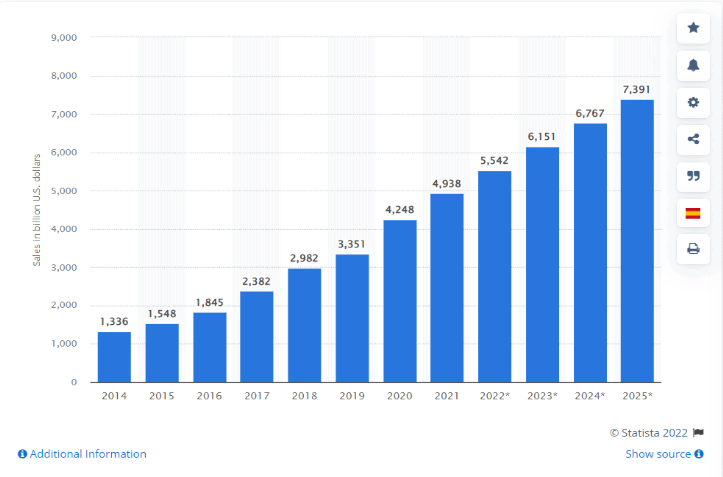
FlexiPlay :
Web-based Interactive 3D Cloth Simulation

Graduation Thesis Seminar I
: Research Topic & Method

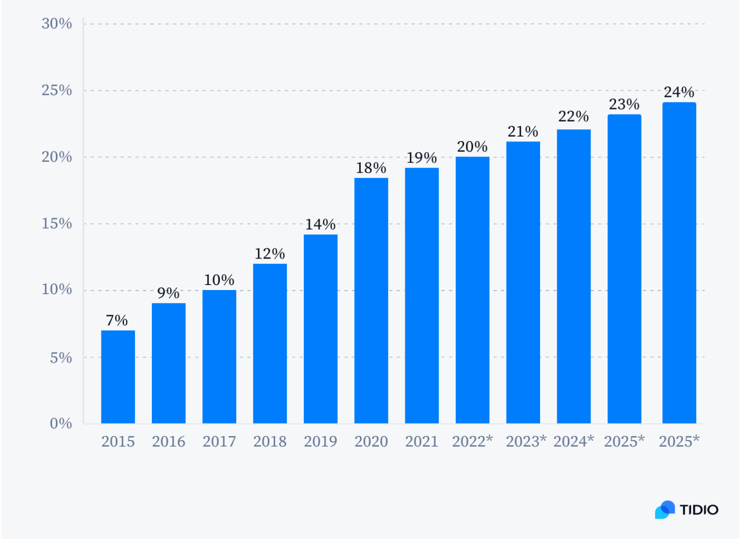
20171194 Yujin Lee

Recap ： Intro Online shopping lacks tactile product experience

Retail e-commerce sales worldwide from 2014 to 2025
(in billion U.S. dollars)



Ecommerce as percentage of total retail sales worldwide from 2015 to 2025



Retail E–commerce sales worldwide

7,391B USD in 2025

E–commerce as percentage of total retail sales worldwide

24% in 2025

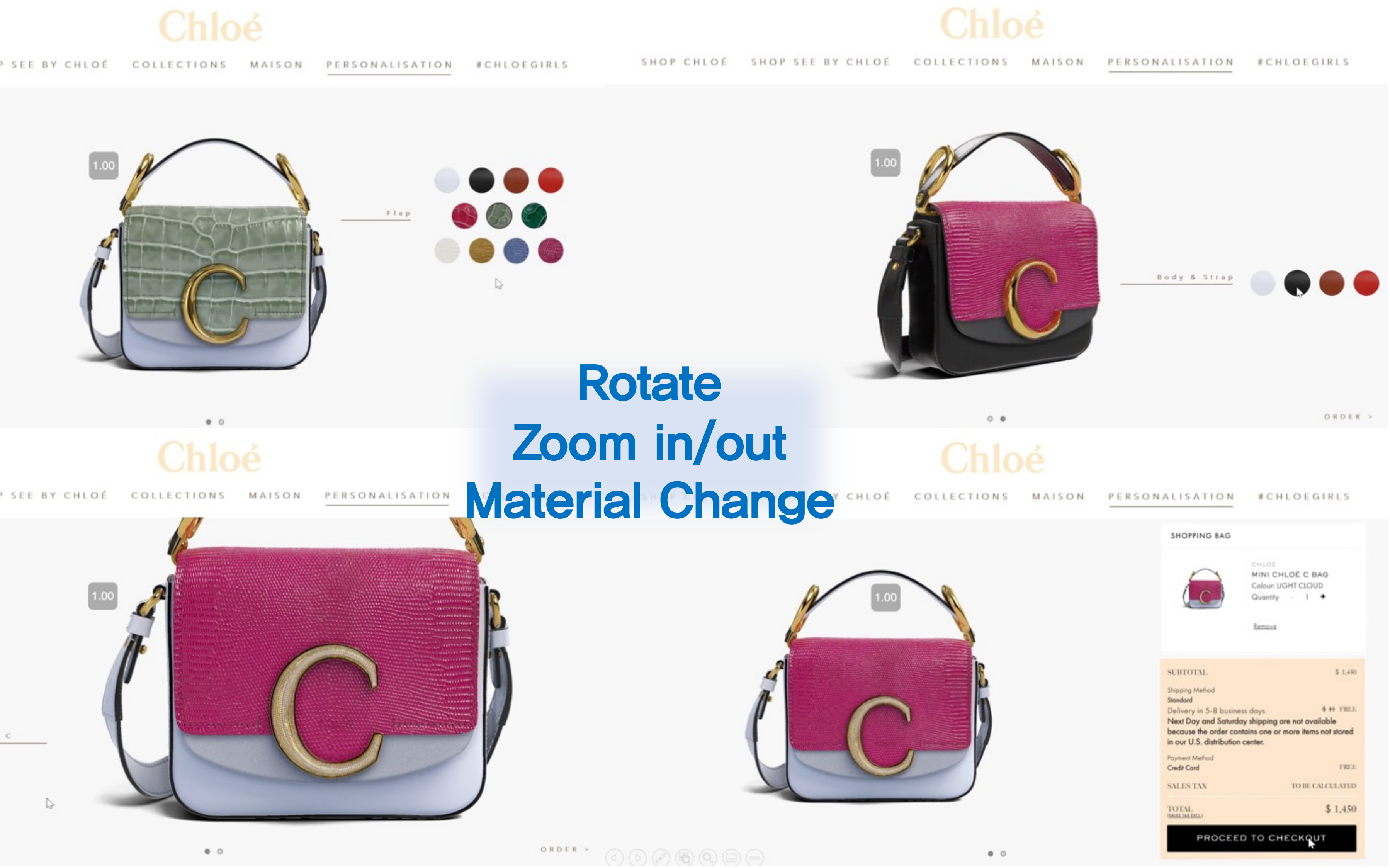
Most major brands have their own web-shops and there are numerous retailers who focus exclusively on online sales.

