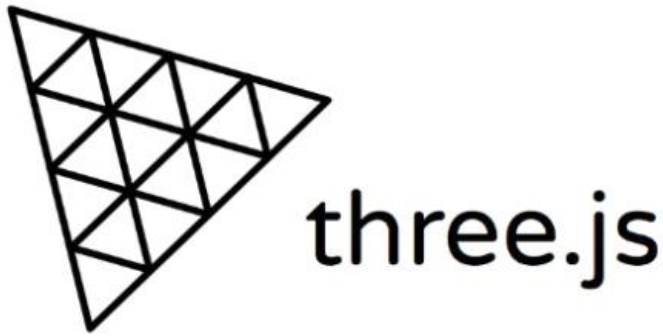
Visualization with Three.js

Benjamin Kenwright



Content

- Why’s Visualization so Important?
- Science behind Visuals
- Why Three.js?
- Basics of 3D Graphics
- Step-by-Step Example
- Interactive Details/Effects
- Pros/Cons
- Questions/Discussion

Why's Visualization so Important?

Communication

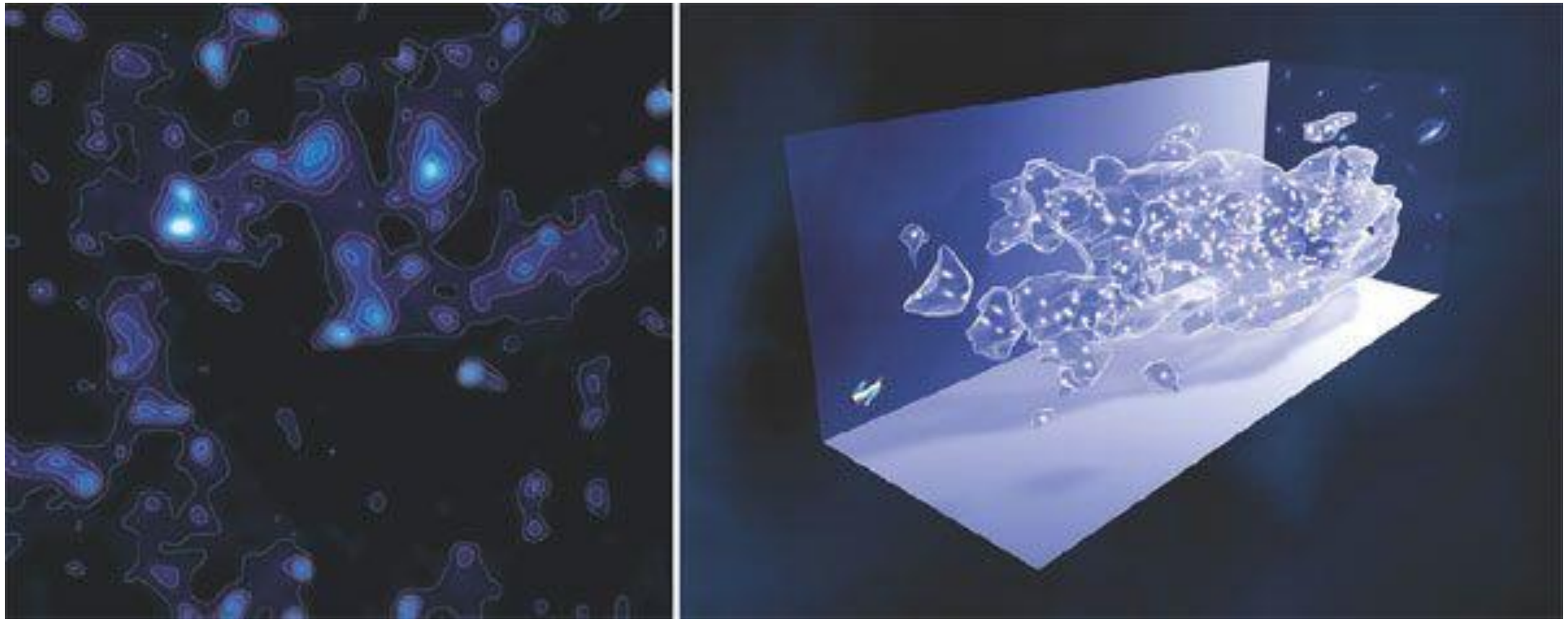
You Cannot Communicate Your Idea Until You Can Visualize (see) It

POWER of Visual Communication
(Science behind Visuals)

As humans, we learned to communicate with pictures long before we invented words.

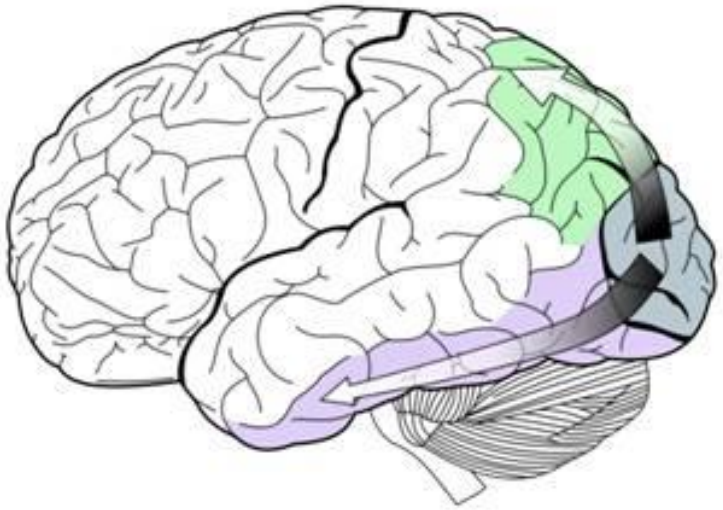
The proof is present in the form of **images in caves**

A two-dimensional map (left) of the Universe's mysterious dark matter can be translated into three dimensions (right) for clarity and impact



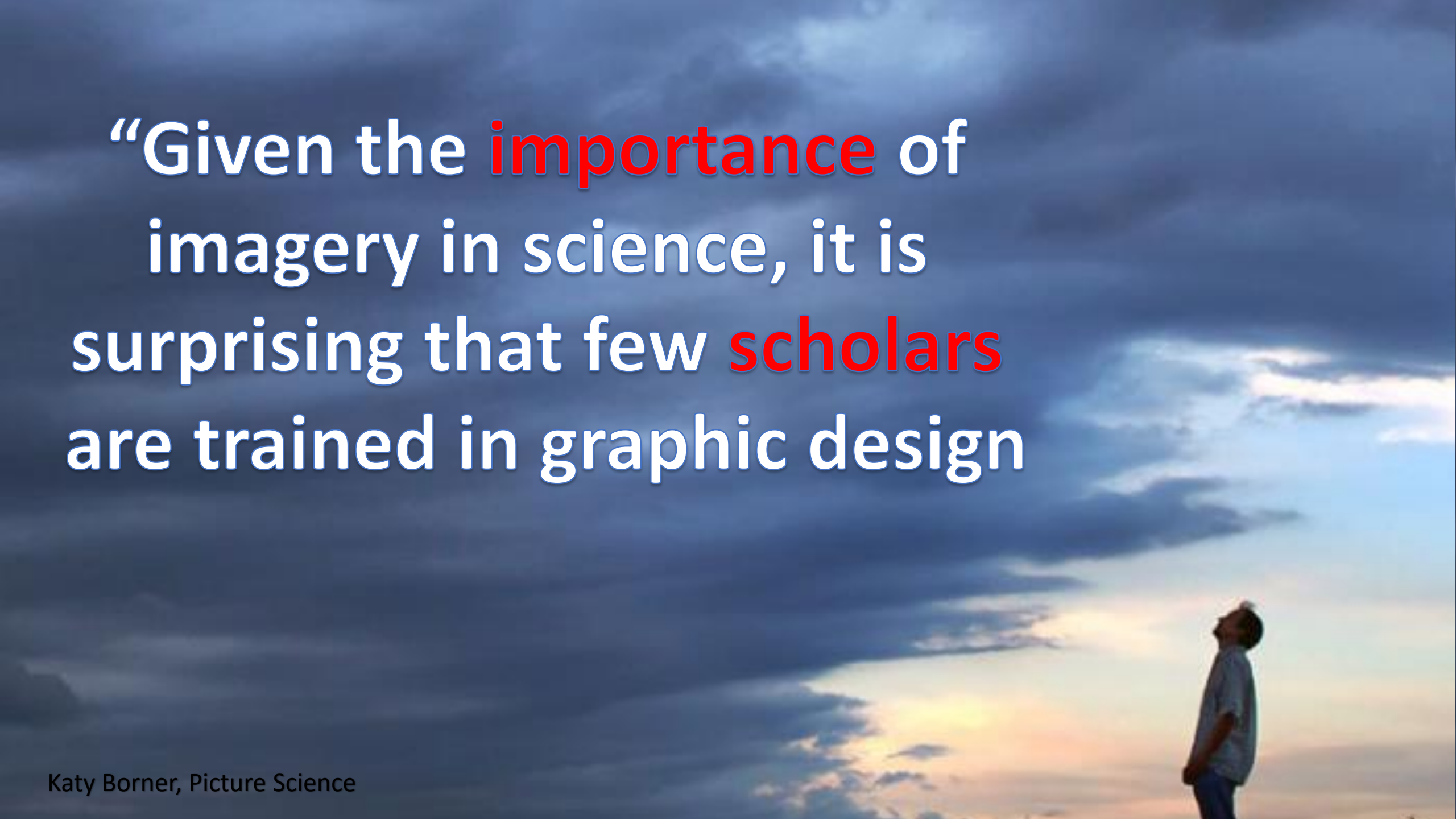
How do Visuals Helps with Learning & Memory?

Our mind translates words into **visuals** before processing its **meaning**



Visuals Helps with Learning & Memory

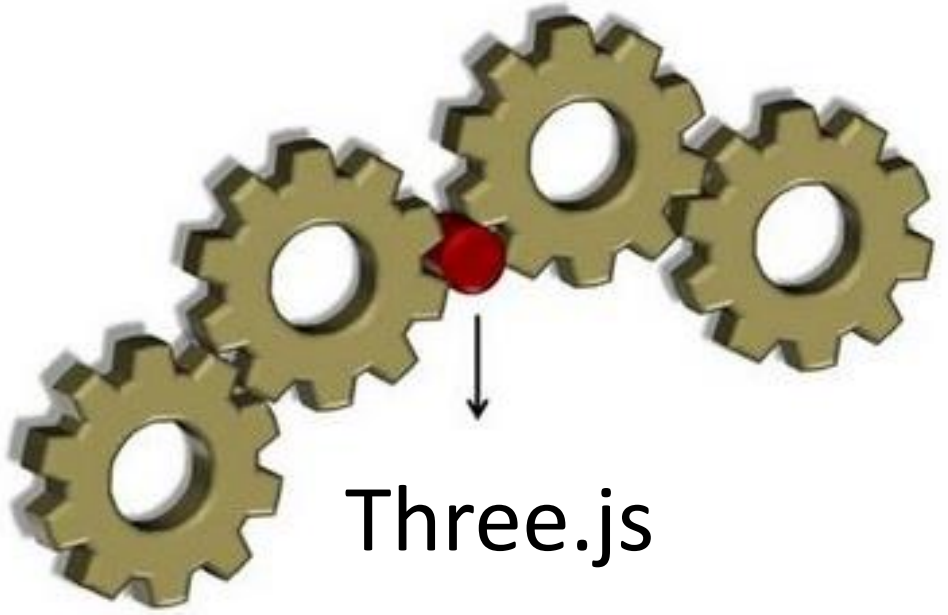
- Helps process and retain information better
- It is not enough to use `text’


"Given the importance of imagery in science, it is surprising that few scholars are trained in graphic design
Katy Borner, Picture Science


How to Unlock
Creative Freedom
To Explore &
Experiment?
Don’t want to be Limited by Software Packages/Tools
Develop Innovative and Bespoke Visual Solutions

Visual Creative Abilities

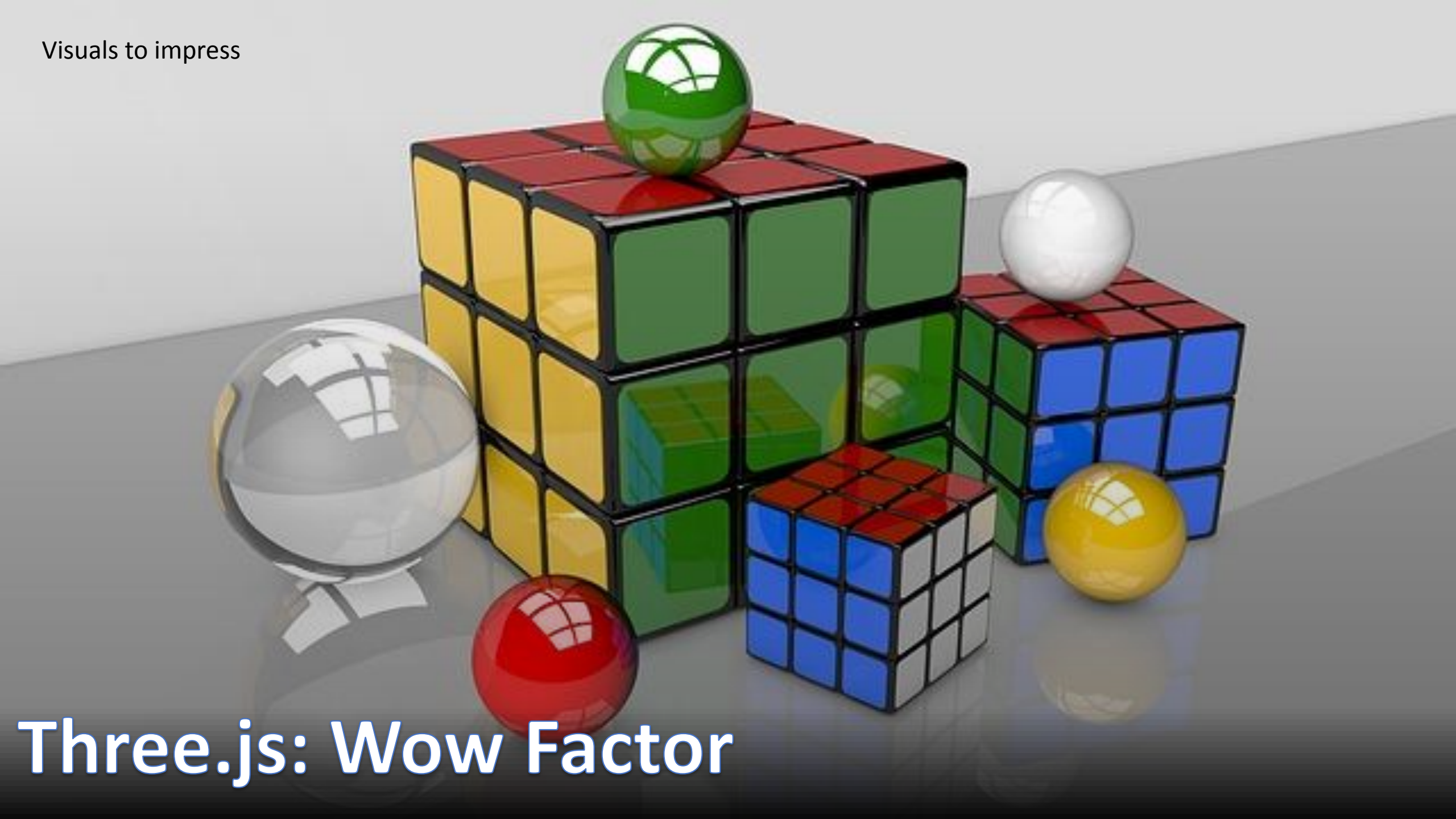
(Blocked or Limited)



