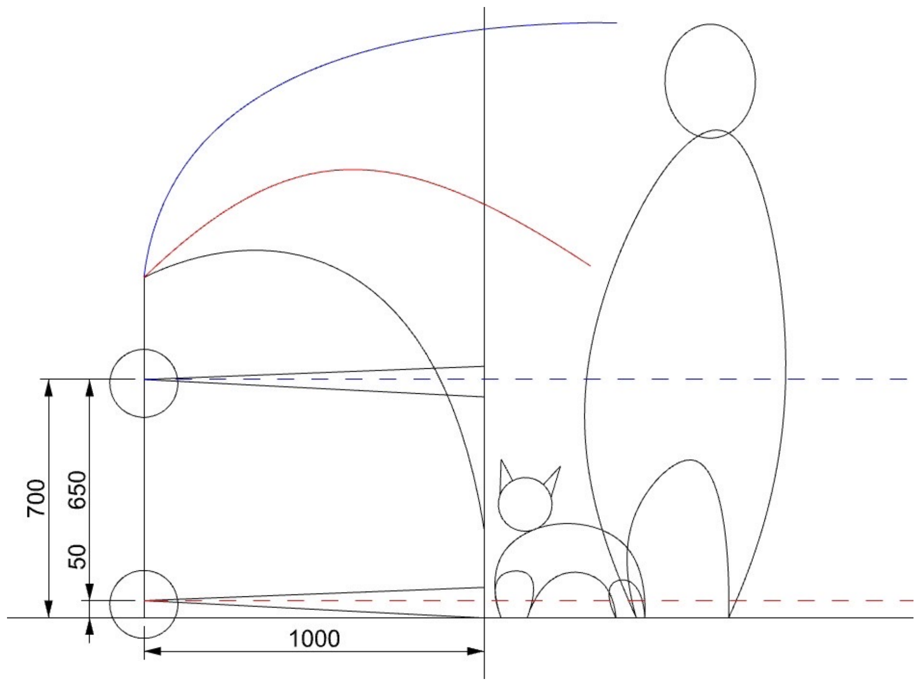

Case : HIGH LIFT

# Interaction

Sensor arrangement based on 6 arms structure.