While online shopping is convenient and simple, **it cannot replace the actual physical experience of touching the items** you would like to buy.

This often leaves the consumer with doubts about confidence in purchases.

Recap : Intro

Existing Solutions provide limited interactions



Rotate
Zoom in/out
Material Change

Source : SmartPixels
https://www.smartpixels.fr/

3d model creation

3d scan (photogrammetry)

+ product modeling + render

Maya Unity 3D

+

Render (Web)

<model-viewer>

three.js JS

Recap: Intro Examples of Elastic E-commerce products

Elasticity visualization can enhance the shopping experience for a variety of e-commerce products, but it is particularly **valuable for products where fabric and material characteristics**, as well as fit and comfort, **are essential considerations.**

Some types of e-commerce products for which elasticity visualization can make a significant difference are :

Footwear

Shoes and sneakers, especially those with stretchable materials or designs that affect comfort and fit.

Undergarments and Hosiery

Bras, underwear, and shapewear, as elasticity plays a significant role in support and fit.

Tights, stockings, and socks, where elasticity determines how well they stay in place and conform to the legs.

Home Textiles

Bedding, blankets, and towels, where customers may want to understand the feel and durability of the fabric.

Maternity and Baby Products

Maternity wear and baby clothing, where comfort and flexibility are vital for both expectant mothers and infants.

Outdoor Gear

Tents, sleeping bags, and camping gear, where elasticity can impact durability and comfort.

Medical Products

Compression garments and orthopedic braces, where proper fit and support are critical for health and comfort.

Clothing and Apparel

Clothing items such as dresses, jeans, shirts, and lingerie, where the fit, drape, and stretch of the fabric are crucial for customer satisfaction.

Sportswear and activewear, where elasticity and flexibility affect performance and comfort.

Furniture Upholstery

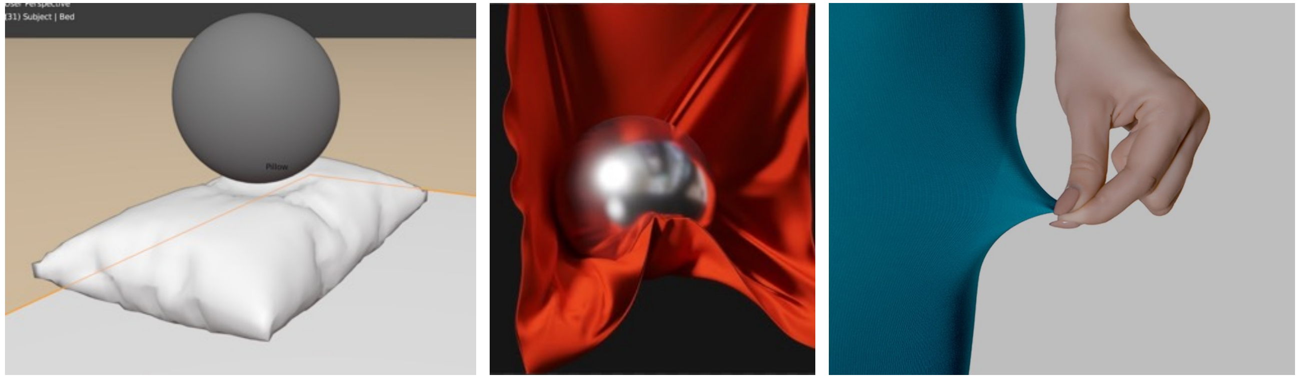
Sofas, chairs, and cushions, where customers may want to visualize how the fabric stretches and conforms to their body.

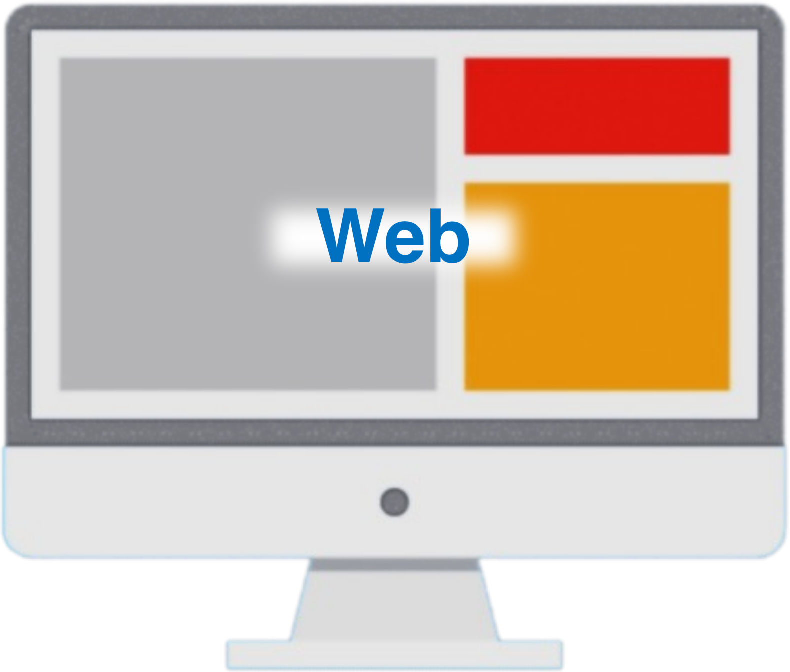
Smart Clothing and Wearables

Wearable technology integrated into clothing, where elasticity affects the placement and comfort of sensors and devices.