Three.js

Unblock/Free You

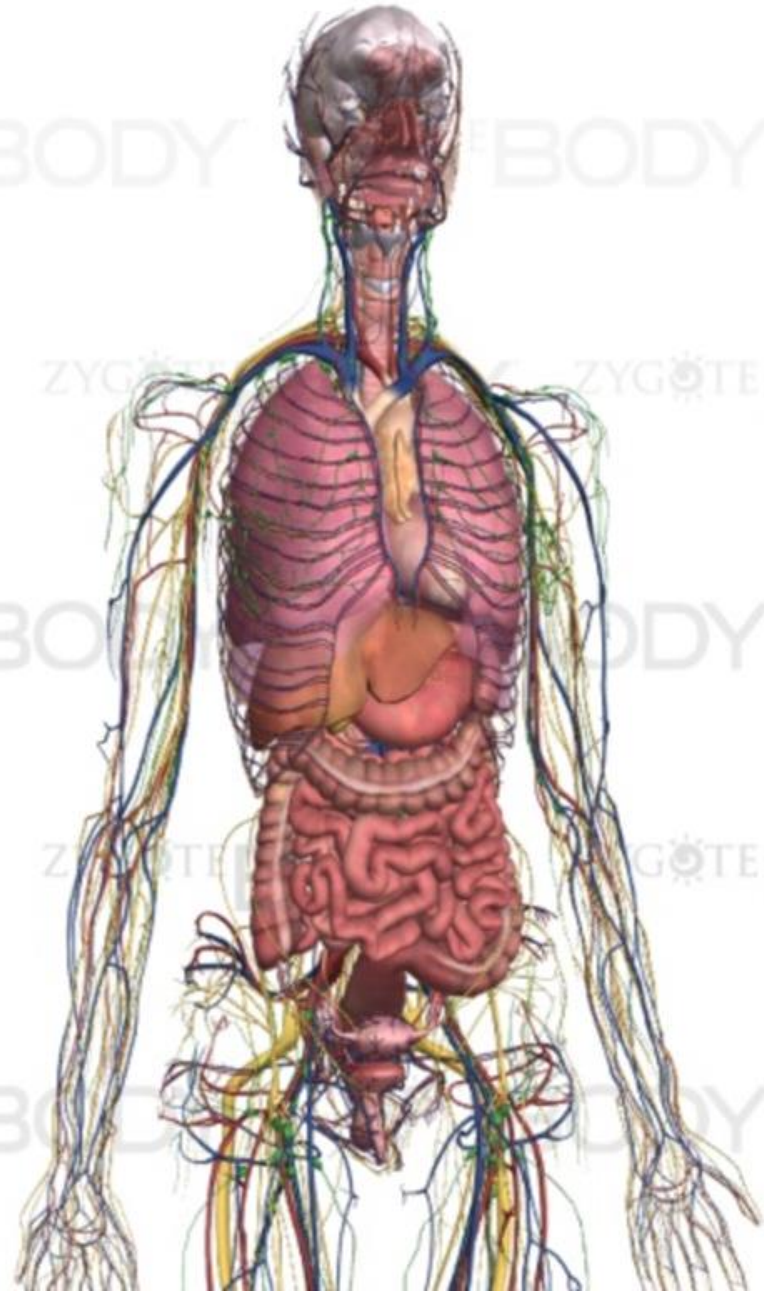
Visuals to impress



Three.js: Wow Factor


EXAMPLES

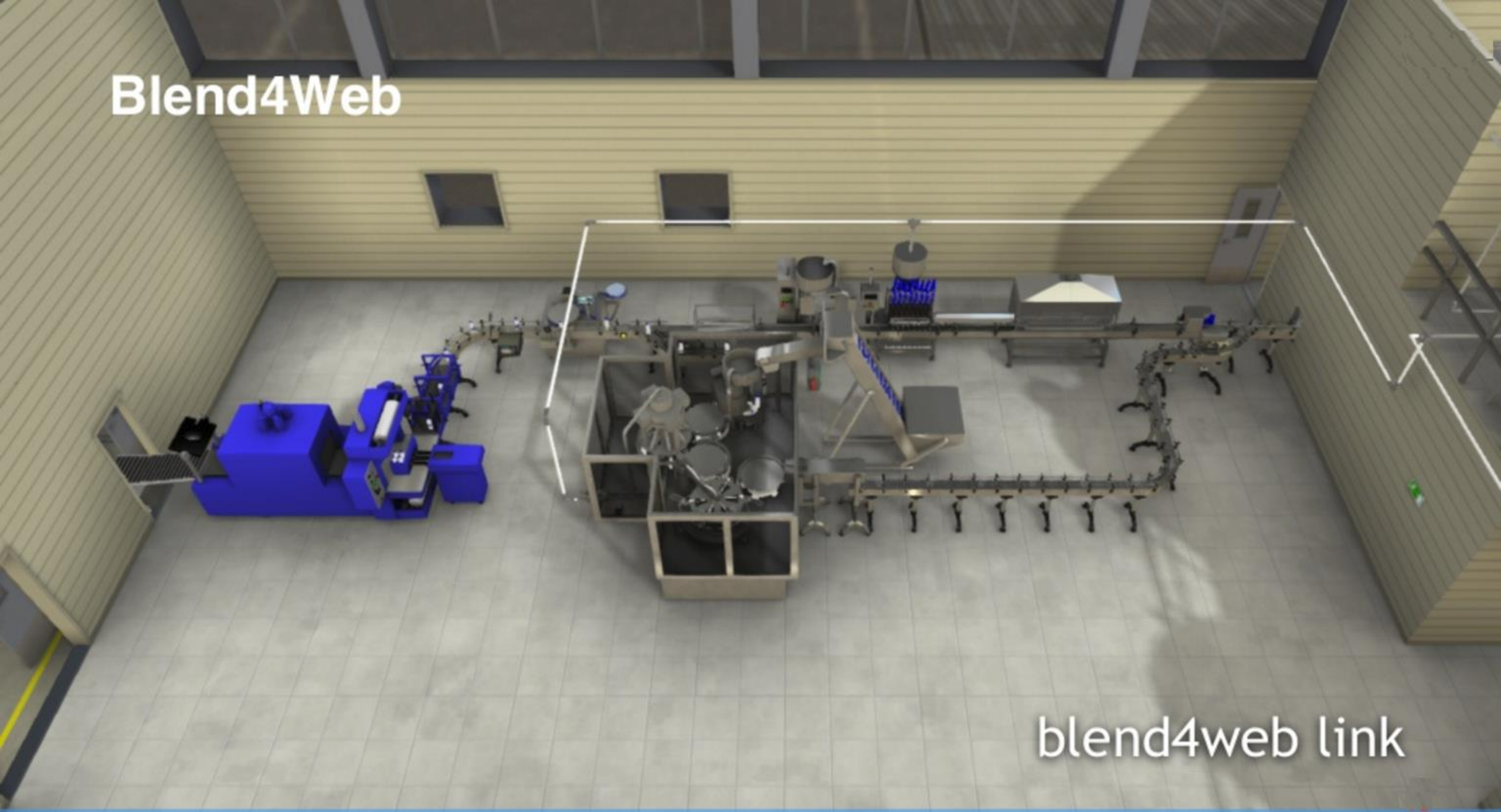
Learn your body

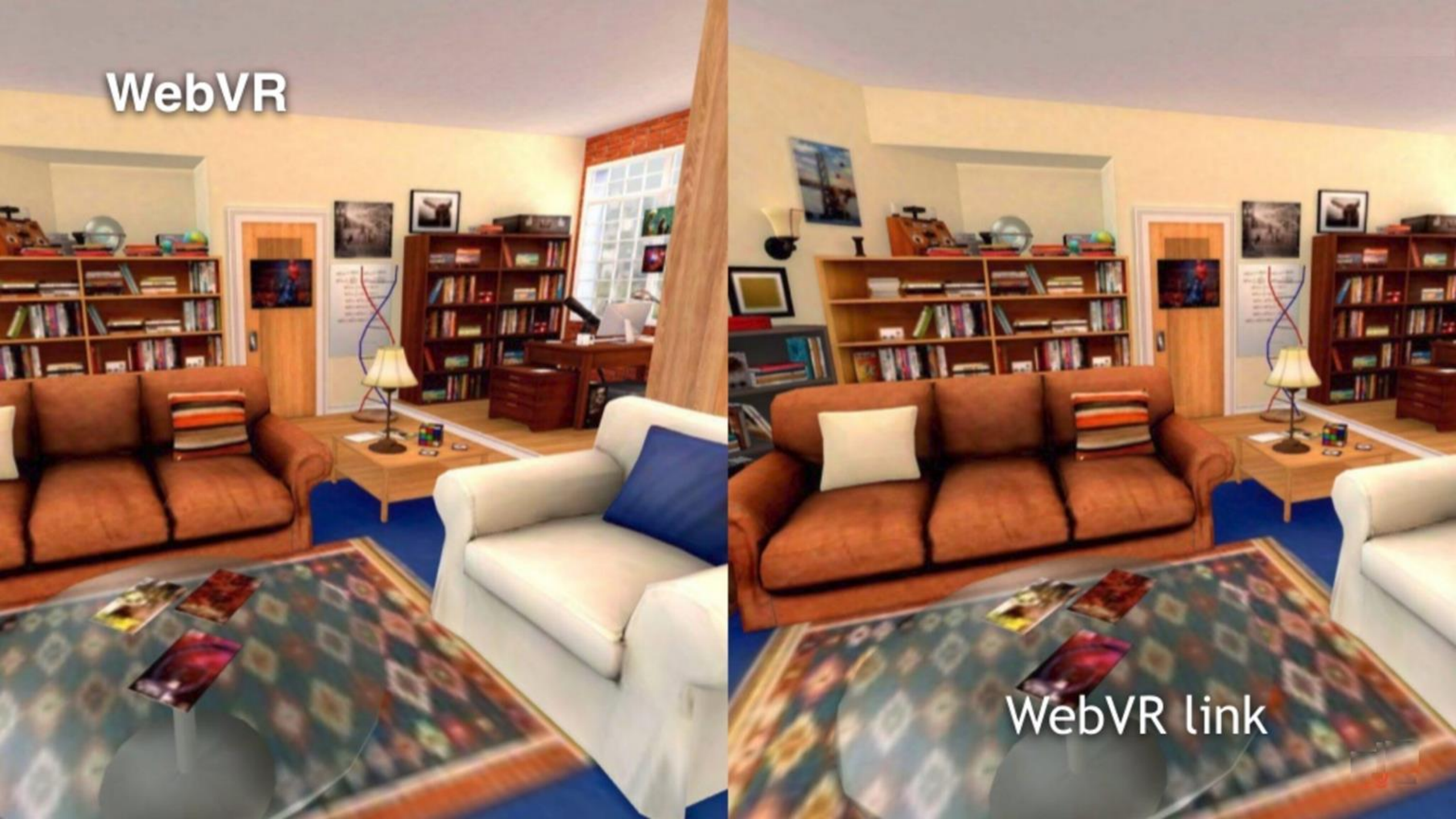


human.biodigital

zygotebody


mall Arms and Ammunition — Imports & Exports
interactive visualization of government-authorized small arms and ammunition transfers from 1992 to 2010.
RUSSIAN FEDERATION
Statistics
$0.11B
AMMUNITION
ITALY
RUSSIAN FEDERATION
imported: $36,420,7
exported: $142,405,
$9.76M
MMUNITION
$26.7M
CIVILIAN
WEAPONS
$27.7M
CIVILIAN
WEAPONS
chromeexperiments
IMP