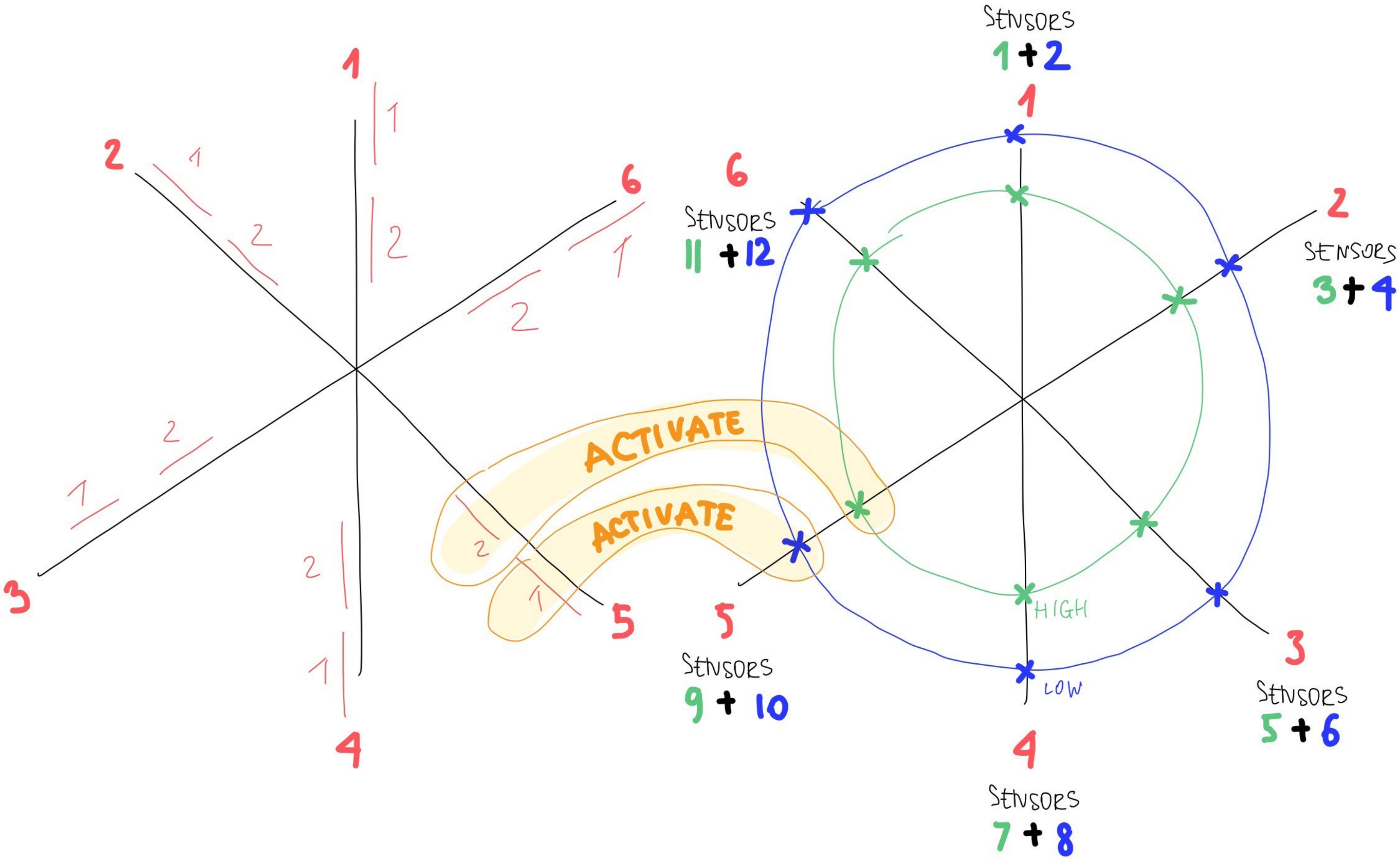
Plan



Section

# Interaction

Sensor activation based on 6 arms structure.



# Processing

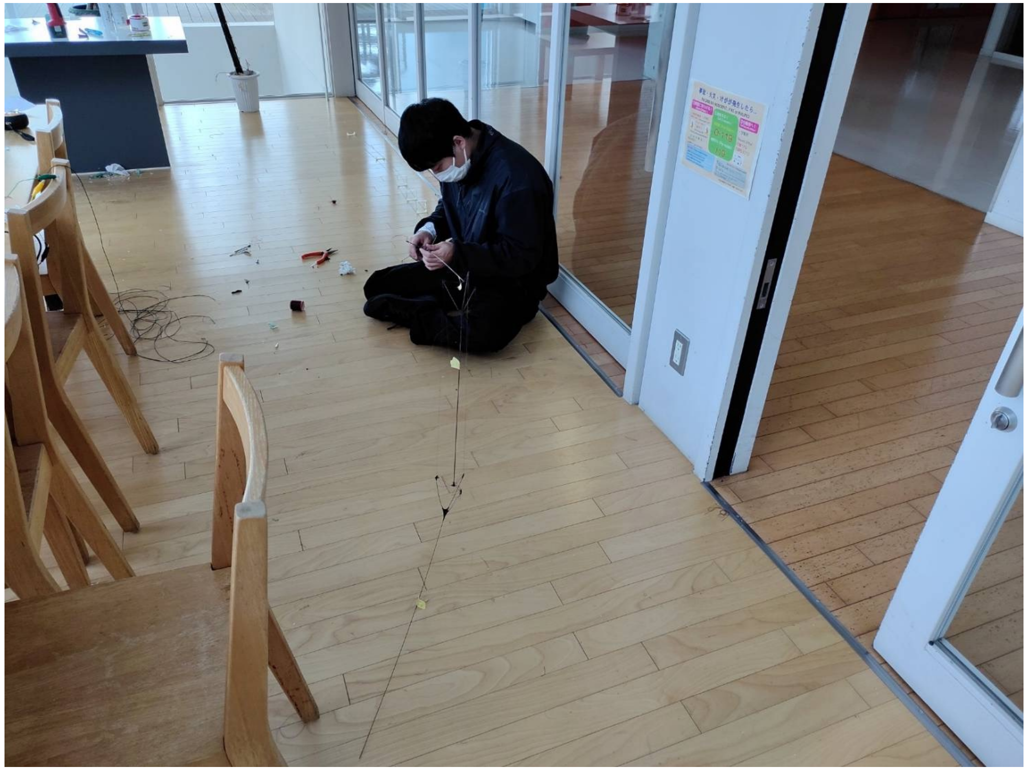
# Processing

1. Making the parts of the branches
2. Pull the strings tight at the joints of the branches(give them initial tensions)
3. Connect each part of branches
4. Connect strings while adjusting each angles
5. Connect BMF