Recap: Research Topic

FlexiPlay :
Web–based Interactive 3D Cloth Simulation





This research aims to develop a **web-based system** with a user-friendly interface for **interactive 3D cloth simulation.**

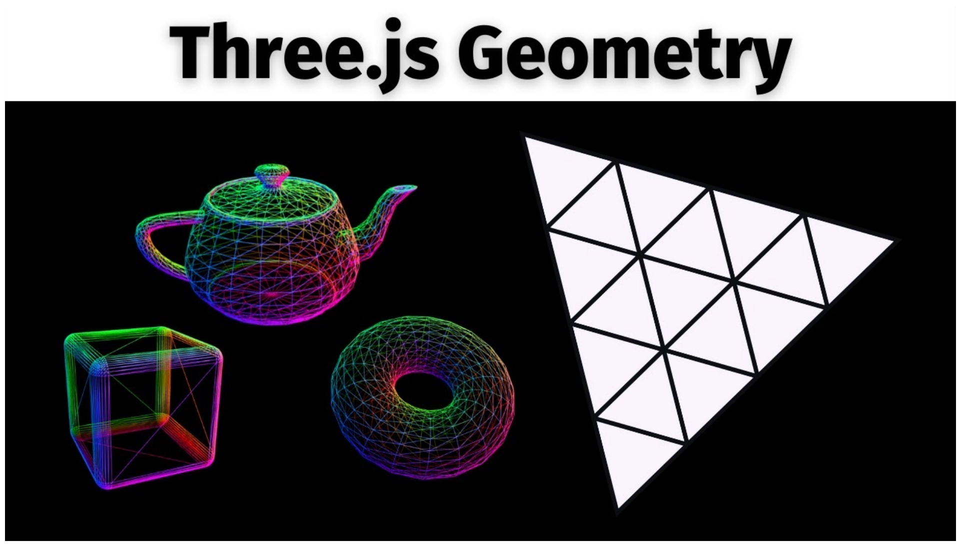
The primary objective is to provide users with an intuitive experience in understanding the **elasticity of 3D cloth**, thereby enhancing user interactions with virtual cloth.

Example of Clothes : woven, knitted, or non-woven

Progress： Settings

Module : npx

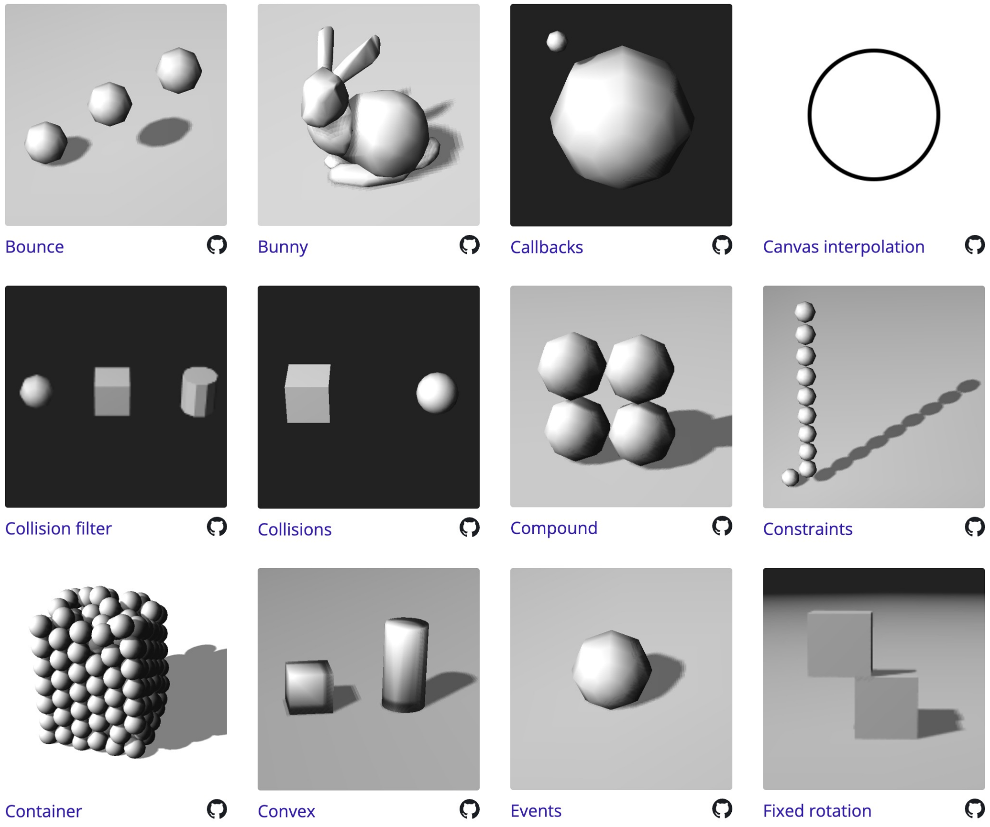
three.js



Three.js : a cross-browser JavaScript library and application programming interface used to create and display animated 3D computer graphics in a web browser using WebGL.