Blend4Web
blend4web link


WebVR
WebVR link

1-КОМНАТНАЯ КВАРТИРА
40,7 м²

2-КОМНАТНАЯ КВАРТИРА
64,0 м²

3-КОМНАТНАЯ КВАРТИРА
97,6 м²

ВИД СВЕРХУ

ГОСТИНАЯ

СПАЛЬНАЯ

ДЕТСКАЯ

КУХНЯ

ВАННАЯ

ТУАЛЕТ

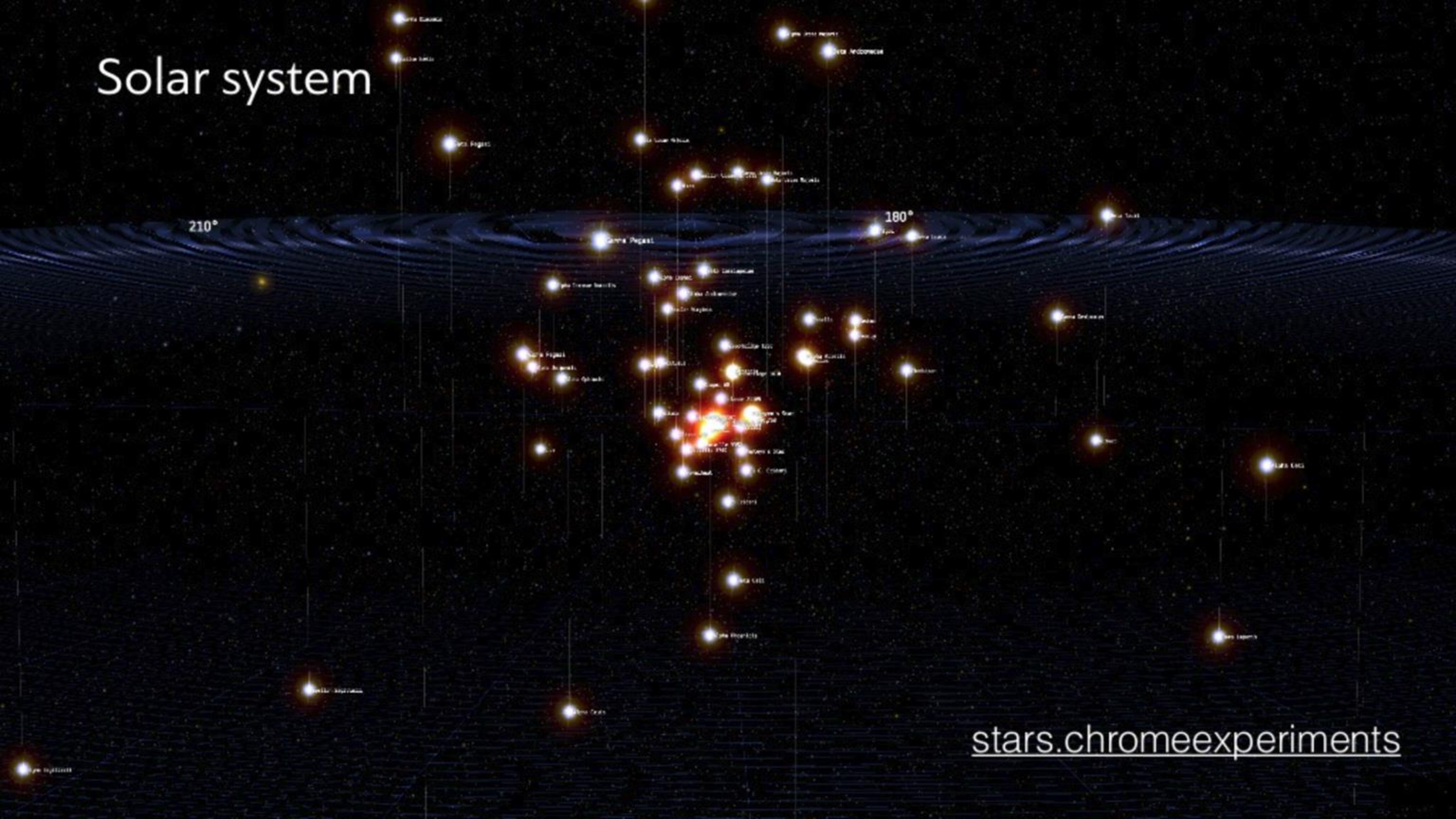
ПРИХОЖАЯ


Panorama
Colosseo link
Google

Book shop

Car viewer

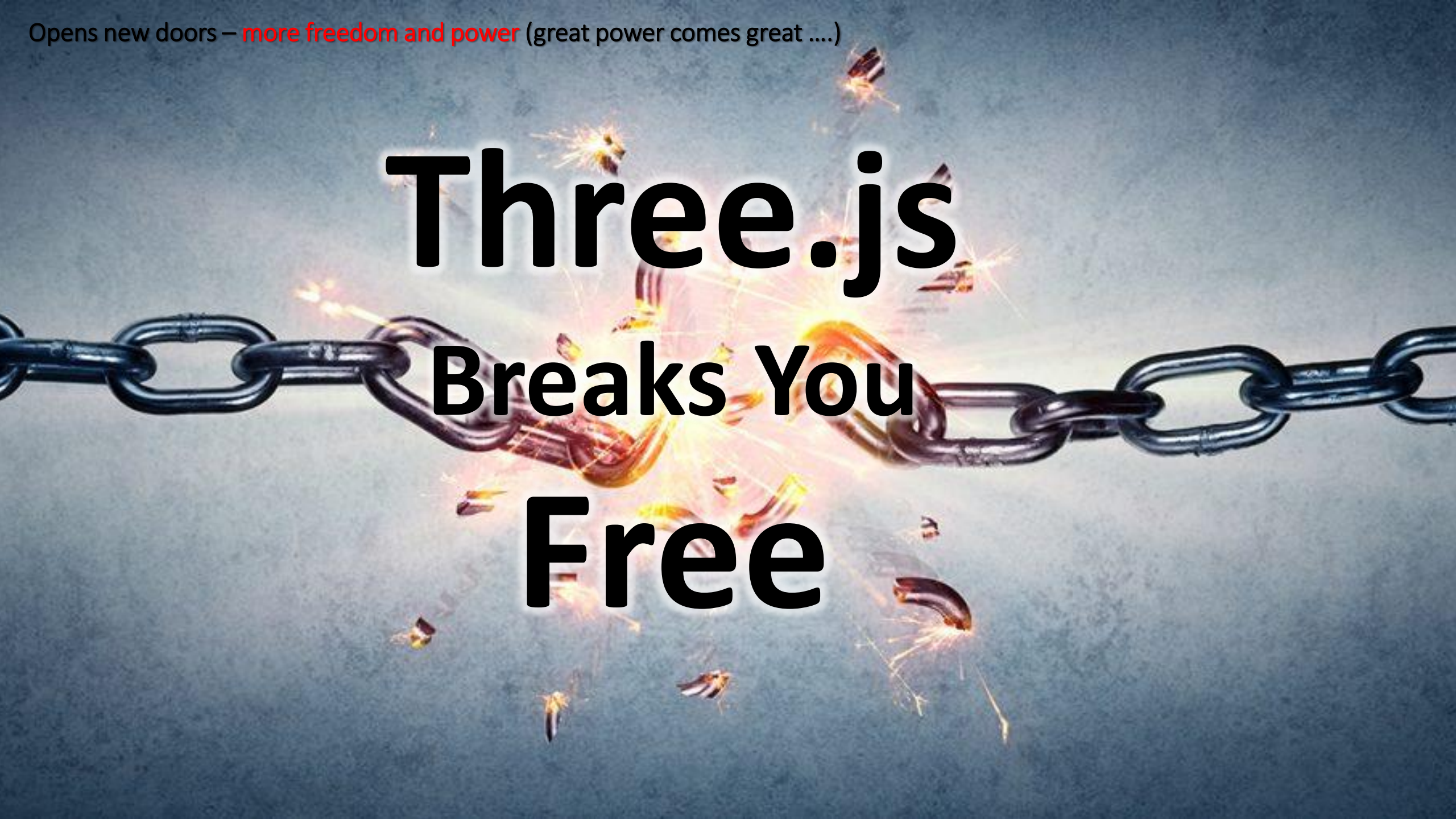
Solar system



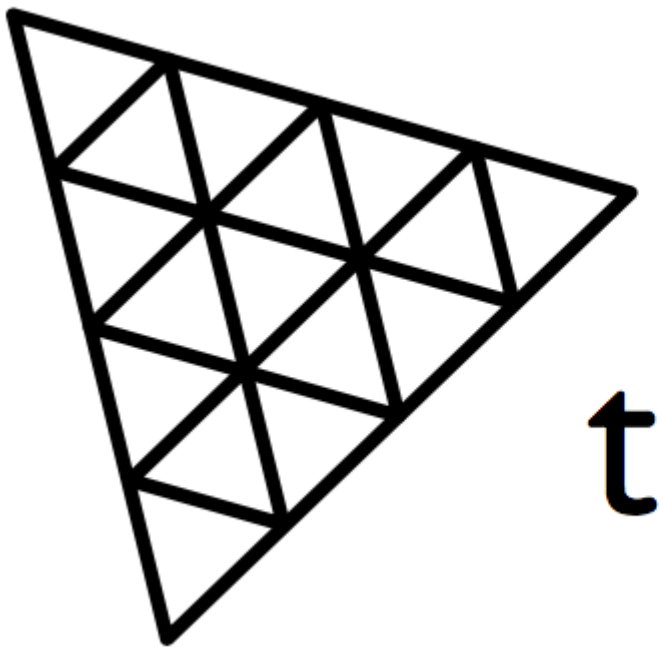
stars.chromeexperiments


Three.js
helps you build your
visually
immersive skills

Opens new doors – more freedom and power (great power comes great ….)



What is Three.js?



three.js

WebGL

Javascript 3D Library for WebGL

- HTML5 <canvas>
- OpenGL ES 2.0
- GLSL ES 1.10
- 2D/3D

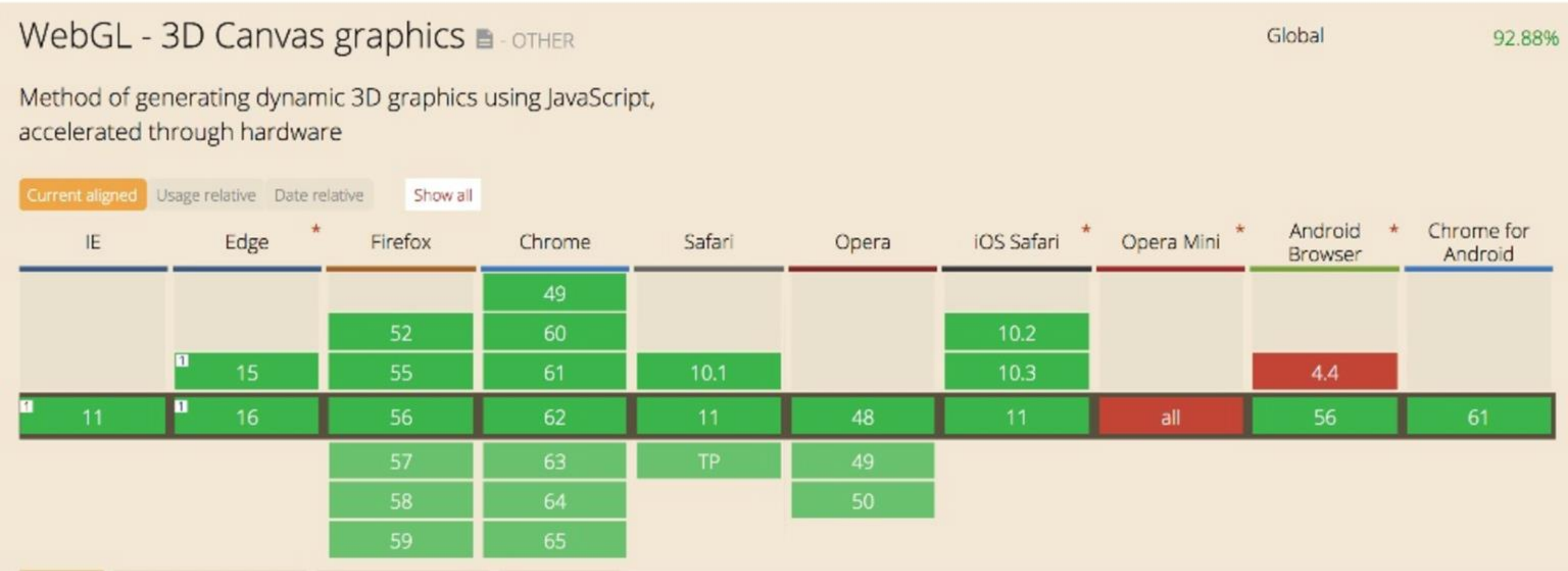
KHRONOS GROUP

Components of WebGL

<canvas/>

OpenGL
Shading Language

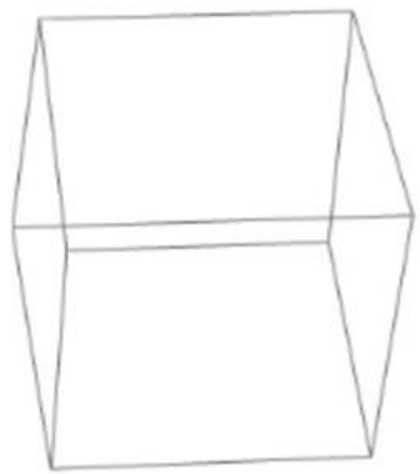
Browser Support



Your browser supports WebGL

You should see a spinning cube. If you do not, please
visit the support site for your browser.

get.webgl.org



What Three.js Resources are Available?


WITHIN

TRACK

HERACLES



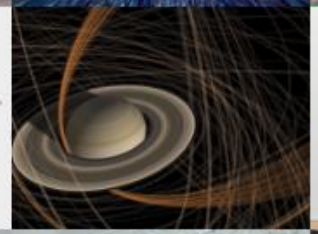

world draw
An AI Experiment to draw the world together



Filmmaker
TAO
AJIMA
from
TANGRAM co.,ltd.

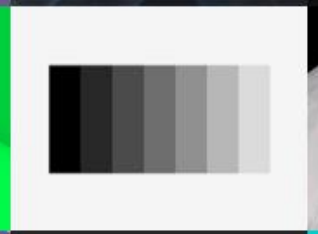
Poly
Explore the world of 3D

Optimistic Technologist


NORMAN


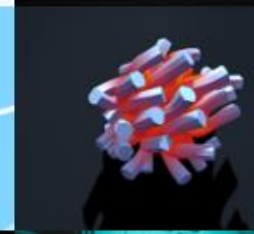
the gallery of emerging species


SONG EXPLODER PRESENTS
INSIDE MUSI

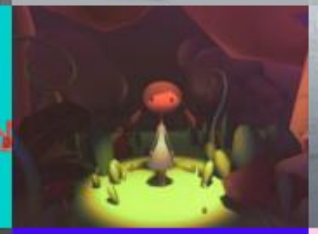


Change Gout

esurrecting a Dragon


studio

HAPPINESS



3DC

SAMSY LAB
CREATIVE TECH / 3D DEVELOPER


KASPERSKY
arth 2050

ANAGRAM

Climatune

TOPO
TOPO

FILLORY

MASHUP
MUSIC PLAYER

ACSL
MADE IN
JAPAN

CHRISTMAS XP
One day · One experiment

ROBERTA CAMERINO
"The birth of a Legend"

React VR

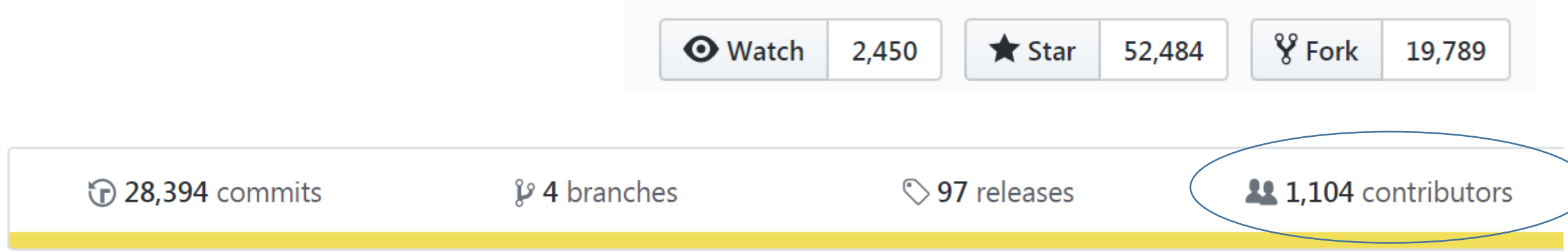
DEPROGRAMMED

analysis

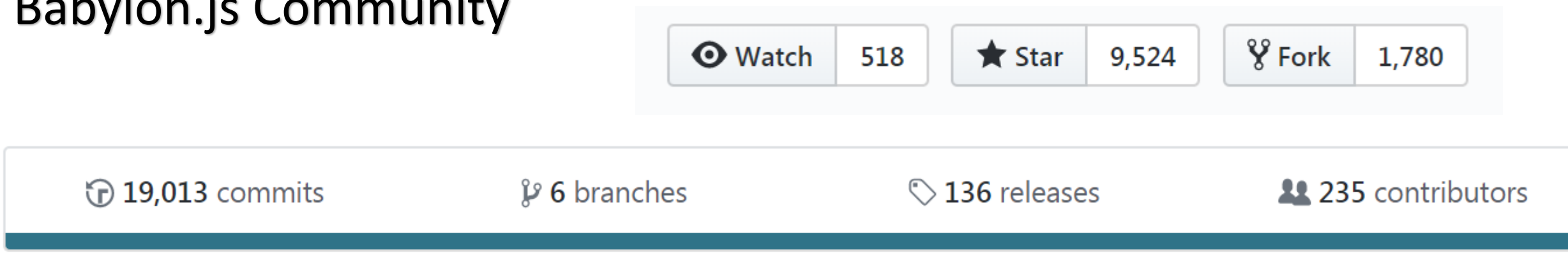
Hennessy

Aviator

Three.js Community



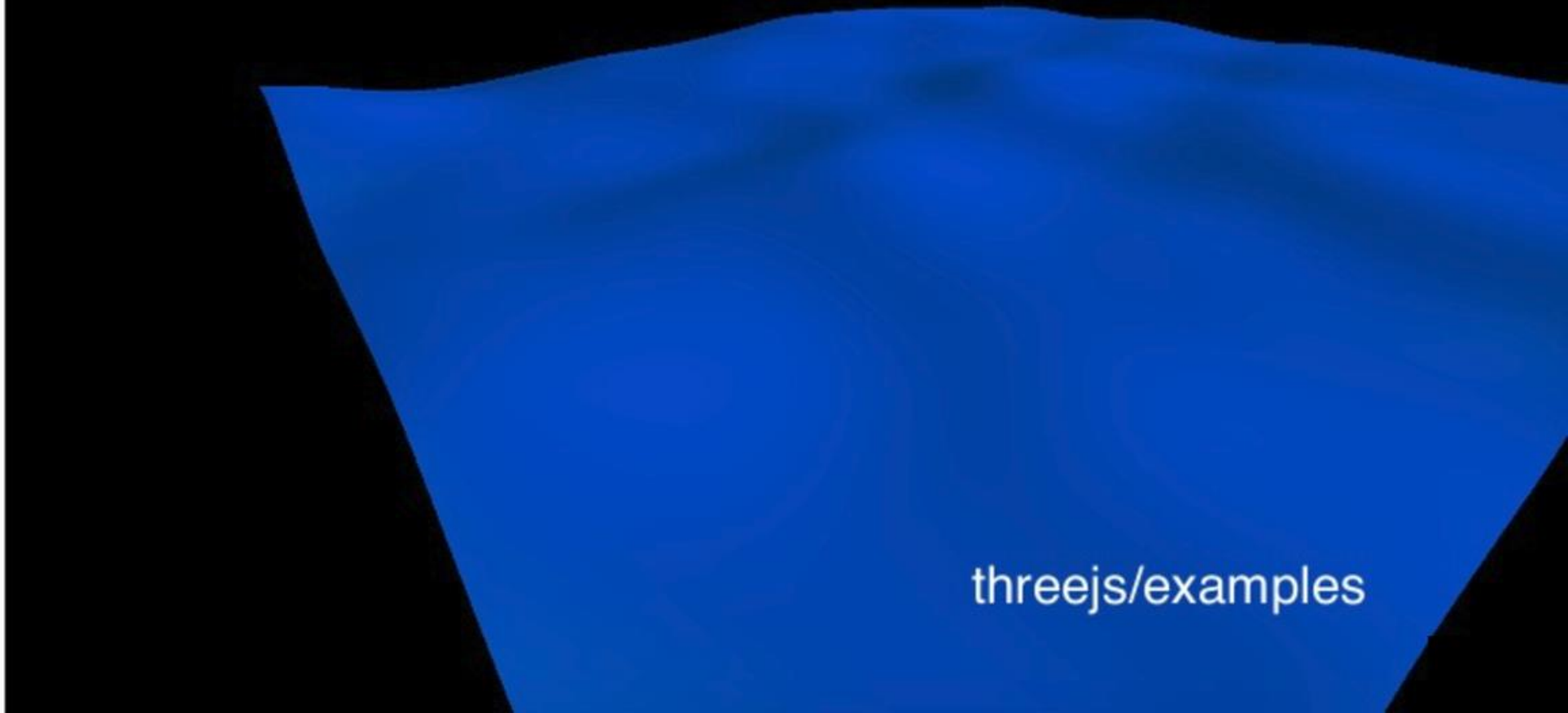
Babylon.js Community



depth / texture
effects / anaglyph
effects / parallaxbarrier
effects / peppersghost
effects / stereo
exporter / obj
geometries
geometries2
geometry / colors
geometry / colors / blender
geometry / colors / lookuptable
geometry / convex
geometry / cube
geometry / dynamic
geometry / extrude / shapes
geometry / extrude / shapes2
geometry / extrude / splines
geometry / hierarchy
geometry / hierarchy2
geometry / minecraft
geometry / minecraft / ao
geometry / normals
geometry / nurbs
geometry / shapes
geometry / spline / editor
geometry / teapot
geometry / terrain
geometry / terrain / fog
geometry / terrain / raycast
geometry / text
geometry / text / earcut
geometry / text / pnltri
gpgpu / birds
gpgpu / water
gpgpu / protoplanet
gpu / particle / system
hdr

Move mouse to disturb water.
Press mouse button to orbit around. 'W' key toggles wireframe.

Three.js Examples



threejs/examples

Loader →

CubeTextureLoader

Class for loading a CubeTexture. This uses the ImageLoader internally for loading files.