# Processing

1. Making the parts of the branches
2. Pull the strings tight at the joints of the branches(give them initial tensions)
   (while connecting each part of branches)
3. Connect strings while adjusting each angles
4. Connect BMF

# Processing



1. Making the parts of the branches
2. Pull the strings tight at the joints of the branches(give them initial tensions) (while connecting each part of branches)
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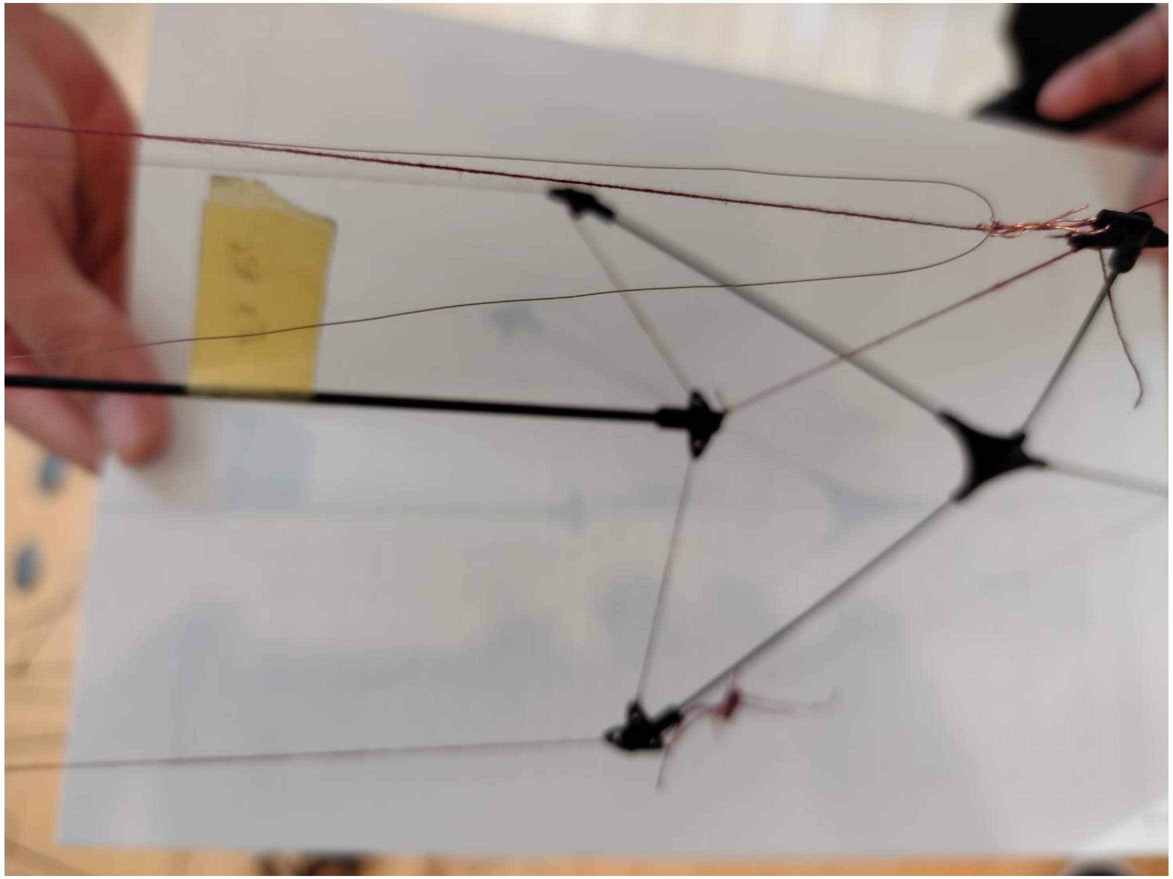
# Processing