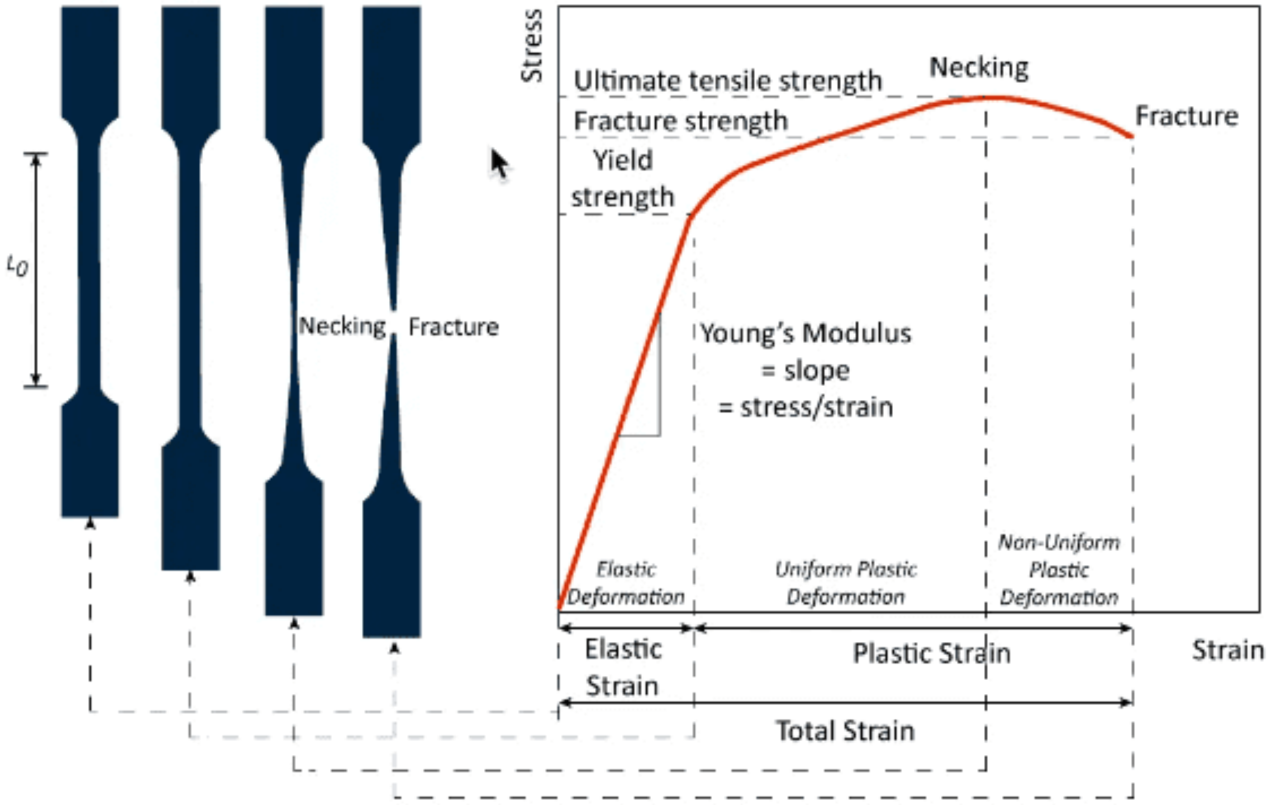
cannon-es

A lightweight and simple 3D physics engine for the web.



Lightweight 3D physics for the web

Progress：Research



1.Stress (σ): Stress is the force applied per unit area, measured in Pascals (Pa). In tensile testing, stress is calculated as the applied force divided by the original cross-sectional area of the specimen.

2.Strain (ε): Strain is the ratio of the change in length of a material to its original length. It represents the deformation of a material under stress and is often expressed as a percentage.

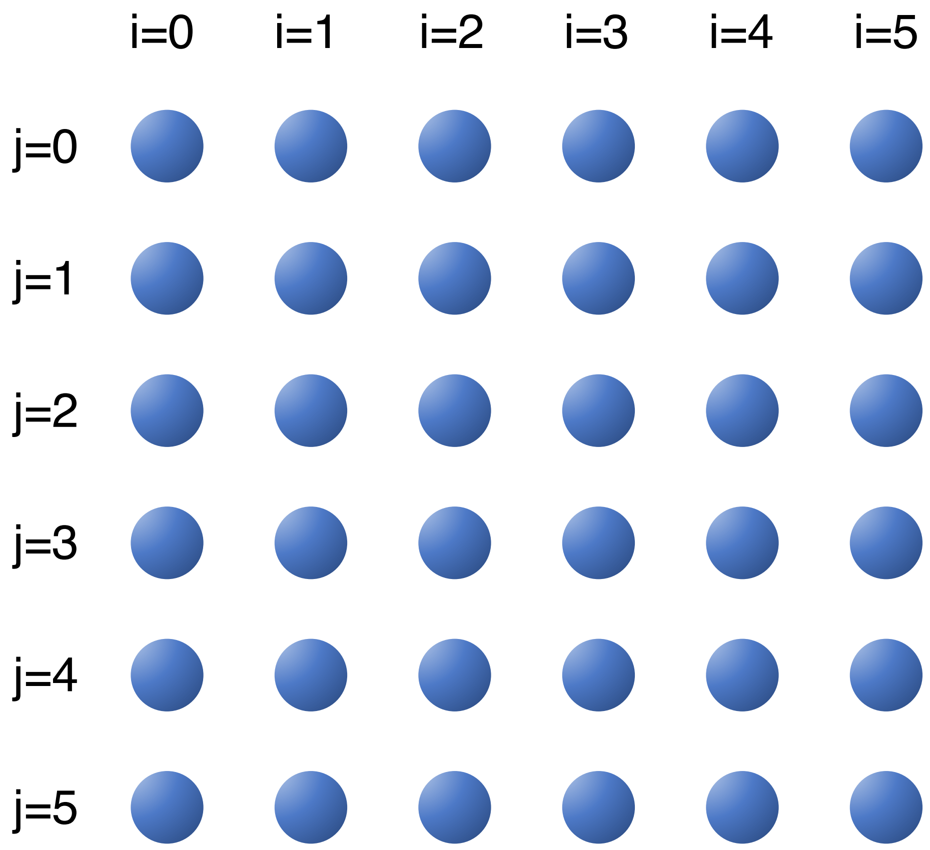
3.Young's Modulus (E): Young's Modulus is a measure of a material's stiffness and is calculated as the ratio of stress to strain within the elastic (linear) region of the stress-strain curve. It quantifies how much a material will deform under a given load.

4.Ultimate Tensile Strength (UTS): UTS is the maximum stress a material can withstand without breaking. It is a critical parameter indicating the material's overall strength.

5.Elastic Deformation vs. Plastic Deformation: In the elastic region, materials return to their original shape after the applied force is removed. Beyond the elastic limit, plastic deformation occurs, resulting in permanent changes to the material's shape.

6.Necking: Necking is a localized narrowing of a material during tensile deformation, typically occurring just before fracture. It is a phenomenon observed in ductile materials.