Example

materials / cubemap
materials / cubemap / balls / reflection
materials / cubemap / balls / refraction
materials / cubemap / dynamic
materials / cubemap / refraction

```
var scene = new THREE.Scene();
scene.background = new THREE.CubeTextureLoader()
    .setPath( 'textures/cubeMaps/' )
    .load( [
        'px.png',
        'nx.png',
        'py.png',
        'ny.png',
        'pz.png',
        'nz.png'
    ] );
```

Constructor

CubeTextureLoader(manager : LoadingManager)

manager — The loadingManager for the loader to use. Default is THREE.DefaultLoadingManager.

Creates a new CubeTextureLoader.

Great Documentation

Export files

- PLYLoader.js
- PVRLoader.js
- PlayCanvasLoader.js
- RGBELoader.js
- STLLoader.js
- SVGLoader.js
- TGALoader.js
- TTFLoader.js
- UTF8Loader.js
- VRMLLoader.js
- VTKLoader.js
- XLoader.js
- draco_decoder.js
- FBXLoader2.js
- GLTF2Loader.js
- GLTFLoader.js
- HDRCubeTextureLoader.js
- KMZLoader.js
- MD2Loader.js
- MMDLoader.js
- MTLLoader.js
- NRRDLoader.js
- OBJLoader.js
- PCDLoader.js
- PDBLoader.js
- PLYLoader.js
- PVRLoader.js
- PlayCanvasLoader.js
- RGBELoader.js
- STLLoader.js
- collada
- ctm
- deprecated
- sea3d
- 3MFLoader.js
- AMFLoader.js
- AWDLoader.js
- AssimpJSONLoader.js
- AssimpLoader.js
- BVHLoader.js
- BabylonLoader.js
- BinaryLoader.js
- ColladaLoader.js
- ColladaLoader2.js
- DDSLoader.js
- DRACOLoader.js
- FBXLoader.js

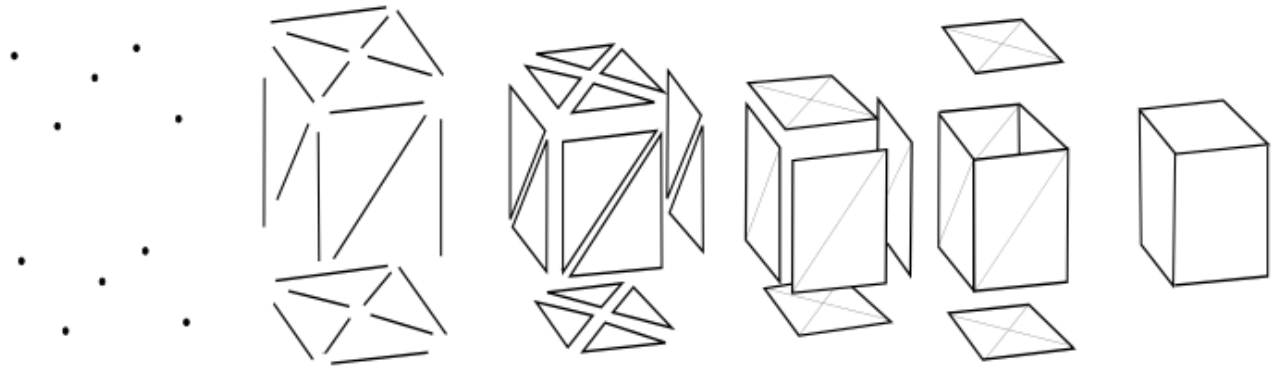
Most important file (and only essential file for three.js)

three.js

three.js

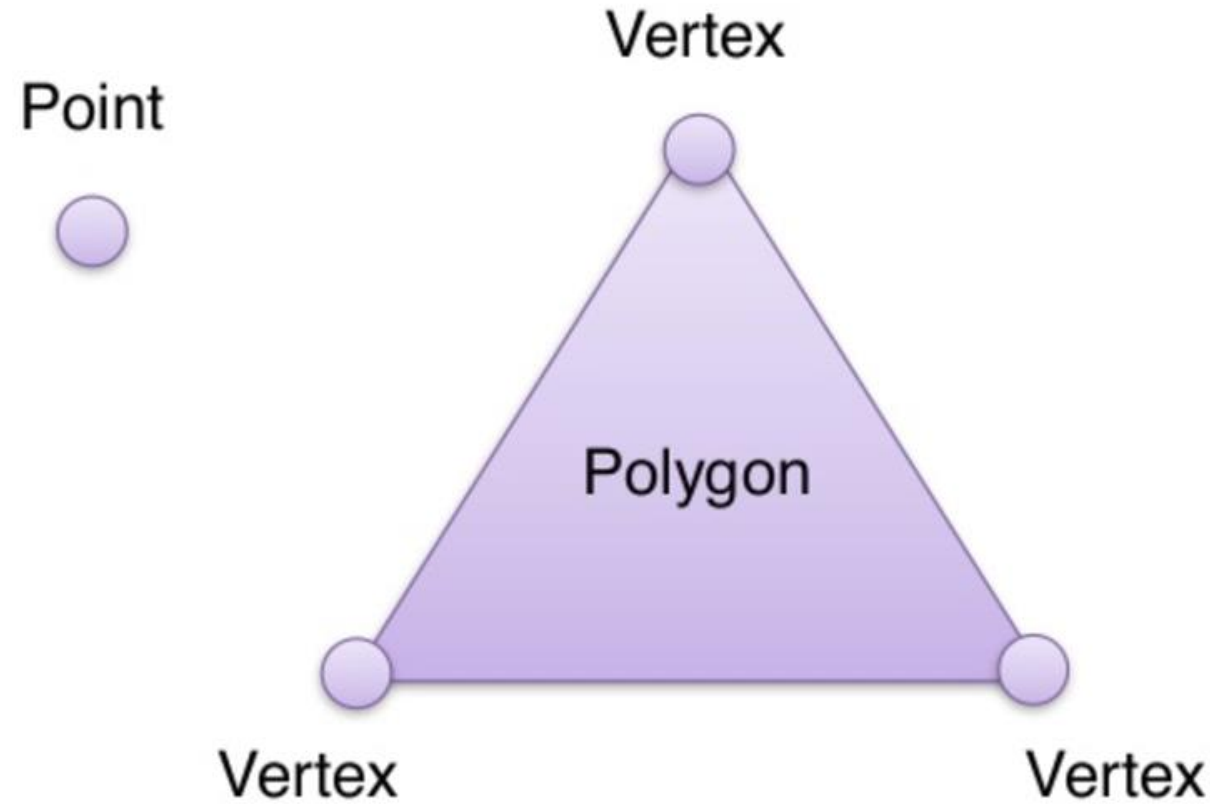
three.min.js is a minified version of three.js. It is totally identical code-wise but less human-readable

3D Basics



3D basics

- Point
- Polygon
- Object (mesh)
- Geometry
- Material
- Texture



Object Data

Example model.obj

Vertex list with coords (x,y,z)

```
v 13.825026512145996 -96.140419006347656 3.6714630126953125
v 15.503727912902832 -96.428817749023438 2.1252975463867187
v 14.864977836608887 -95.269874572753906 1.5220794677734375
v 12.35379695892334 -91.997489929199219 1.42974853515625
v 13.748141288757324 -93.280204772949219 1.0182418823242187
v 7.9108209609985352 -85.125518798828125 3.9087066650390625
v 11.508156776428223 -94.102958679199219 4.5504951477050781
v 13.997708320617676 -95.774742126464844 2.4739608764648437
v 13.337004661560059 -94.254402160644531 1.780059814453125
v 10.512875556945801 -90.527717590332031 2.5589218139648438
v 9.9423093795776367 -91.974296569824219 4.4449958801269531
v 12.121970176696777 -93.814460754394531 2.7707862854003906
v 8.8889608383178711 -89.88848876953125 4.7834281921386719
v 8.5577688217163086 -87.575393676757813 3.7520294189453125
v 65.255134582519531 50.347309112548828 32.405288696289063
v 66.766136169433594 50.430992126464844 33.477485656738281
v 63.850997924804687 51.162227630615234 31.309993743896484
v 61.49749755859375 53.767066955566406 30.037763595581055
v 62.612274169921875 55.586418151855469 32.590259552001953
v 63.765449523925781 56.516639709472656 34.983329772949219
v 86.712333679199219 -29.699516296386719 67.651824951171875
v 86.298973083496094 -27.467063903808594 67.311981201171875
v 87.931144714355469 -26.754478454589844 69.544113159179688
v 87.254051208496094 -28.534954071044922 69.252769470214844
v 54.208457946777344 52.926681518554688 17.700454711914063
v 55.330917358398438 51.7030029296875 17.893693923950195
```

Texture coordinates (u,v)

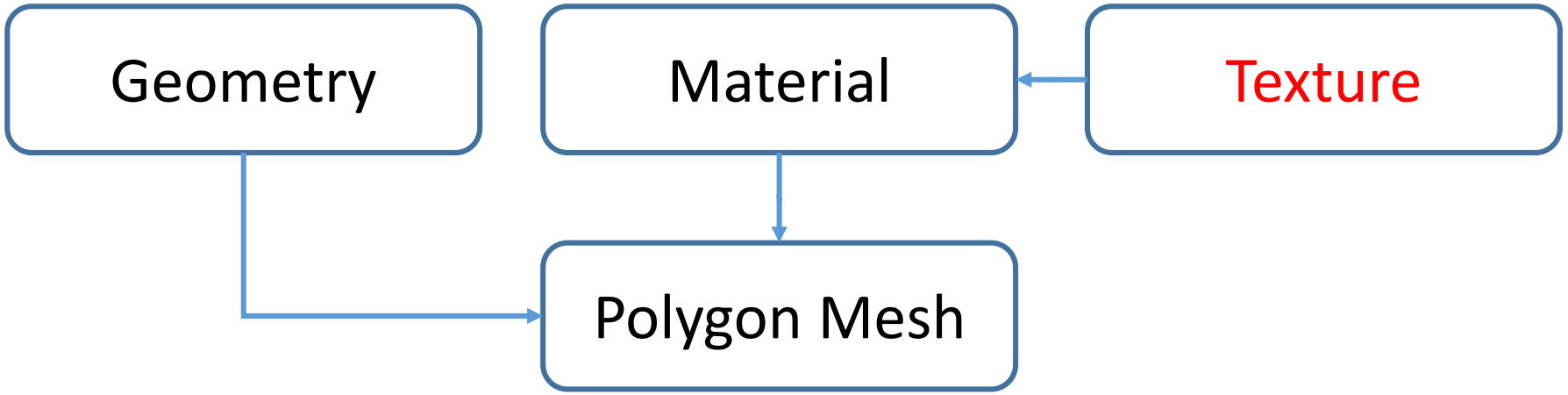
```
vt 0.056318659335374832 0.626133084297180 18
vt 0.061030514538288116 0.6244666576385498
vt 0.059739273041486 74 0.62342357635498047
vt 0.060924597084522247 0.623282074928283 69
vt 0.058572947978973389 0.623525619506835 94
vt 0.056074466556310654 0.622569322586059 57
vt 0.044292308390140533 0.488384068012237 55
vt 0.044125389307737 35 0.48736923933029175
vt 0.043935131281614304 0.486187517642974 85
```

Faces (v/vt)

```
f 70220/29439 91099/29452 70267/29440
f 91099/29452 71051/29454 71061/29455
f 70265/29449 70272/29442 70288/29456
f 70262/29434 70272/29442 70265/29449
f 91099/29452 71061/29455 70299/29453
f 70265/29449 70288/29456 98620/29450
f 70267/29440 70299/29453 70363/29448
```

Object

More than just ‘Triangles’



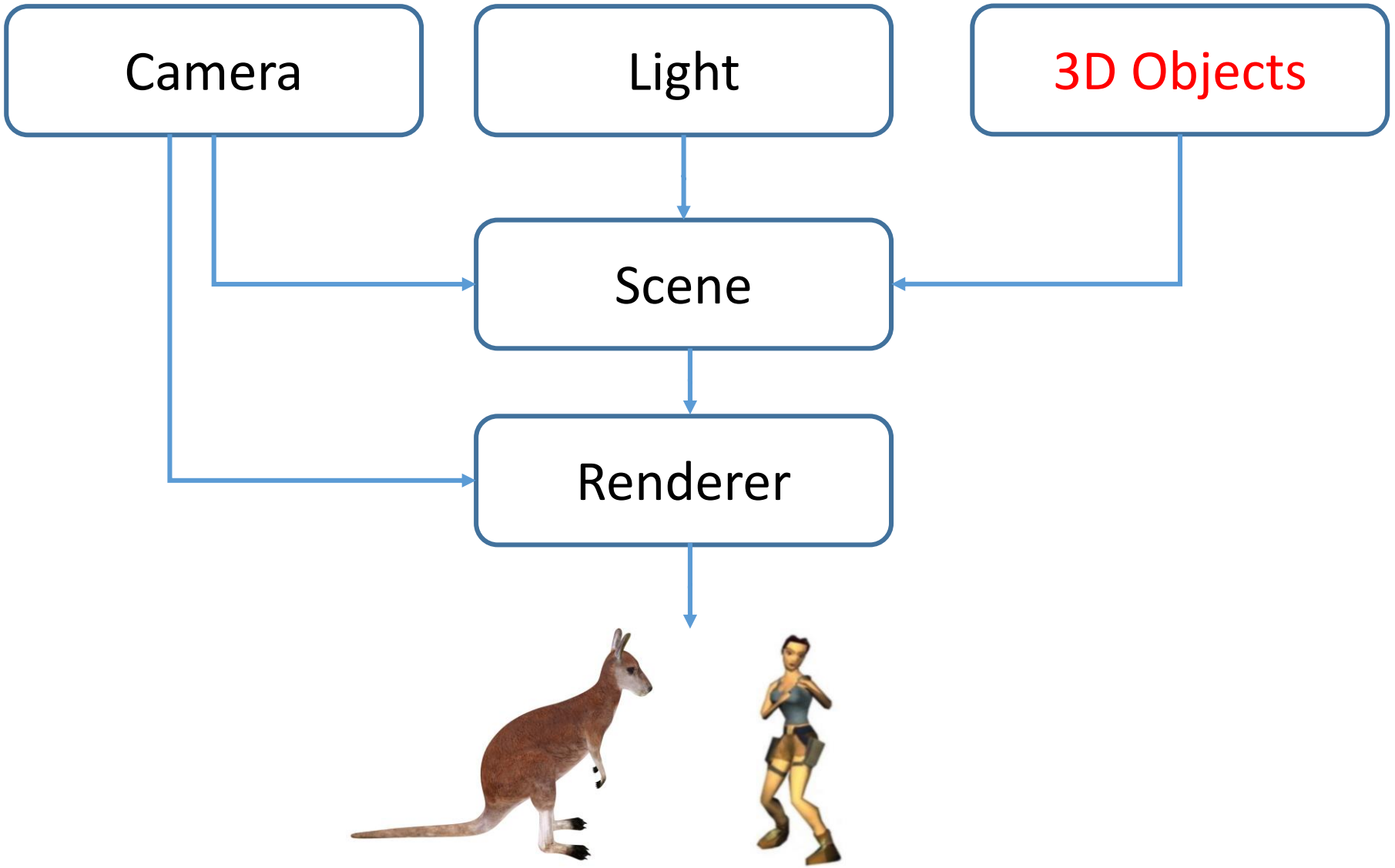
Textures

texture.jpg

3D Terms

- Scene
- Light
- Camera
- Renderer

How everything connects



Example

(step by step)