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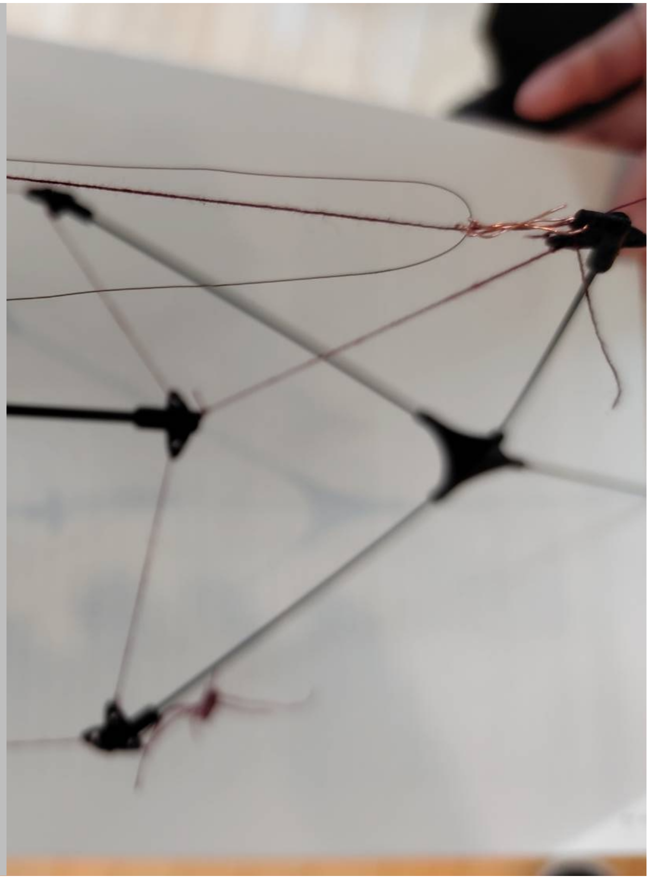
# Processing

1. Making the parts of the branches
2. Pull the strings tight at the joints of the branches(give them initial tensions)
   (while connecting each part of branches)
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# Processing