Progress: Physical Cloth Generation

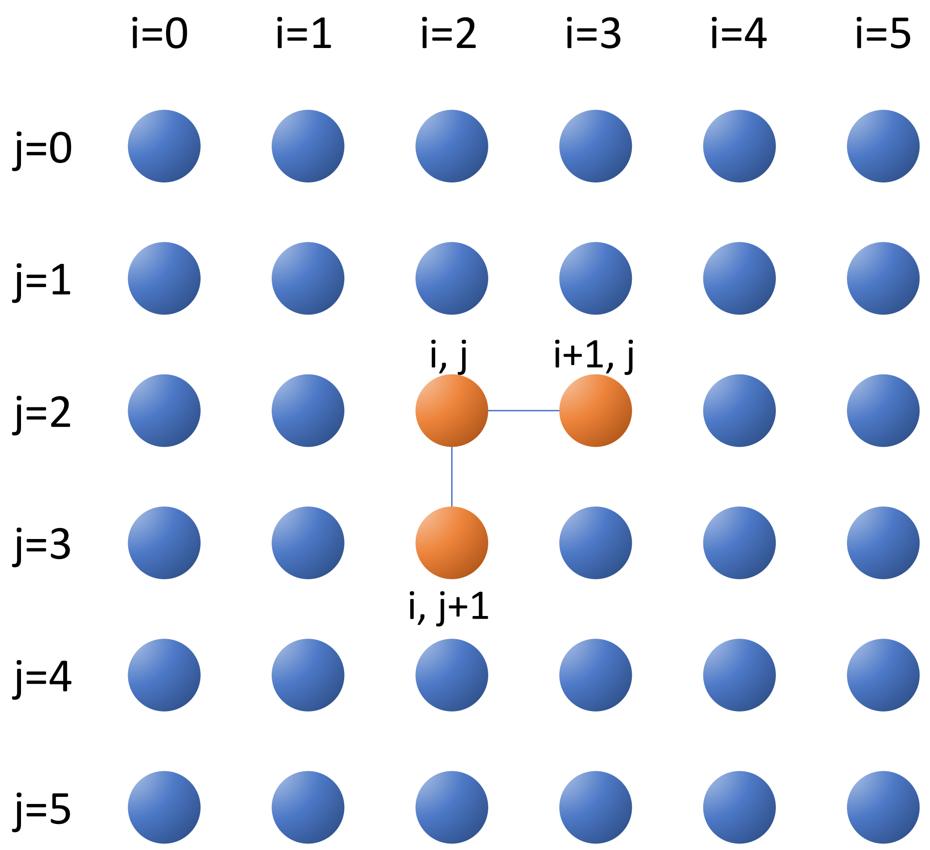


const particles = [];
// each particle : physical body (CANNON.Body)

```
const particle = new CANNON.Body({
  // mass: j == rows || (j == 0) | (i == cols) || i == 0 ? 0 : mass,
  mass: j == rows ? 0 : mass,
  shape: new CANNON.Particle(),
  position: new CANNON.Vec3(
    (i - cols * 0.5) * dist,
    (j - rows * 0.5) * dist,
    0
  ),
  material: particlePhysMat,
});
```

```
scripts.js:191
(16) [Array(16), Array(16), Array(16), Array(16), Array(16), Array
▼ (16), Array(16), Array(16), Array(16), Array(16), Array(16), Array
(16), Array(16), Array(16), Array(16), Array(16)] i
  ▶ 0: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 1: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 2: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 3: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 4: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 5: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 6: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 7: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 8: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 9: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bod
  ▶ 10: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bo
  ▶ 11: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bo
  ▶ 12: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bo
  ▶ 13: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bo
  ▶ 14: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bo
  ▶ 15: (16) [Body, Body, Body, Body, Body, Body, Body, Body, Body, Bo
    length: 16
  ▶ [[Prototype]]: Array(0)
```

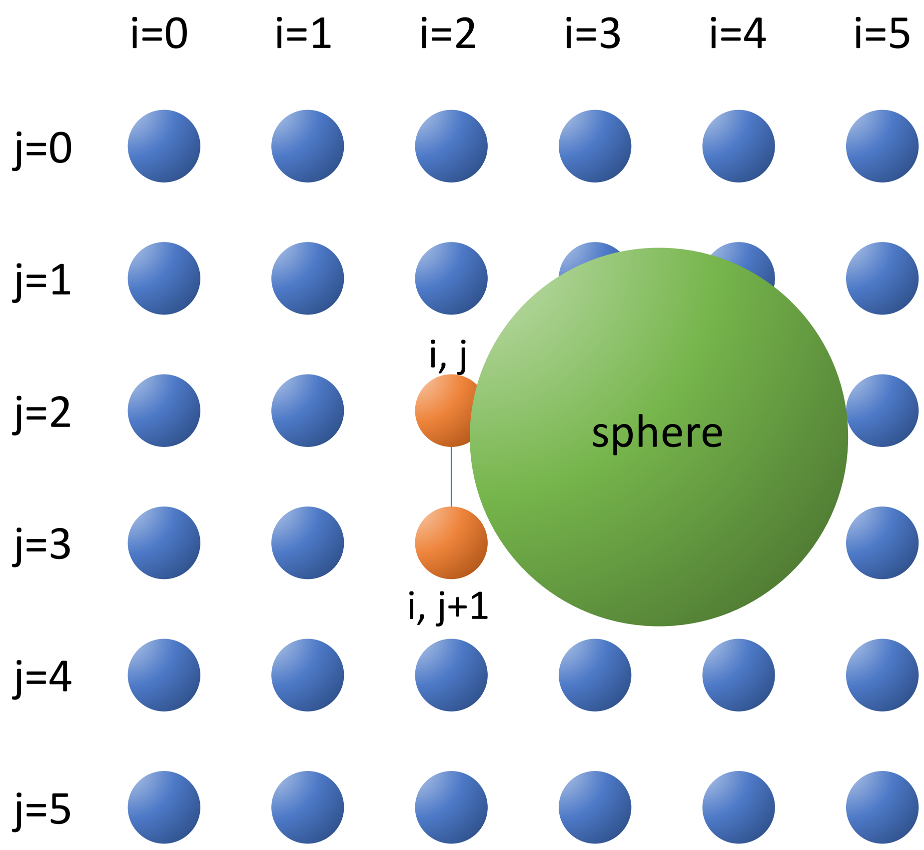
Progress：Physical Cloth Generation

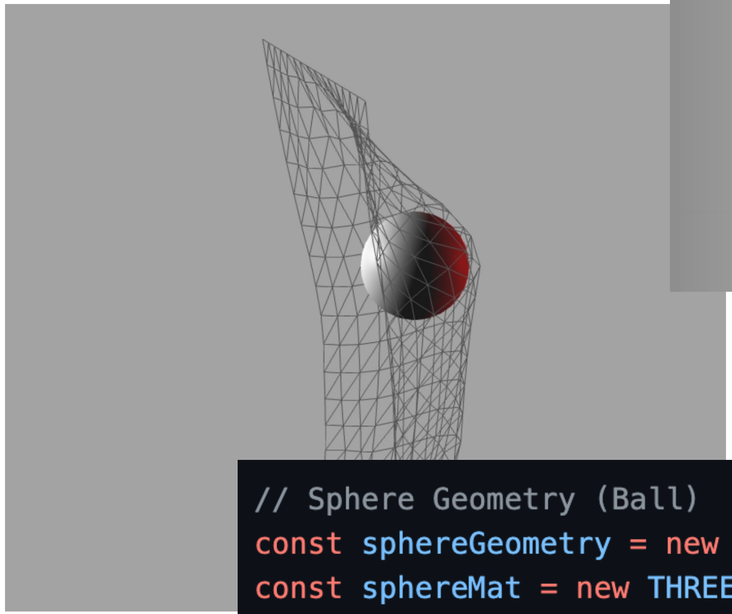


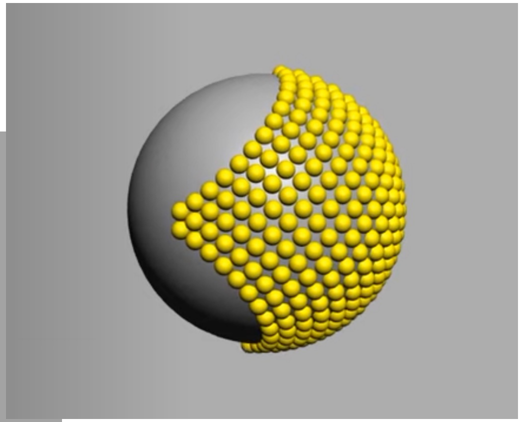

```
function connect(i1, j1, i2, j2) {
  world.addConstraint(
    new CANNON.DistanceConstraint(
      particles[i1][j1],
      particles[i2][j2],
      dist * distOffest
    )
  );
}

for (let i = 0; i < cols + 1; i++) {
  for (let j = 0; j < rows + 1; j++) {
    if (i < cols) connect(i, j, i + 1, j);
    if (j < rows) connect(i, j, i, j + 1);
  }
}
```

const distanceConstraint = new CANNON.DistatnceConstraint(ParticlaA, ParticleB, restDistance)