Practical aspect
Simple (but not too simple example)
JavaScript/Browser

Example will need these files

Most important

three.min.js

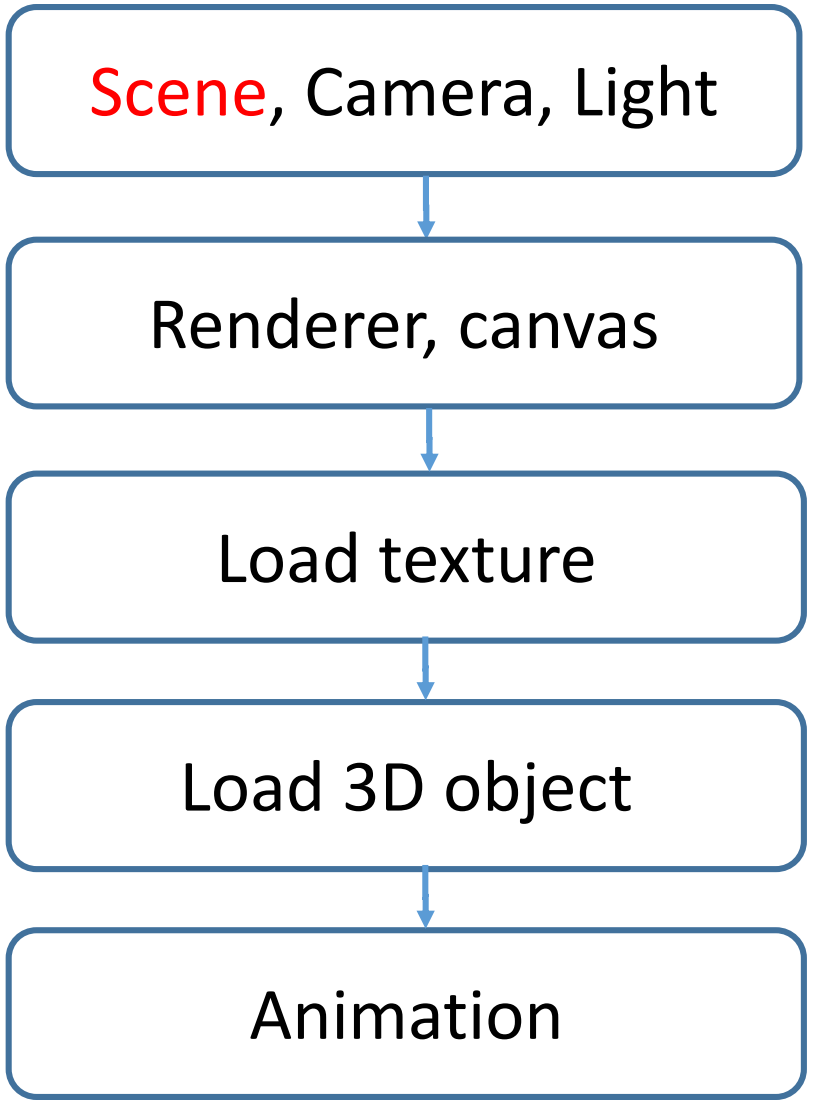
OBJLoader.js

TrackballControls.js

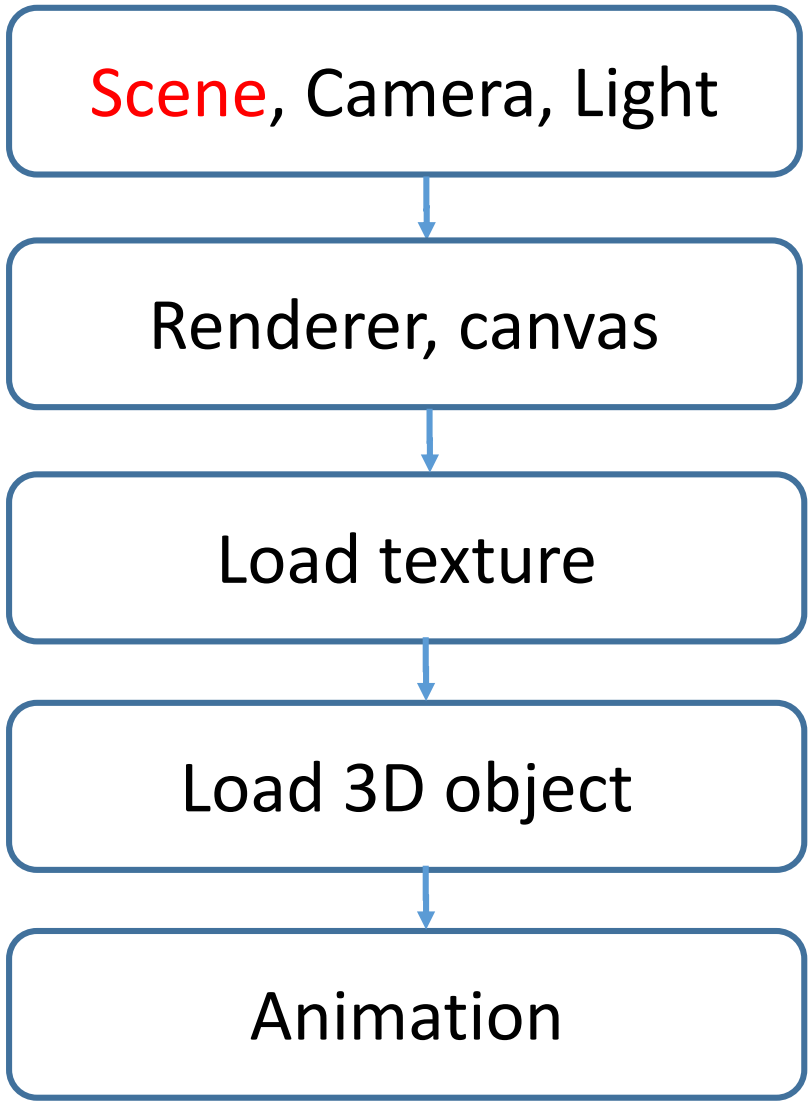
Helpers

Example

How many lines of code?



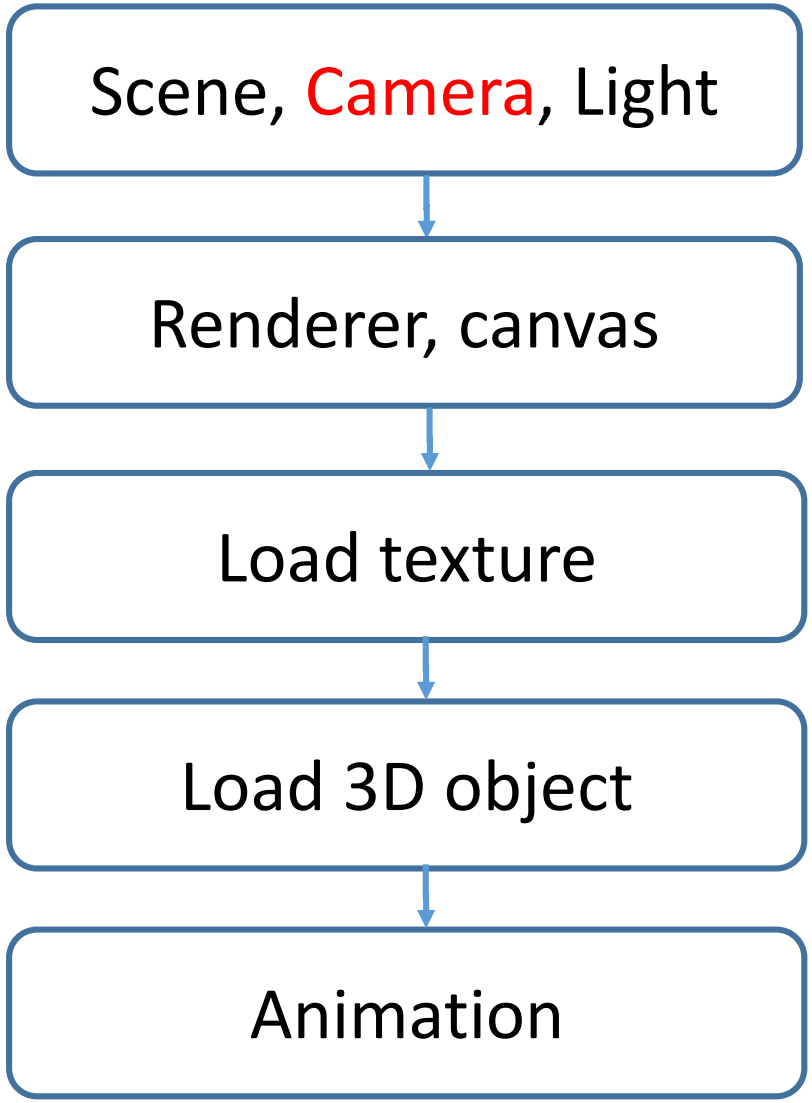
Example



100 Lines of Code
(with comments & spacing)

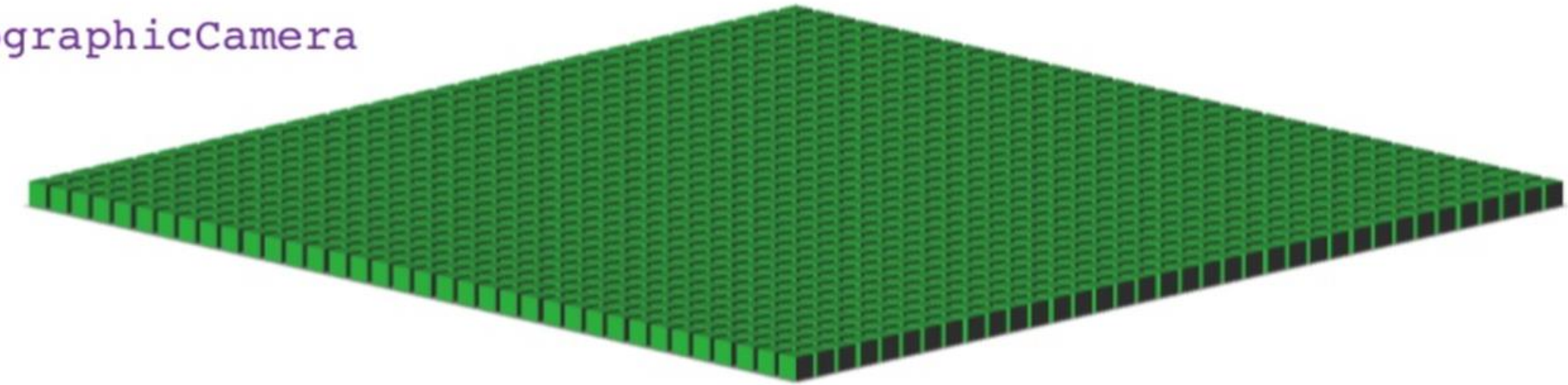
Scene

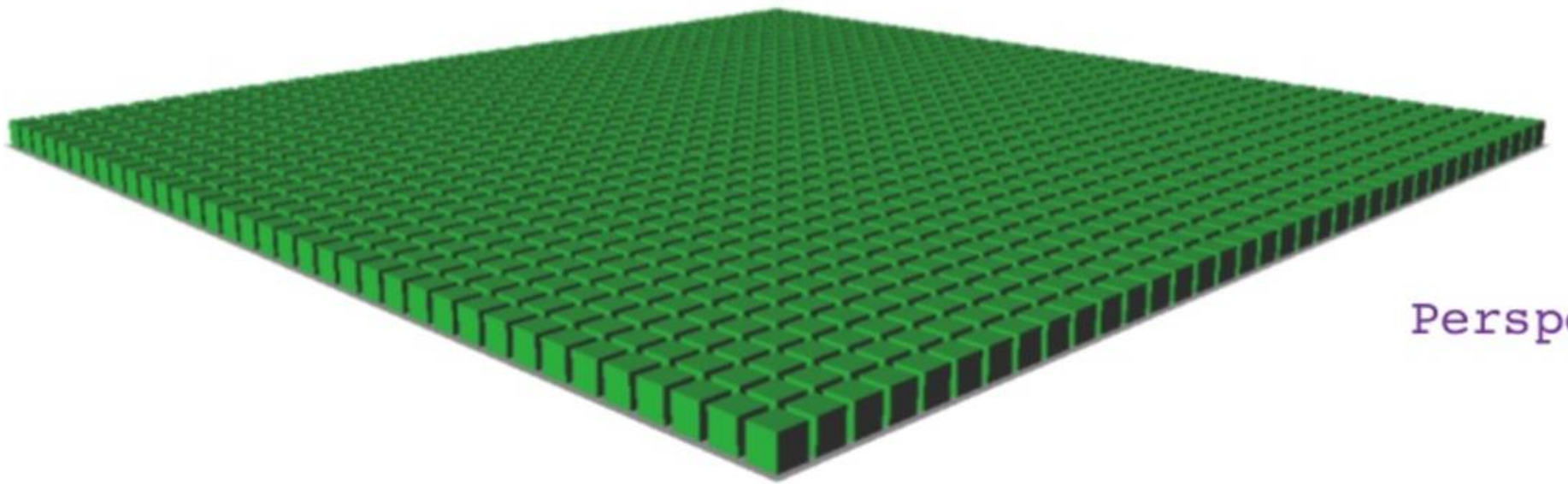
```
Player.container = document.getElementById("webgl-player");


Player.size = {
      width: Player.container.offsetWidth,
      height: Player.container.offsetHeight
};

Player.scene = new THREE.Scene();
```