1. Make the column
2. Insert the branches
3. Sensor in the middle of the trunk

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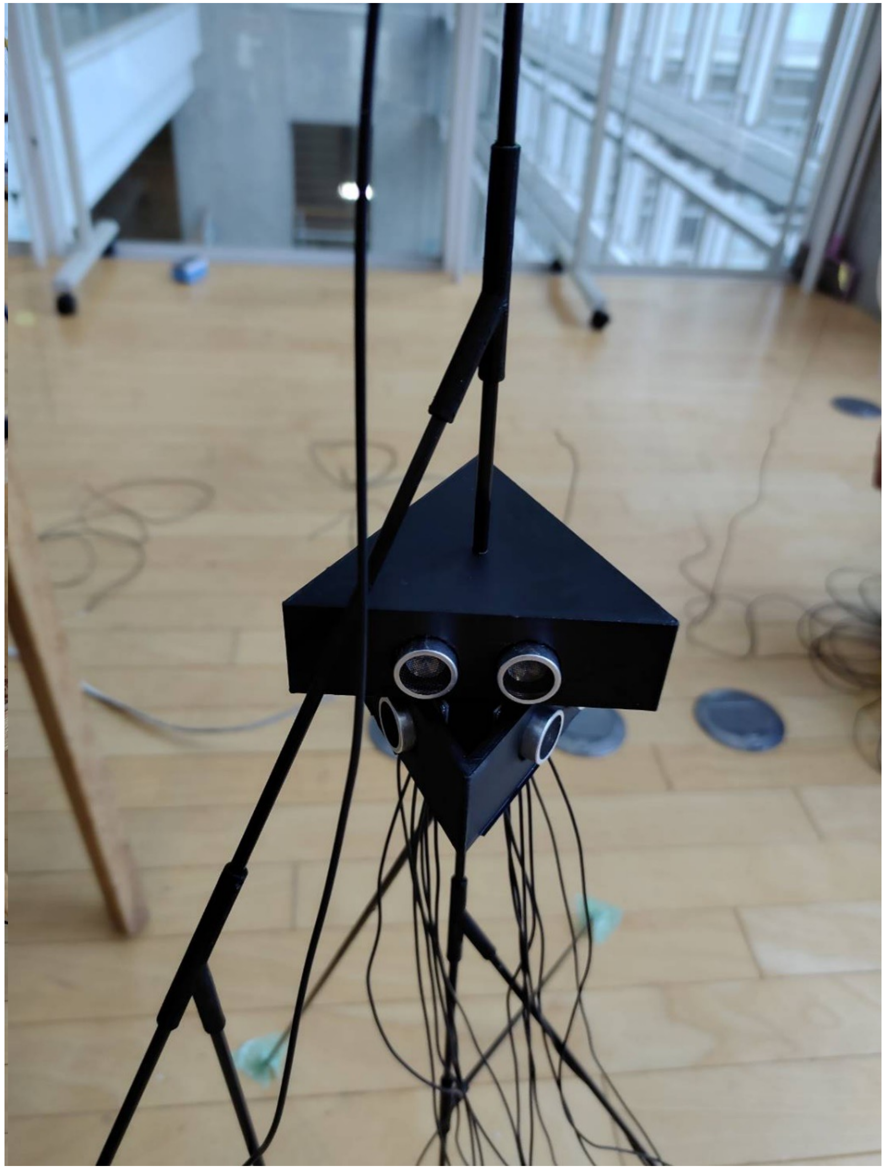
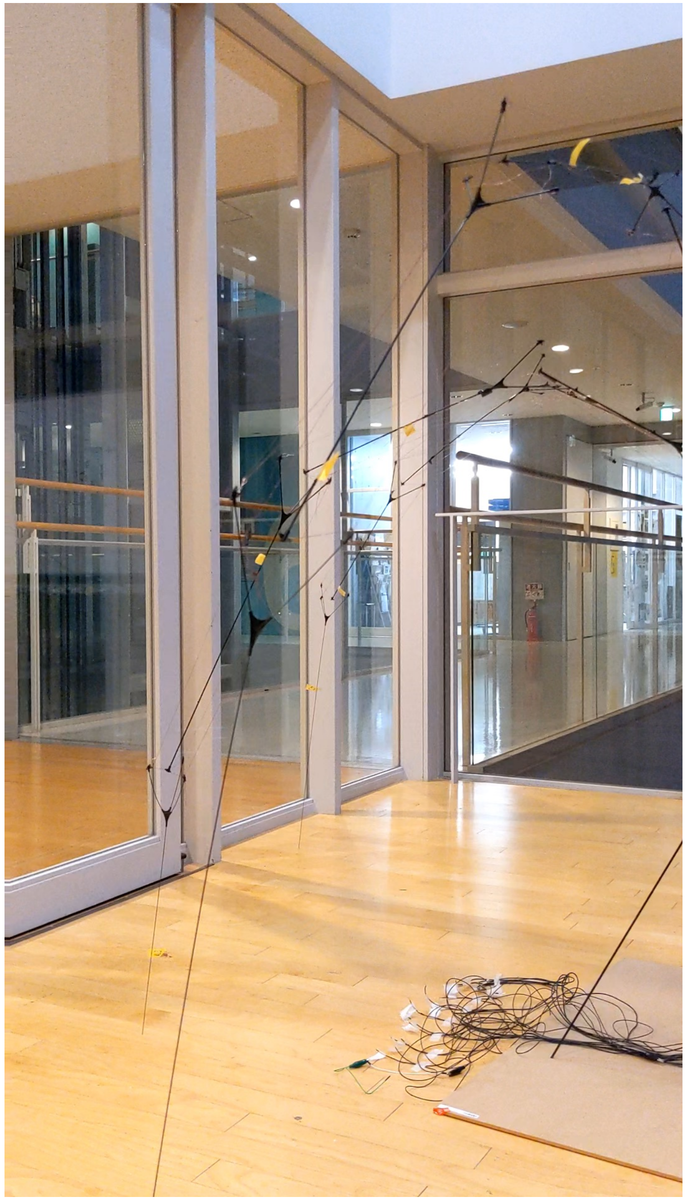


1. Make the column
2. Insert the branches
3. Sensor in the middle of the tunk

# Processing



# Future

駅の改札や行列のできるような場所で、構造物の変化により人の流れを制御することを考える。