Progress: Physical Cloth Generation



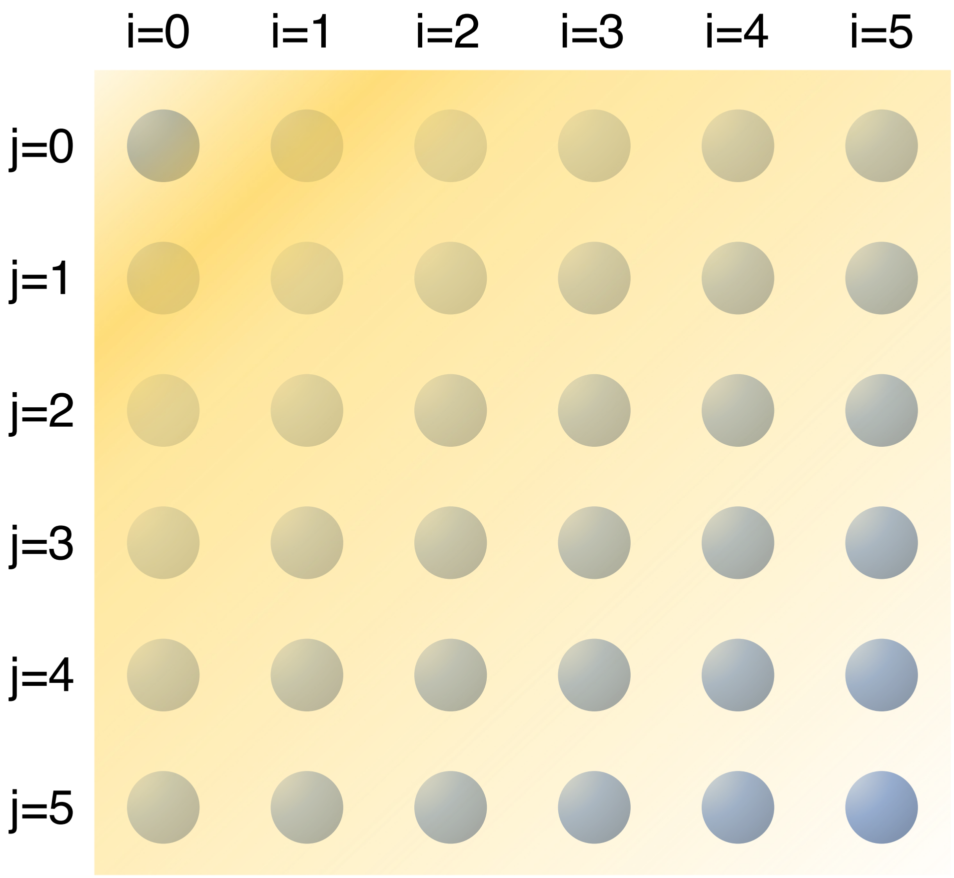


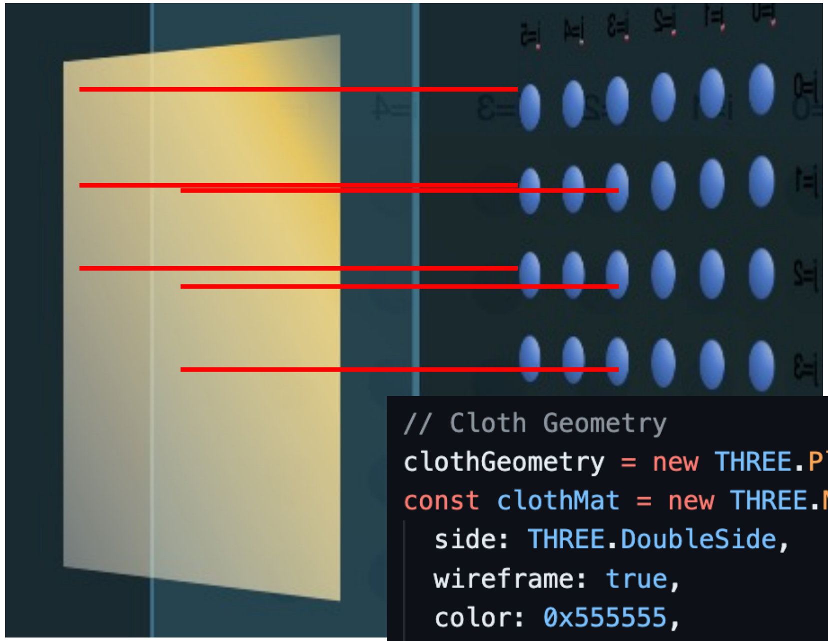


Sphere for user interaction (CANNON.Body)

```
// Sphere Geometry (Ball)
const sphereGeometry = new THREE.SphereGeometry(sphereSize)
const sphereMat = new THREE.MeshPhongMaterial();
sphereMesh = new THREE.Mesh(sphereGeometry, sphereMat);
scene.add(sphereMesh);

const spherePhysMat = new CANNON.Material();
const sphereShape = new CANNON.Sphere(sphereSize * 1.3); //
sphereBody = new CANNON.Body({
  mass: 0,
  shape: sphereShape,
  material: spherePhysMat,
});
world.addBody(sphereBody);
```