Scene, Camera, Light
Renderer, canvas
Load texture
Load 3D object
Animation

Camera types

`OrthographicCamera`



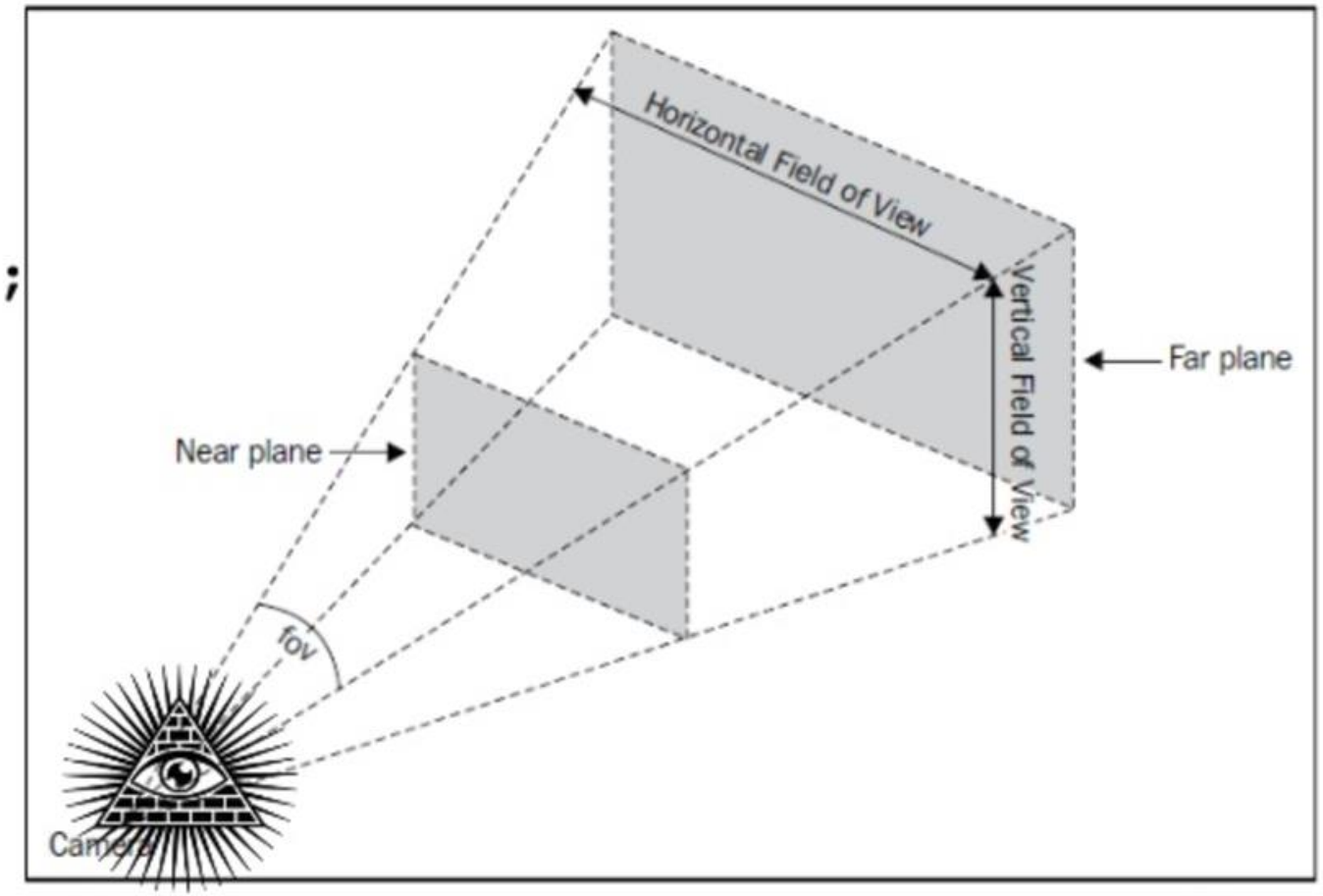


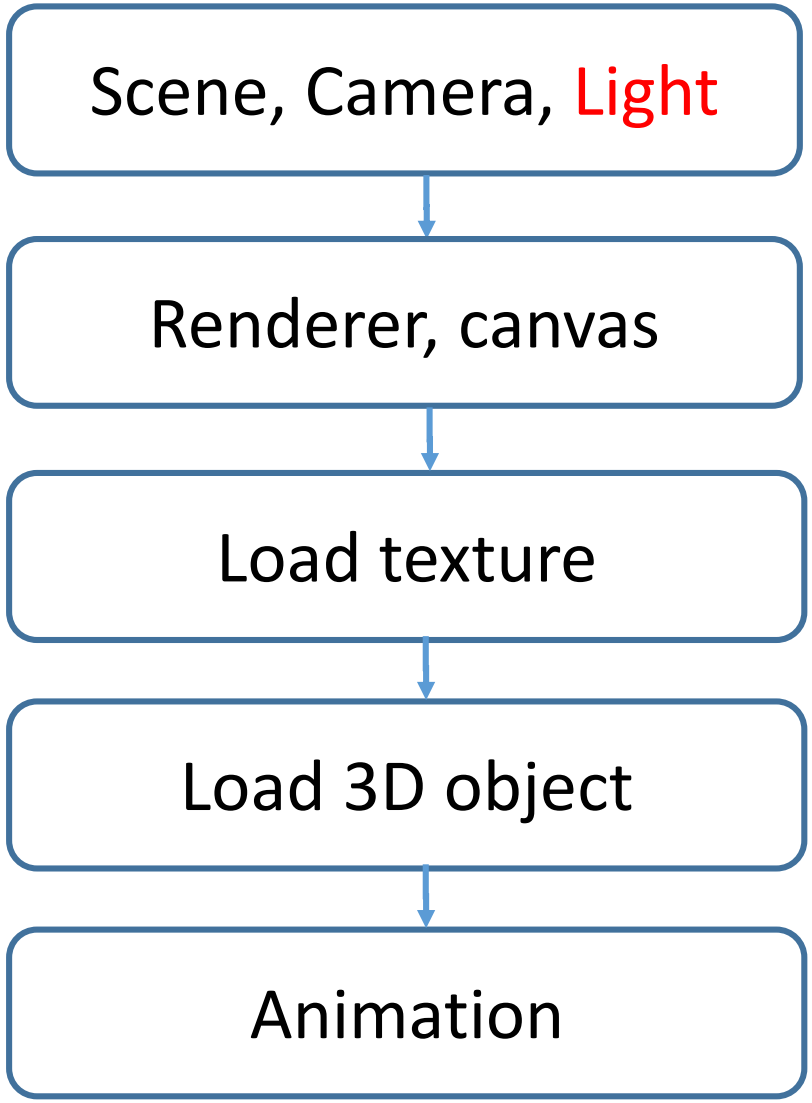
`PerspectiveCamera`

Camera

```
// PerspectiveCamera( fov, aspect, near, far )
aspect = Player.size.width / Player.size.height;
Player.camera = new THREE.PerspectiveCamera(45.0, aspect, 2, 8000);
```

```
Player.camera.position.z = 300;
Player.scene.add(Player.camera);
```

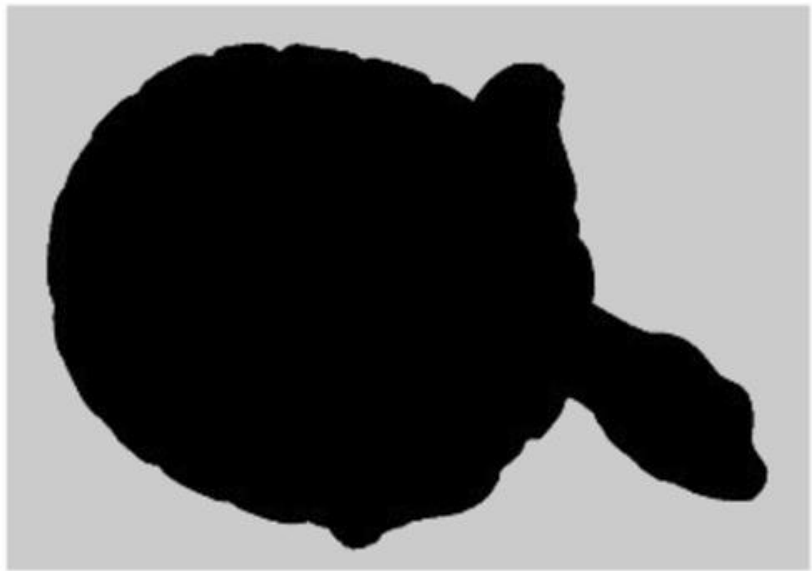



Scene, Camera, Light
Renderer, canvas
Load texture
Load 3D object
Animation

Light

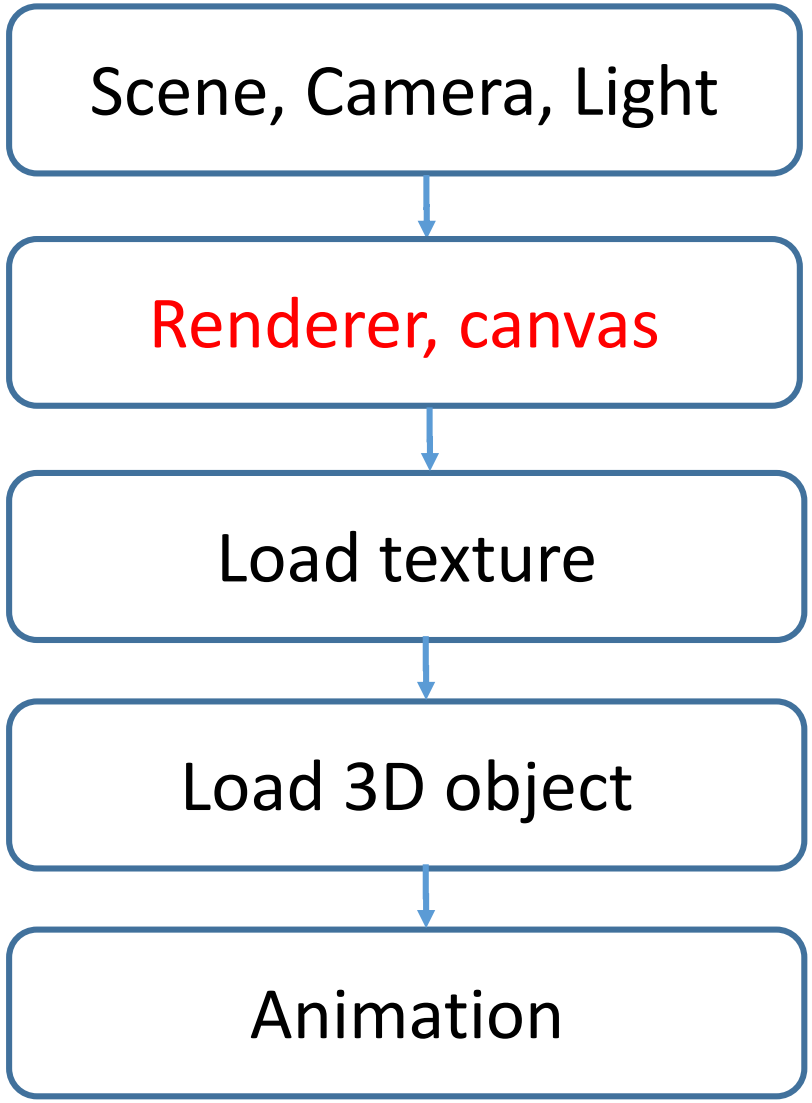
```
Player.light = new THREE.AmbientLight();
Player.scene.add(Player.light);
```

Light



```
// Player.scene.add(Player.light)
```

```
Player.scene.add(Player.light)
```


Scene, Camera, Light
Renderer, canvas
Load texture
Load 3D object
Animation

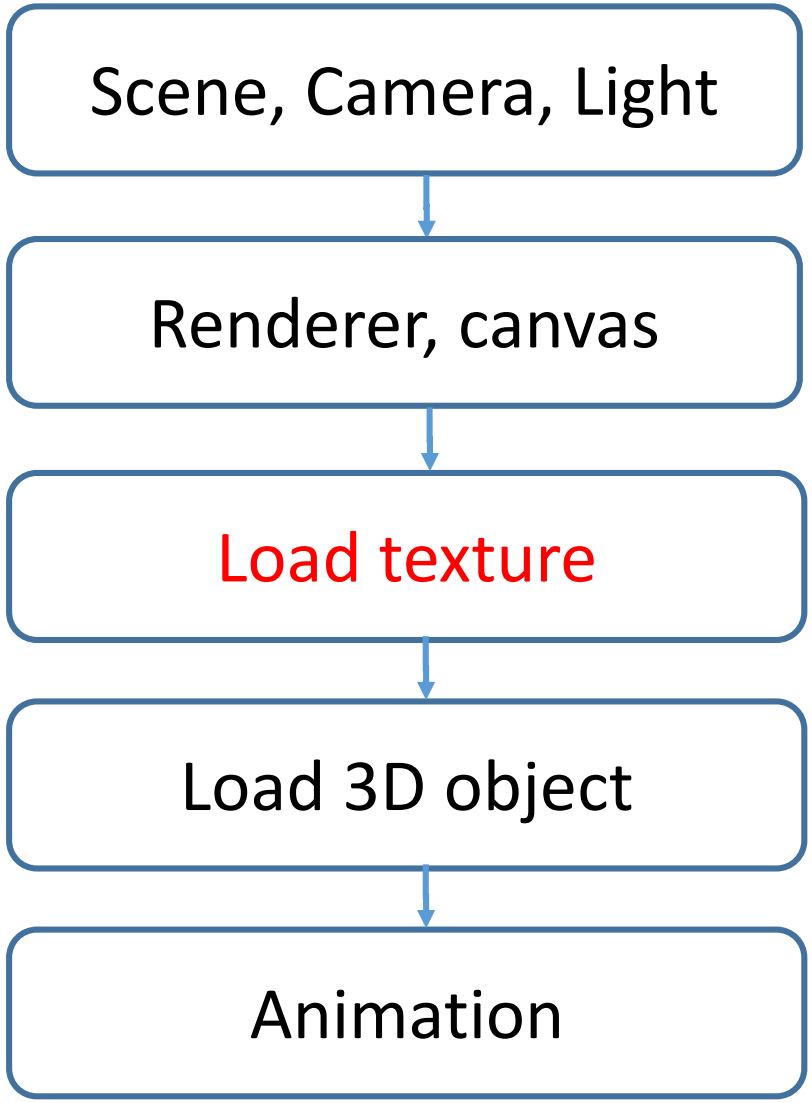
Renderer

```
Player.renderer = new THREE.WebGLRenderer({alpha: true});
Player.renderer.setSize(Player.size.width, Player.size.height);


// canvas
Player.container.appendChild(Player.renderer.domElement);
```

Renderer

```
THREE.WebGLRenderer()
```

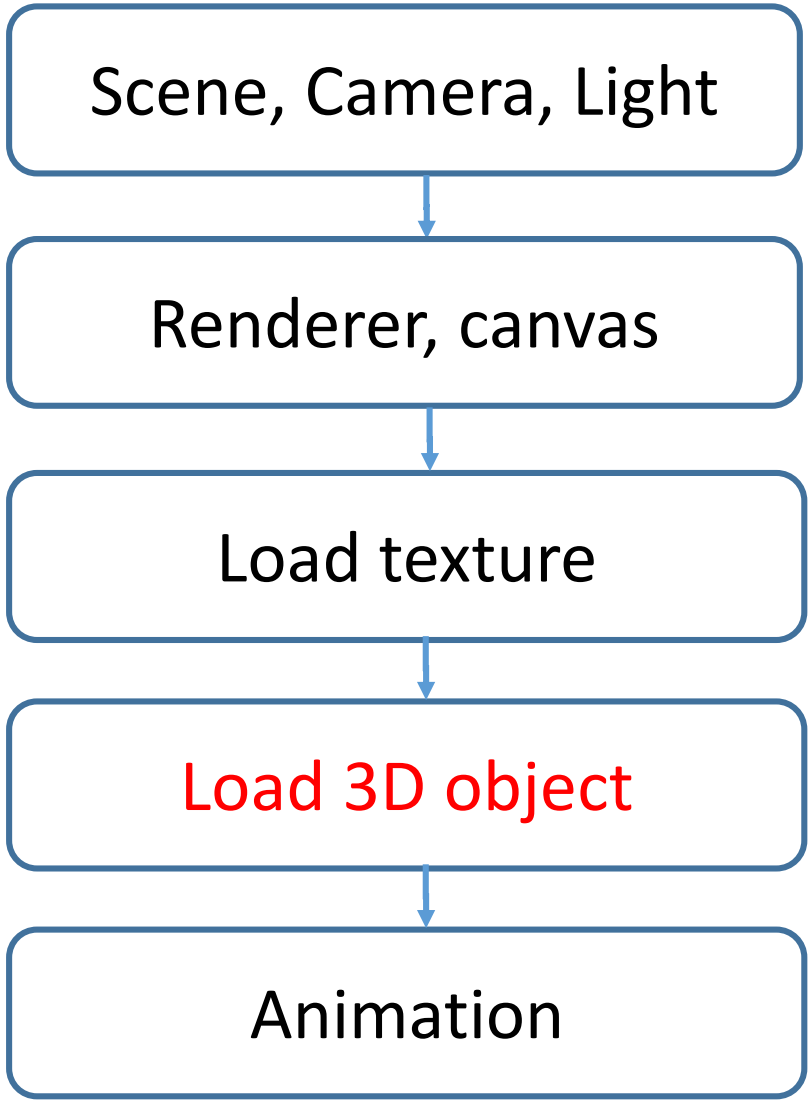
```
THREE.WebGLRenderer({alpha: true})
```


Scene, Camera, Light
Renderer, canvas
Load texture
Load 3D object
Animation

Load texture

```
Player.textureLoader = new THREE.TextureLoader();
```

```
Player.textureLoader.load("texture.jpg", function(texture)
{
	Player.texture = texture;
	Player.loadModel();
});
```


Scene, Camera, Light
Renderer, canvas
Load texture
Load 3D object
Animation

Loading model

```
loadModel: function() {

    objectLoader = new THREE.OBJLoader();

    objectLoader.load("object.obj", function(object) {
        object.traverse(function(child) {
            if (child instanceof THREE.Mesh) {
              child.material.map = Player.texture;
            }
        });
        Player.scene.add(object);
    });
}
```

You may also want to consider JSONLoader

How to run things locally (browser/debugging)

File access blocked by CORS policy

One solution (Python)