Progress: Physical Cloth Generation



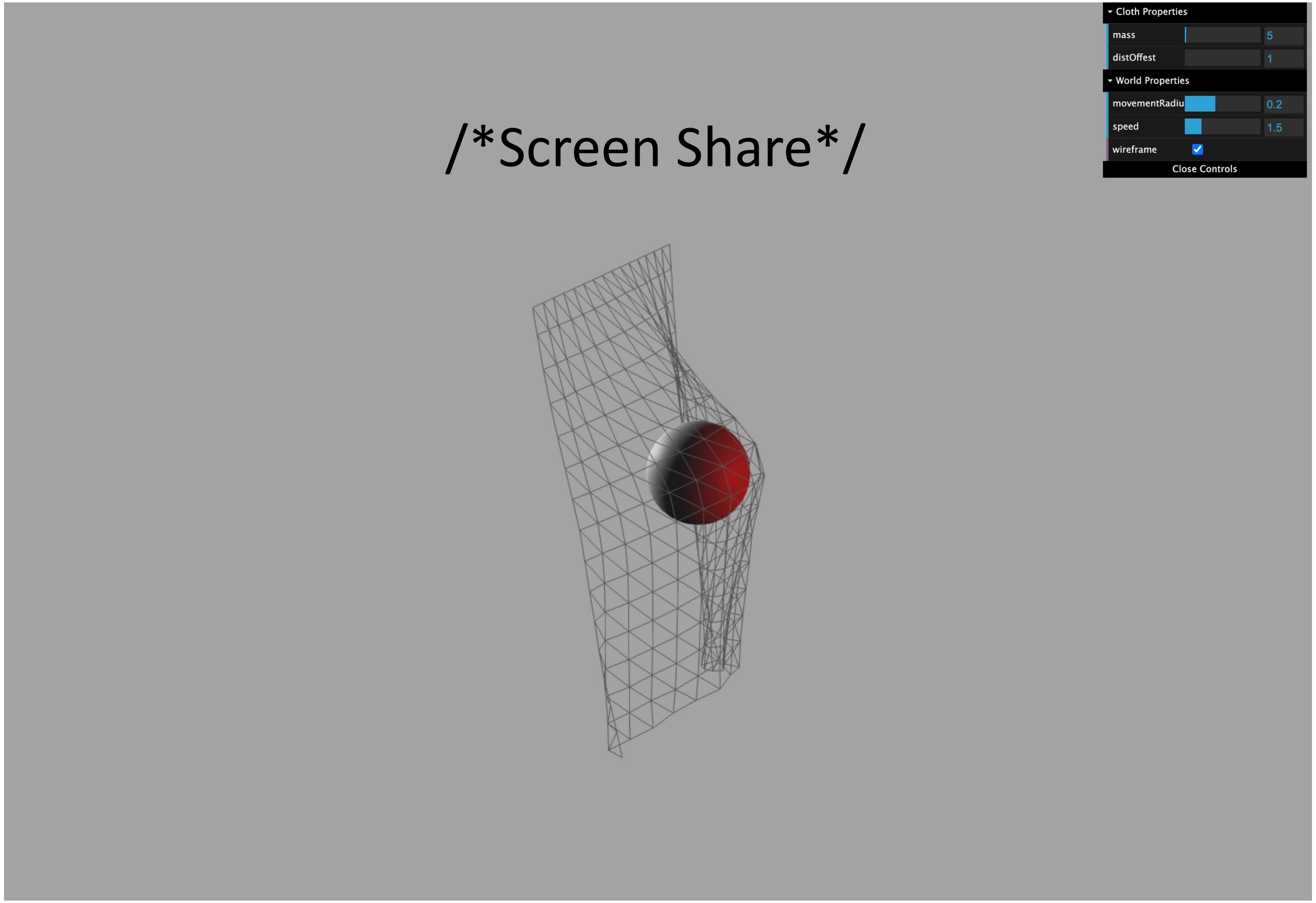


Cloth geometry

```
// Cloth Geometry
clothGeometry = new THREE.PlaneGeometry(1, 1, cols, rows);
const clothMat = new THREE.MeshBasicMaterial({
  side: THREE.DoubleSide,
  wireframe: true,
  color: 0x555555,
  // map: new THREE.TextureLoader().load("./texture.jpg"),
});
clothMesh = new THREE.Mesh(clothGeometry, clothMat);
scene.add(clothMesh);
```

```
function updateParticules() {
  for (let i = 0; i < cols + 1; i++) {
    for (let j = 0; j < rows + 1; j++) {
      const index = j * (cols + 1) + i;
      const positionAttribute = clothGeometry.attributes.position;
      const position = particles[i][rows - j].position;
      positionAttribute.setXYZ(index, position.x, position.y, position.z);
      positionAttribute.needsUpdate = true;
    }
  }
  clothGeometry.normalsNeedUpdate = true;
  clothGeometry.verticesNeedUpdate = true;
```

Progress：demo



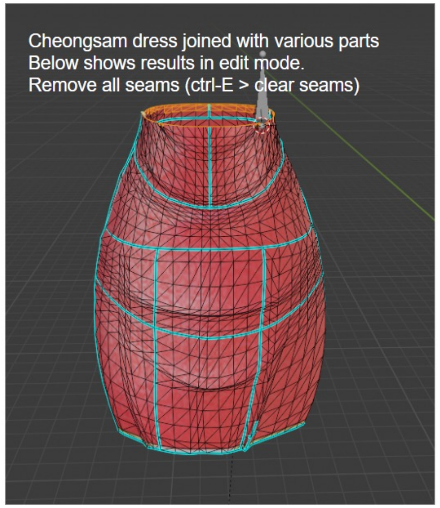
Progress： demo

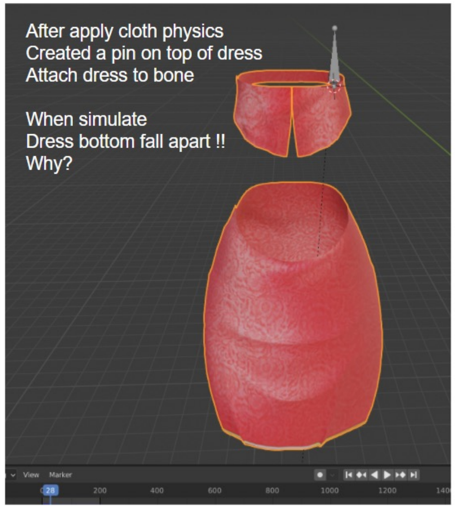
- **How to make the fabric interaction realistic**

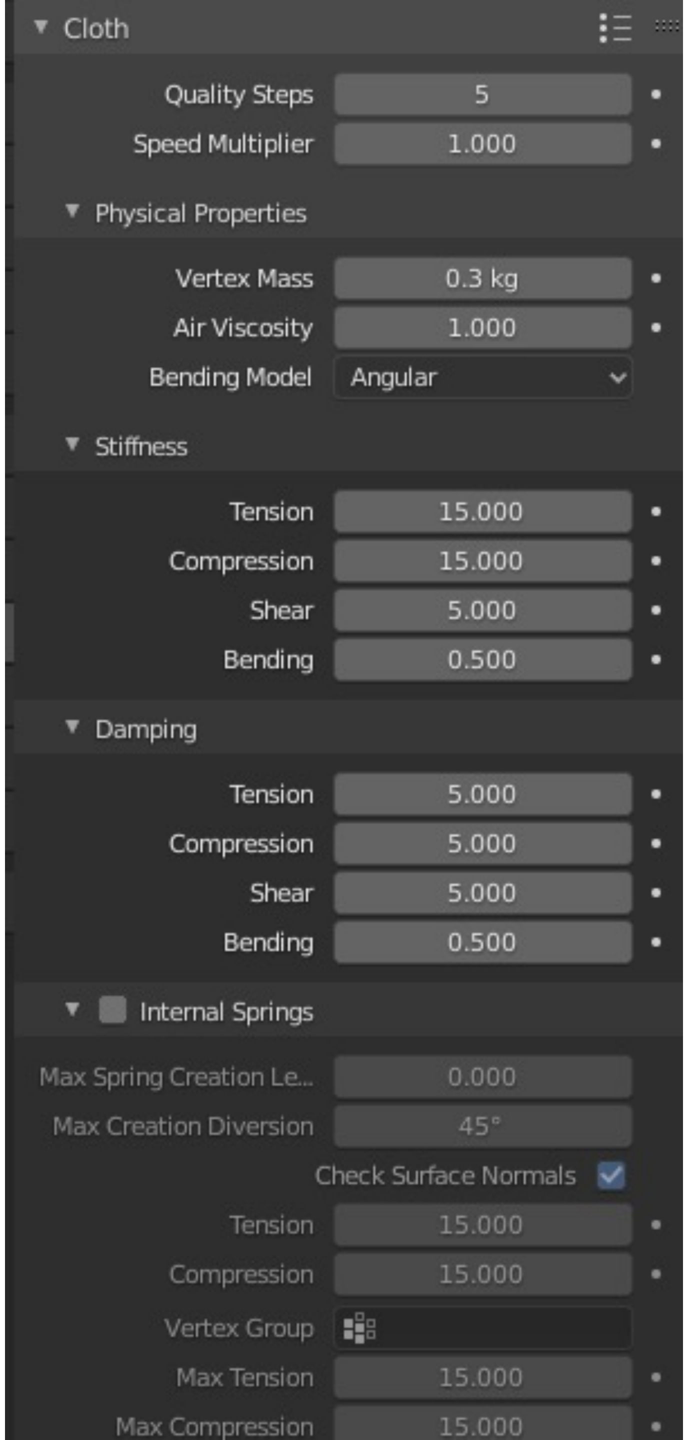
  Reference - Blender : Physics Cloth options (Leather, …)
- ADD Mouse Interaction
- Debugging (e.g. wireframe)
- Optimization (e.g. GUI slowing)
- Testing / Evaluation / Analysis

+ 계획수정(?) : js library로 만드는 것은 다른 이슈.

.







Research Method

1. System Architecture
2. Data Collection
3. Implementation
   Cloth Simulation Algorithm
4. User Interaction
5. Testing and Evaluation
6. Data Analysis
7. Limitation
8. Conclusion

Research Method

1
System Architecture

2
Data Collection

3
Implementation
Cloth Simulation Algorithm

Front-end
- React (user interaction)
- Three.js, WebGL, cannon.js (3d rendering)

Back-end
- Supabase or Firebase (serverless DB)
- CloudFlare (for caching and speed optimization)

Hosting
- Vercel

* List above is subject to change

Gather data for research, such as :
- Cloth material properties
- Tensile properties of the fabric and the garment pressure
- Elastic behavior of stretched cloth

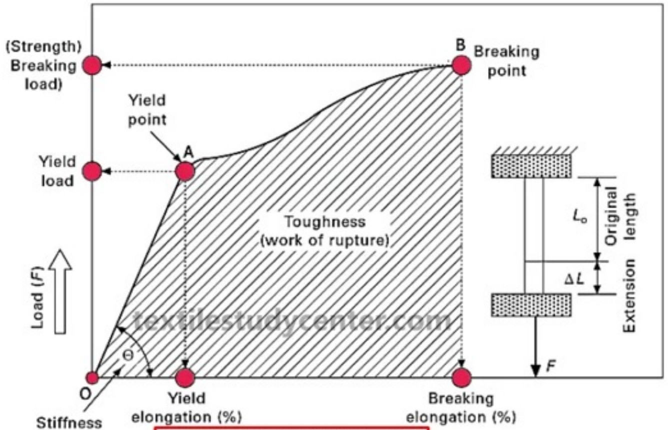
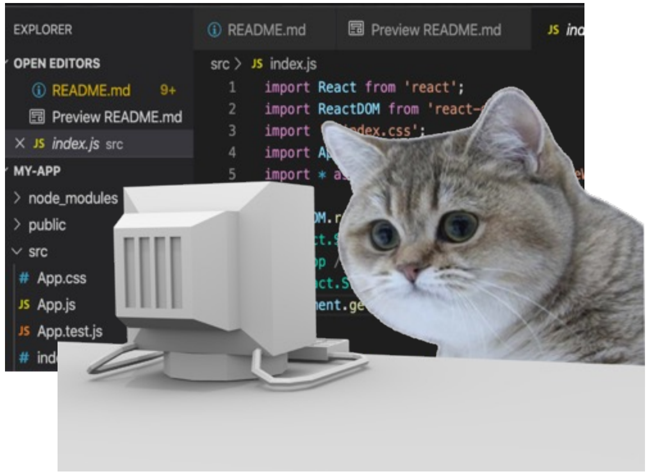


Fig: Load-Elongation curve for a fiber

Write an algorithm simulating cloth elasticity with user interaction and build web pilot system.



Research Method

4
User Interaction

5
Testing and Evaluation

6
Data Analysis

GUI
Describe how users interact with the system's GUI. Users can adjust cloth elasticity parameters.
*to be added

User Controls / Input Methods
Mouse
- Click and Drag

Touch Interaction
- One-Finger Pan

Usability Testing
Gather user feedback on the interface and interaction.

Performance Testing
Assess the system's speed and responsiveness with tests and performance benchmarks.

Analyze the data collected during testing and evaluation.
Use statistical methods or tools to draw conclusions from the data.
*to be added

Research Method

7

Limitation

N/A

8

Conclusion

N/A