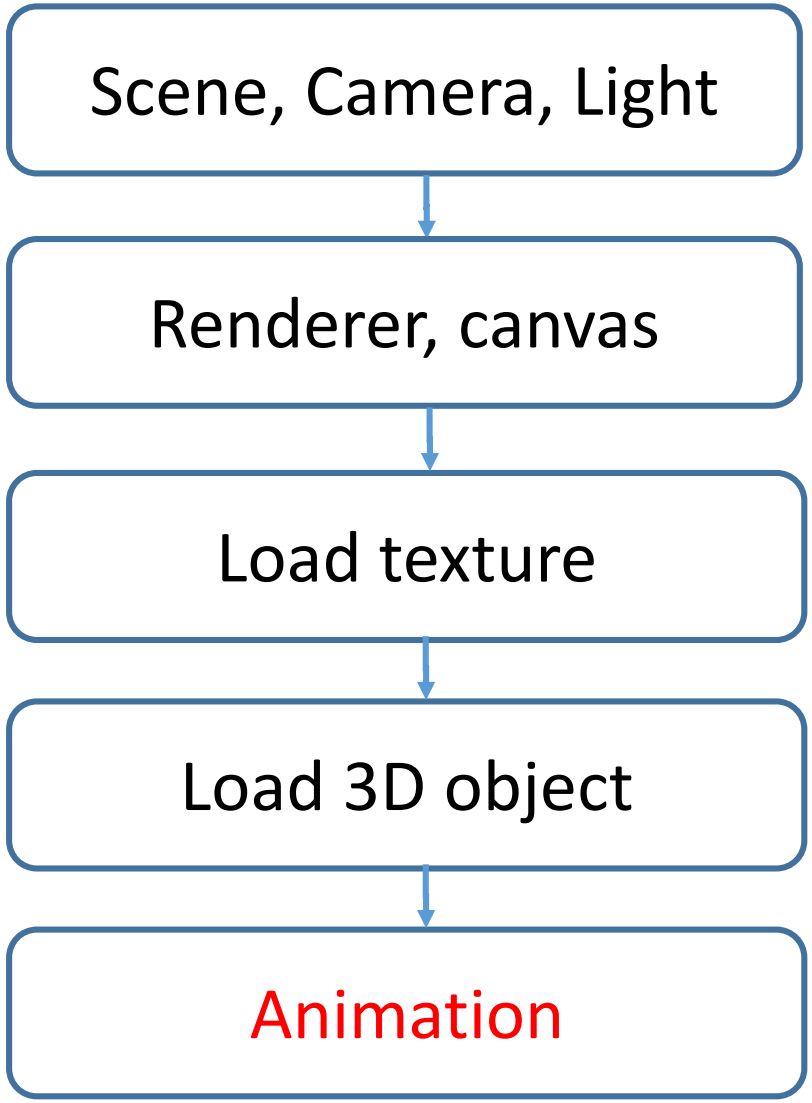
/*

// Workaround for local testing/file loading in browser

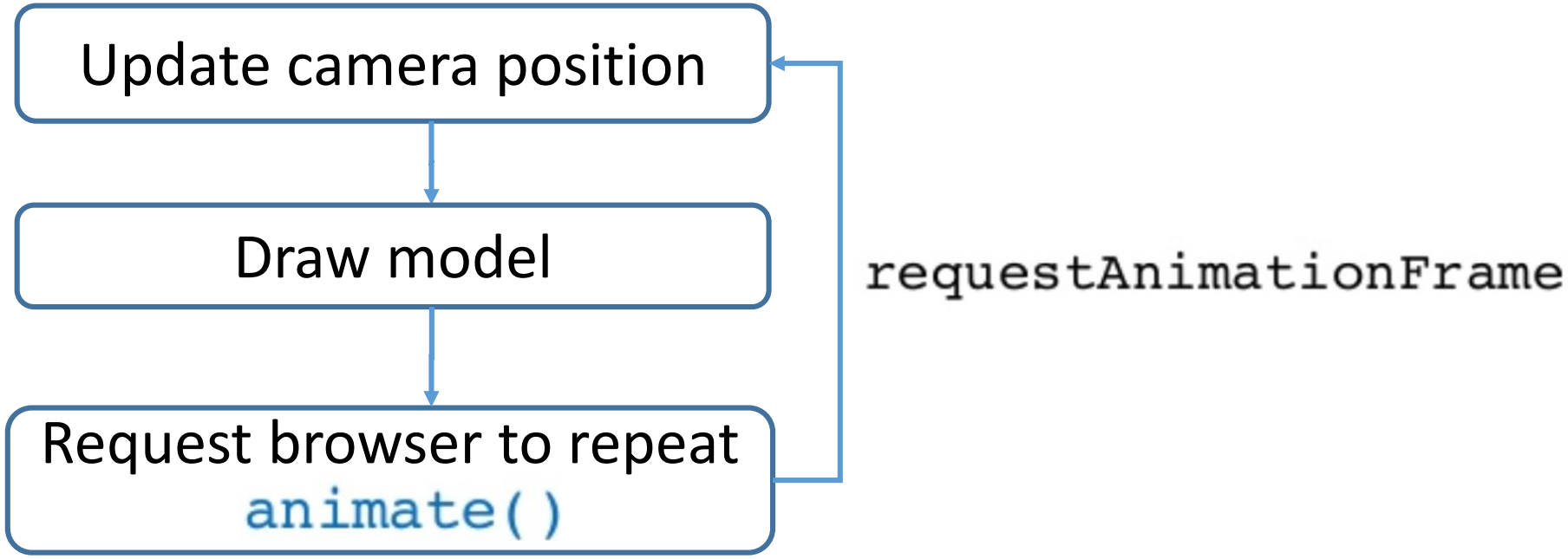
/> python -m http.server 8000 --bind 127.0.0.1

Run this command from inside the directory, see the results by accessing http://localhost:8000/

*/


Scene, Camera, Light
Renderer, canvas
Load texture
Load 3D object
Animation

Animation loop




```
animate: function() {
    requestAnimationFrame(Player.animate);
    Player.controls.update();
    Player.renderer.render(Player.scene, Player.camera);
}
```

Controls

```
Player.controls = new THREE.TrackballControls(Player.camera,
                                              Player.container);

Player.animate();
```

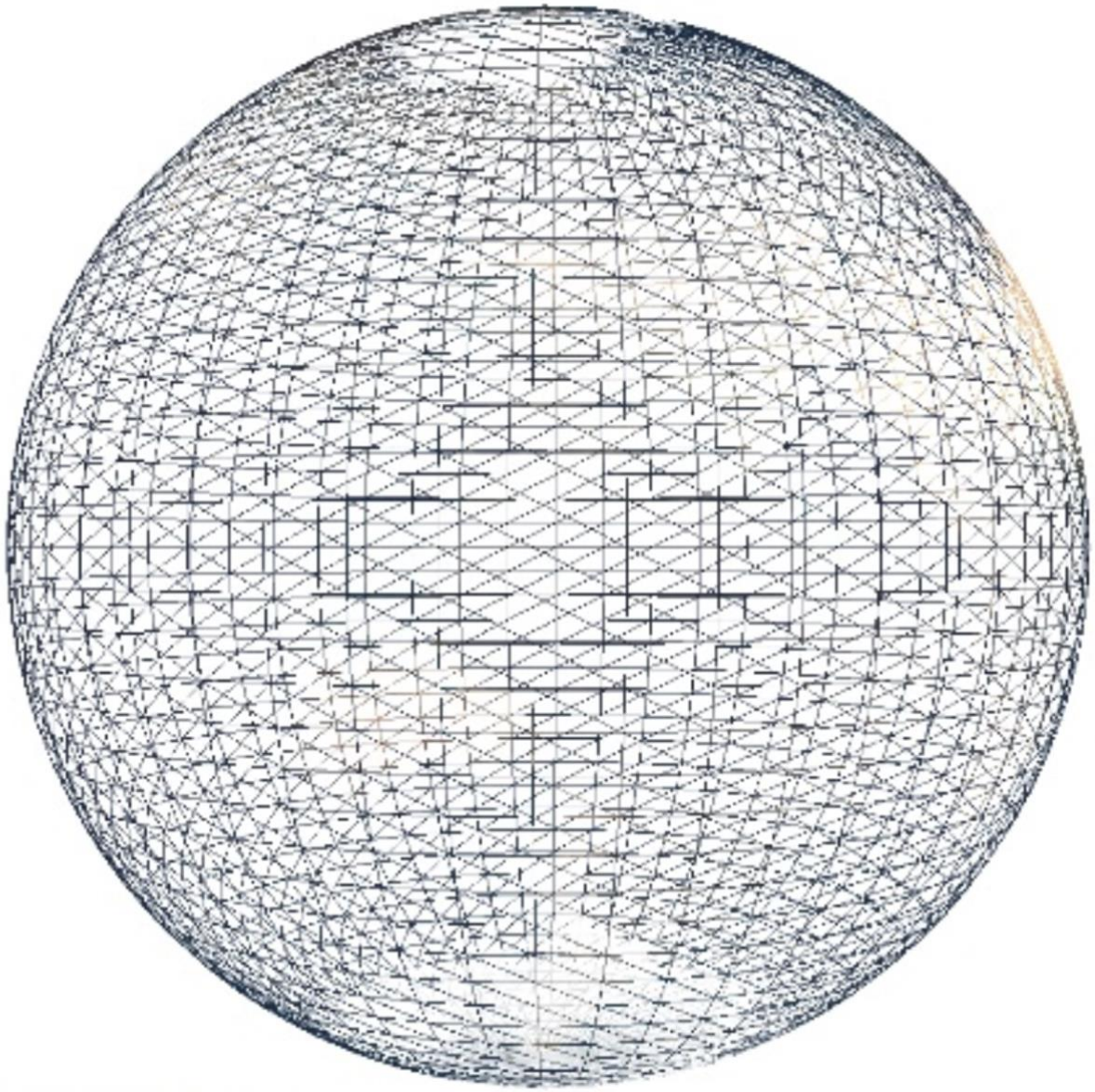
```
animate: function() {
    requestAnimationFrame(Player.animate);
    Player.controls.update();
    Player.renderer.render(Player.scene, Player.camera);
}
```

You may also want to consider OrbitControls

How to Cancel (Stop) Animation?

```
requestId = requestAnimationFrame(animate)

cancelAnimationFrame(requestId)
```

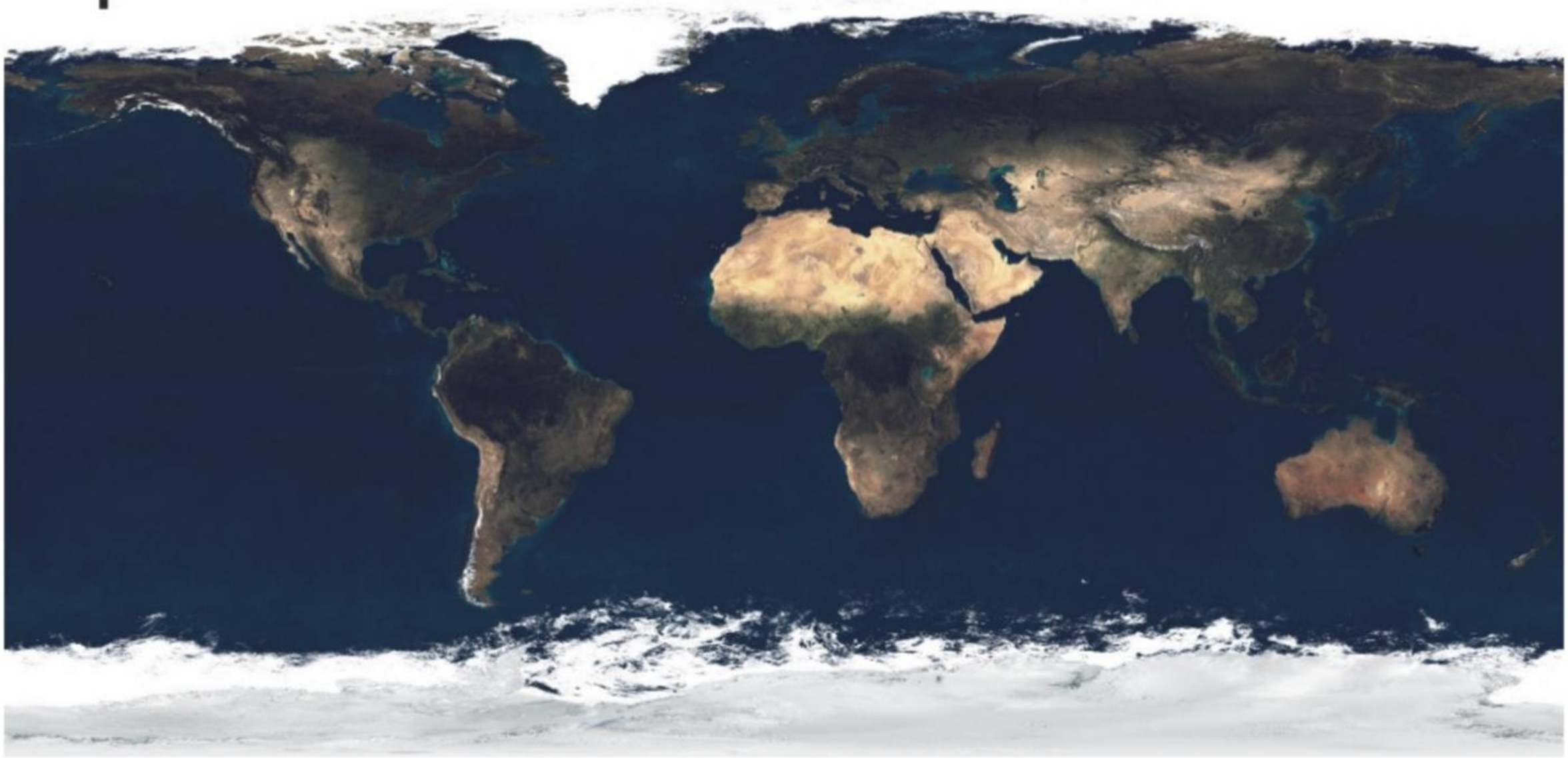
What about Build in Geometry (Shapes)?



Example (Sphere)

```
geometry = new THREE.SphereGeometry(100, 50, 50);

material = new THREE.MeshPhongMaterial({map: texture});

Player.mesh = new THREE.Mesh(geometry, material);

Player.scene.add(Player.mesh);
```

Sphere texture



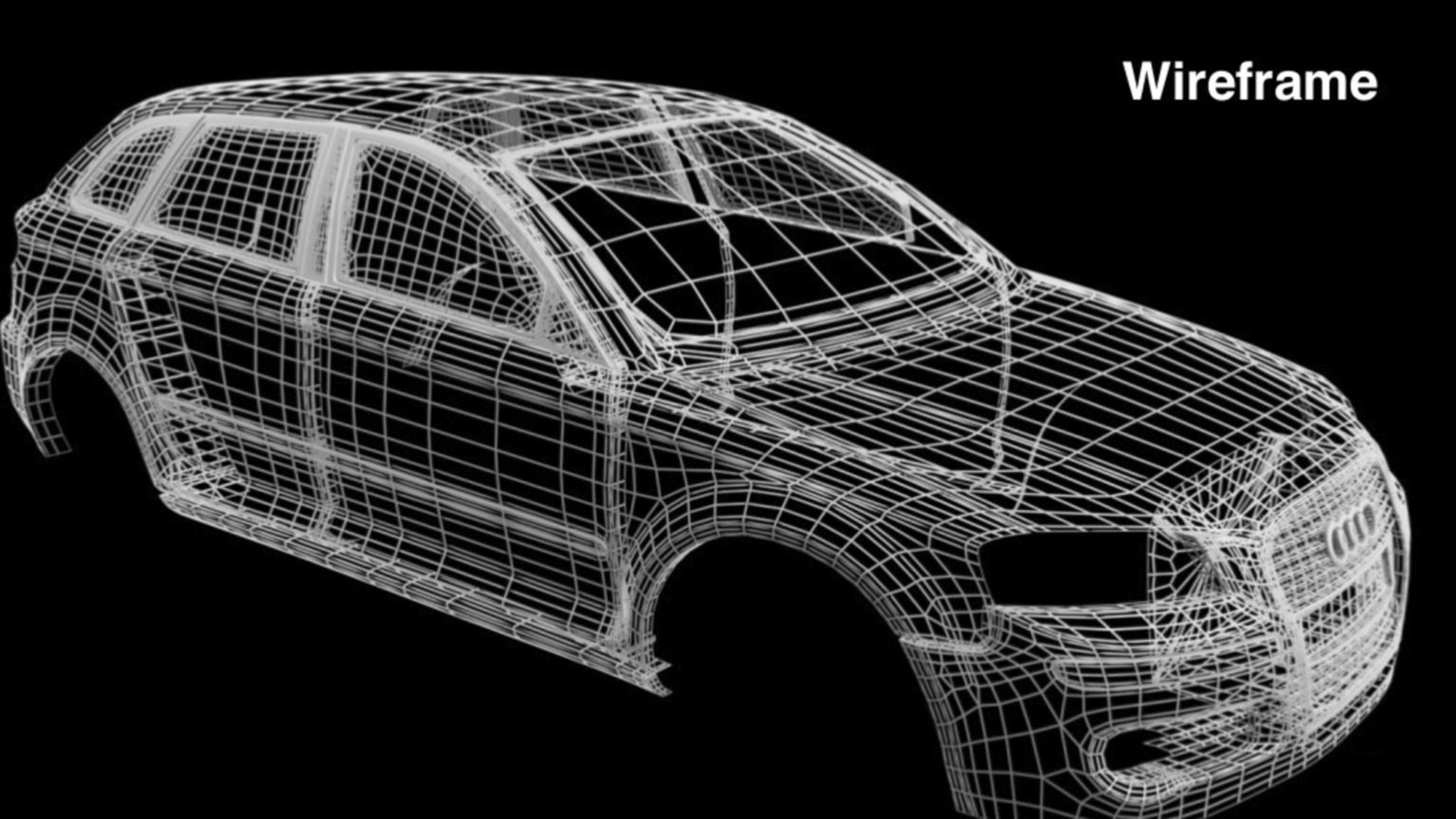
Materials

Materials

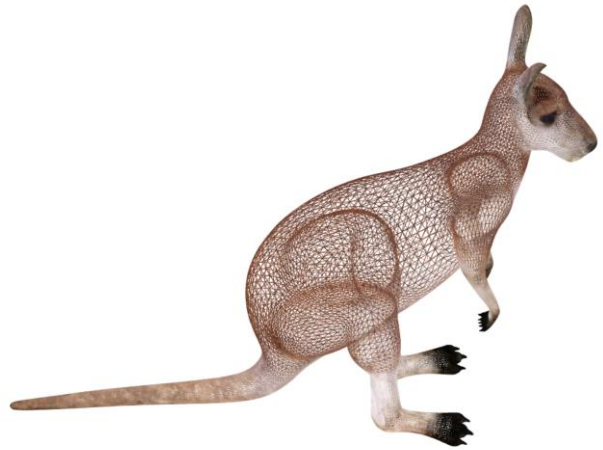
Materials

```
new THREE.MeshPhongMaterial({
    color: option,
    map: texture,
    side: THREE.DoubleSide,
});
```

```
object.material = new THREE.ShaderMaterial( {
    uniforms: {
        u_Sampler: {type: "t", value: texture}
    },
    vertexShader: vShader,
    fragmentShader: fShader,
} );
```


Wireframe

Wireframe Code



```
const material = new THREE.MeshPhongMaterial({
    map: texture,
    wireframe: true
});
```

Environment Map

```
const urls = [
    require('./../../resources/textures/skybox/glass/posx.jpg'),
    require('./../../resources/textures/skybox/glass/negx.jpg'),
    require('./../../resources/textures/skybox/glass/posy.jpg'),
    require('./../../resources/textures/skybox/glass/negy.jpg'),
    require('./../../resources/textures/skybox/glass/posz.jpg'),
    require('./../../resources/textures/skybox/glass/negz.jpg'),
];
```

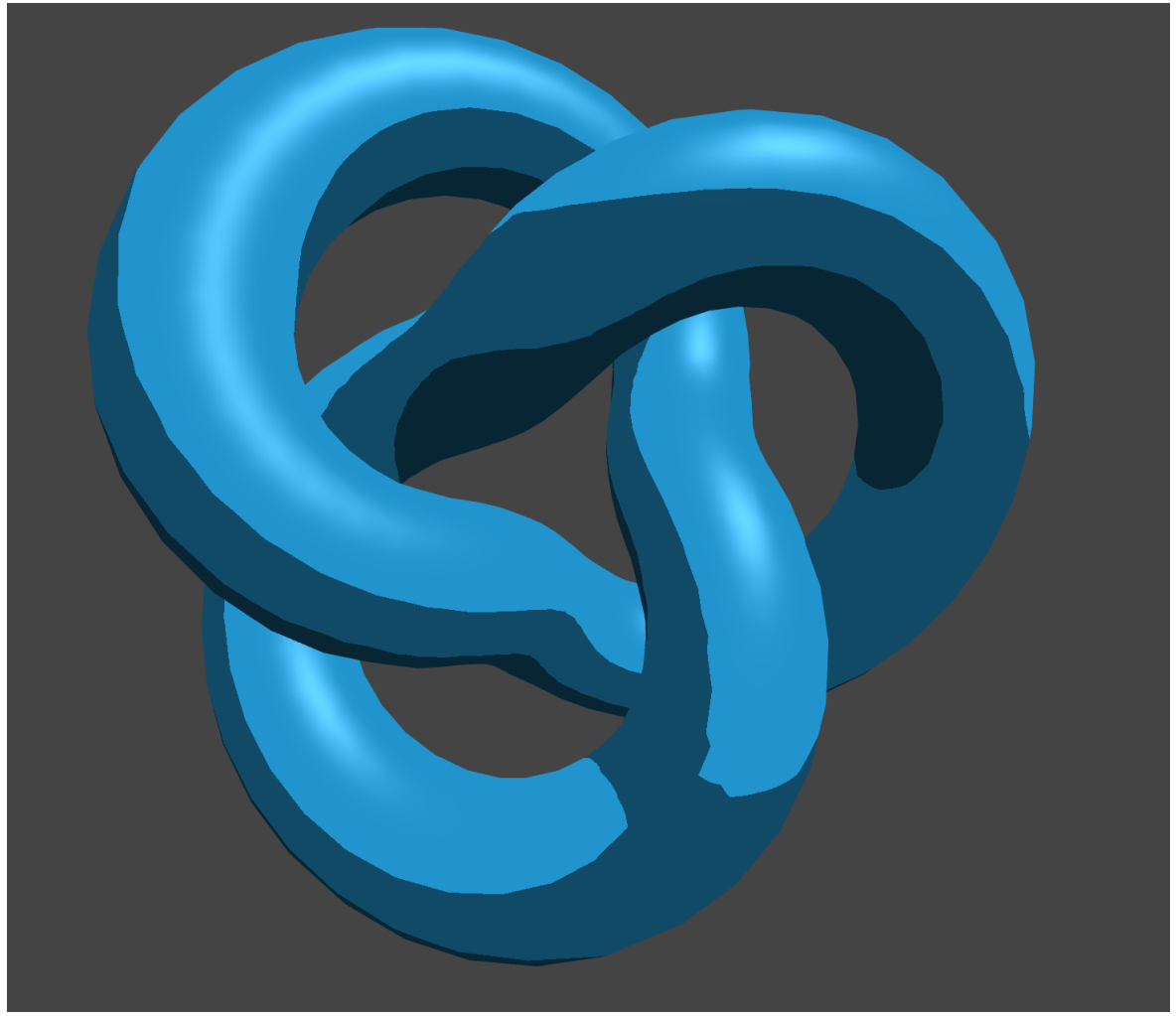
Environment Map (Cube) Skybox

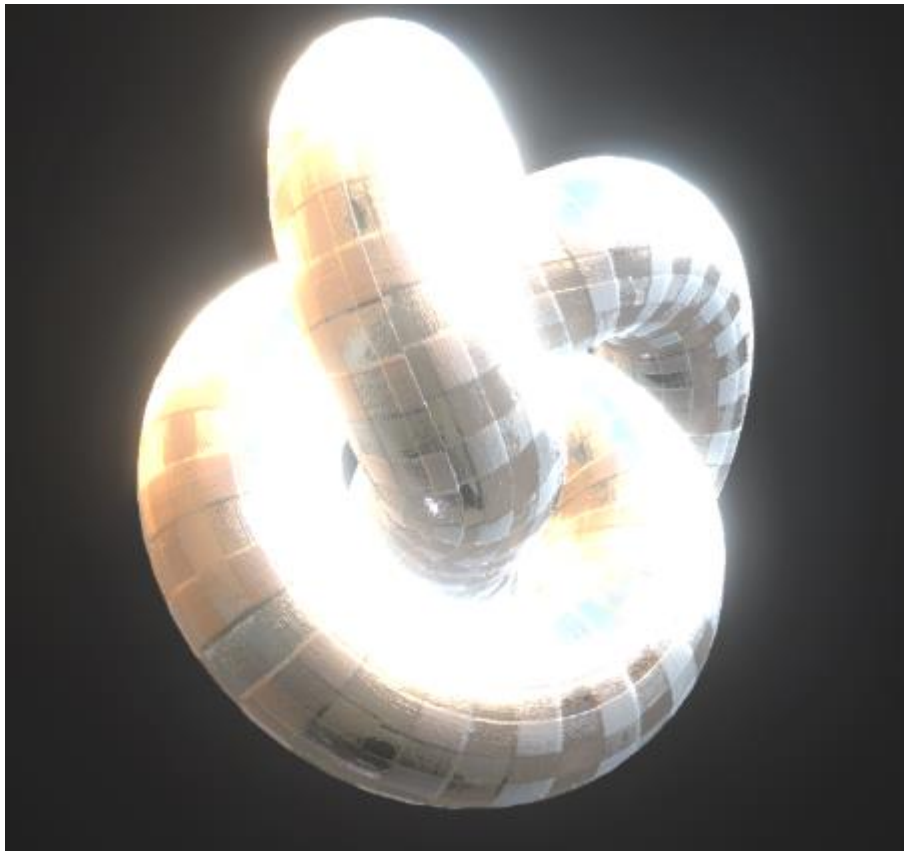
```
let materials = [];

for (let i = 0, length = urls.length; i < length; i++) {
    materials.push(new THREE.MeshBasicMaterial({
        map: new THREE.TextureLoader().load(urls[i]),
        side: THREE.BackSide
    }));
}

const skybox = new THREE.Mesh(
    new THREE.CubeGeometry(7000, 7000, 7000),
    new THREE.MultiMaterial(materials)
);
```

Environment Map (Cube) Model

```
const urls = [
    require('./../../resources/textures/skybox/glass/posx.jpg'),
    require('./../../resources/textures/skybox/glass/negx.jpg'),
    require('./../../resources/textures/skybox/glass/posy.jpg'),
    require('./../../resources/textures/skybox/glass/negy.jpg'),
    require('./../../resources/textures/skybox/glass/posz.jpg'),
    require('./../../resources/textures/skybox/glass/negz.jpg'),
];

const textureCube = new THREE.CubeTextureLoader().load(urls);
textureCube.mapping = THREE.CubeRefractionMapping;
textureCube.format = THREE.RGBFormat;

return new THREE.MeshPhongMaterial({
    color: option === 'white' ? '#e6ffcc' : option,
    shininess: 35,
    emissive: 0x000000,
    specular: 0x333333,
    envMap: textureCube,
    reflectivity: 0.95,
    refractionRatio: 0.95,
    side: THREE.DoubleSide,
    polygonOffset: true,
    polygonOffsetFactor: 1,
    polygonOffsetUnits: 1,
    transparent: true,
    opacity: 1
});
```

Post-Processing



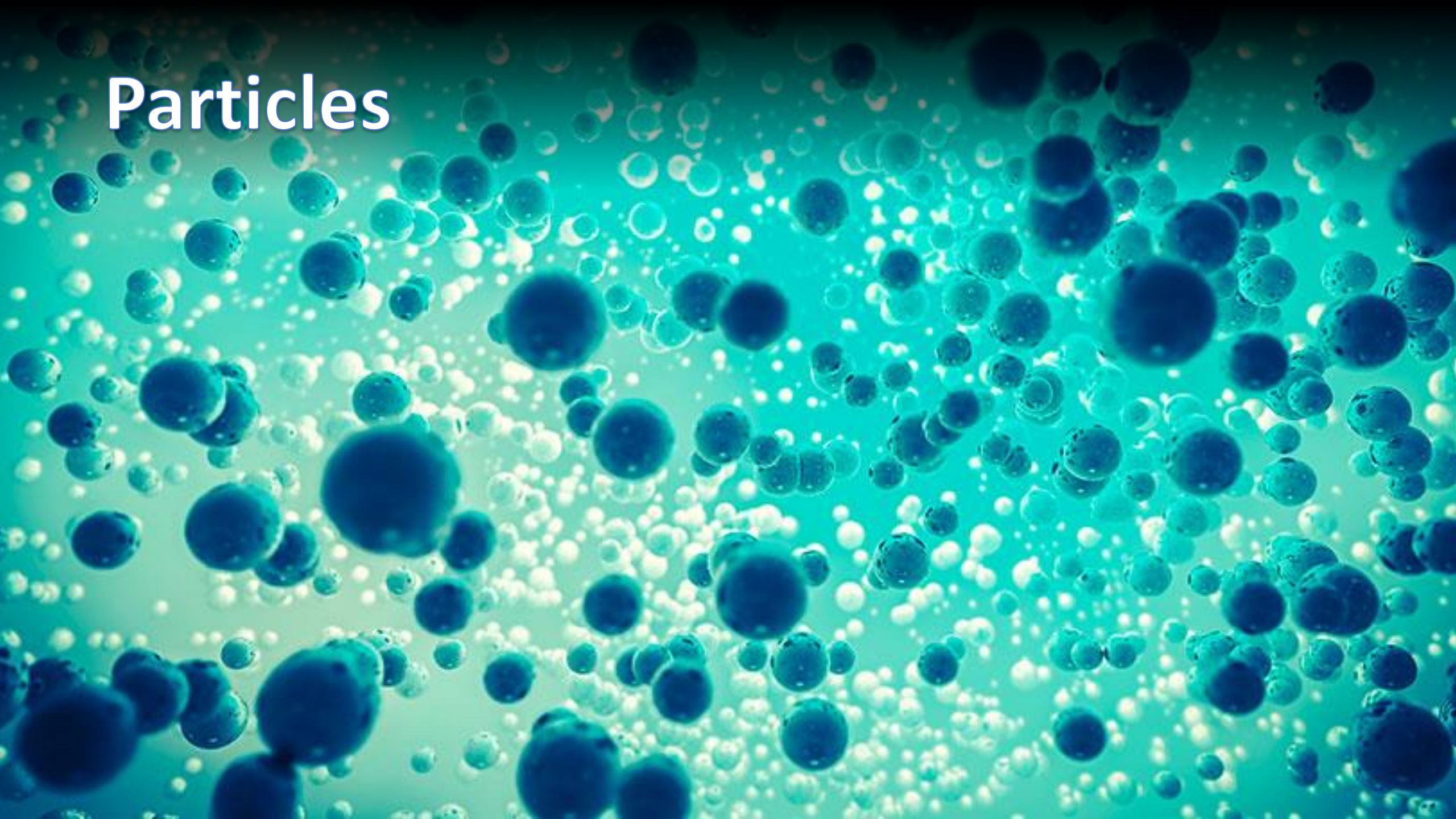


Post-Processing

```
composer = new THREE.EffectComposer(renderer);
composer.addPass( new THREE.RenderPass(scene, camera) );
Toon = { uniforms: uniforms,
         vertexShader: vertexShader,
         fragmentShader: fragmentShader,
       };
effect = new THREE.ShaderPass(Toon);
effect.renderToScreen = true;
composer.addPass(effect);
```

https://threejs.org/docs/scenes/material-browser.html#MeshToonMaterial

Particles



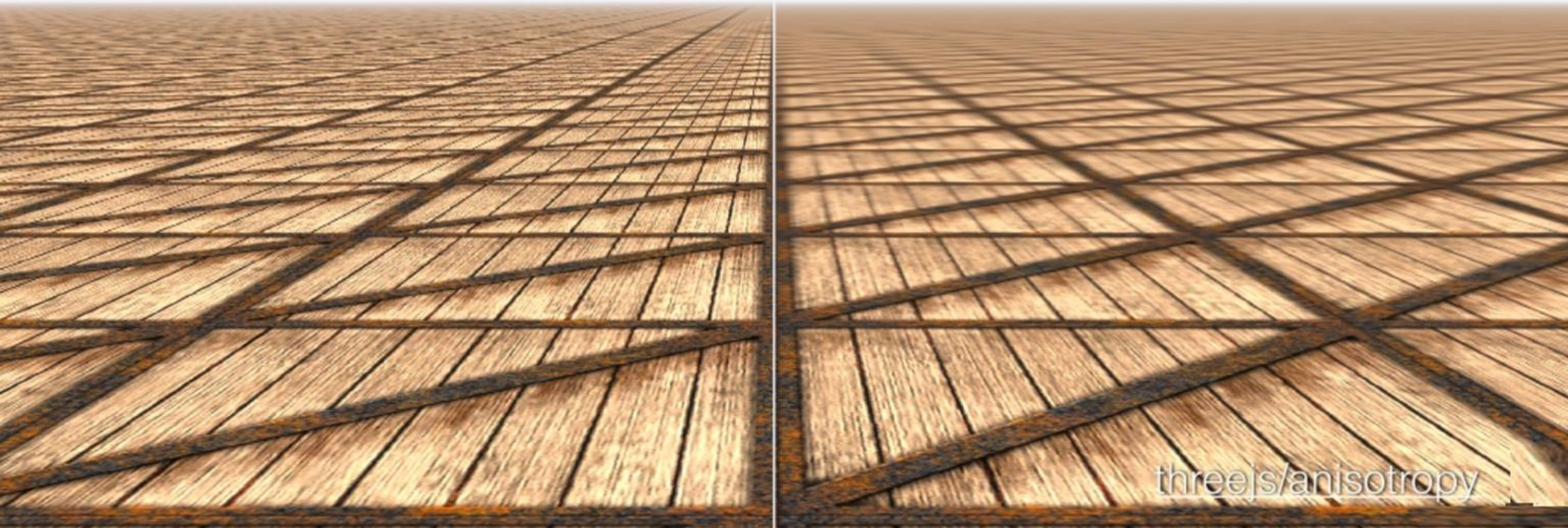
Particles

```
particleObj = new THREE.ParticleSystem(geometry, material);
particleObj.position.set(0, 50, 0);
particleObj.dynamic = true;
particleObj.sortParticles = true;
scene.add( particleObj );
```

Particles

oos.moxiecode.com

Texture Quality/Filtering



Anisotropic Filtering

A method for enhancing the image quality of textures on surfaces that are at oblique viewing angles with respect to the camera

```
const renderer = new THREE.WebGLRenderer();
const maxAnisotropy = renderer.getMaxAnisotropy();

const textureLoader = new THREE.TextureLoader();
const texture1 = textureLoader.load('texture1.png');
texture1.anisotropy = maxAnisotropy;
```

Review

Syntax/Core Setup Principles
1 Model – to 100 Models
1 Texture – to 100 Textures
Customize Effects/Materials

Tasks
Add more models, lights, textures,
Add movement (dynamic), ..
Experiment

Pros

No compilation
High performance (GPU)
Cross-platform
Open standard
Automatic memory management

Cons

Poly-polygonal scenes
Optimization required
Raster graphics

Interactivity

Useful Links/Resources

Three.js

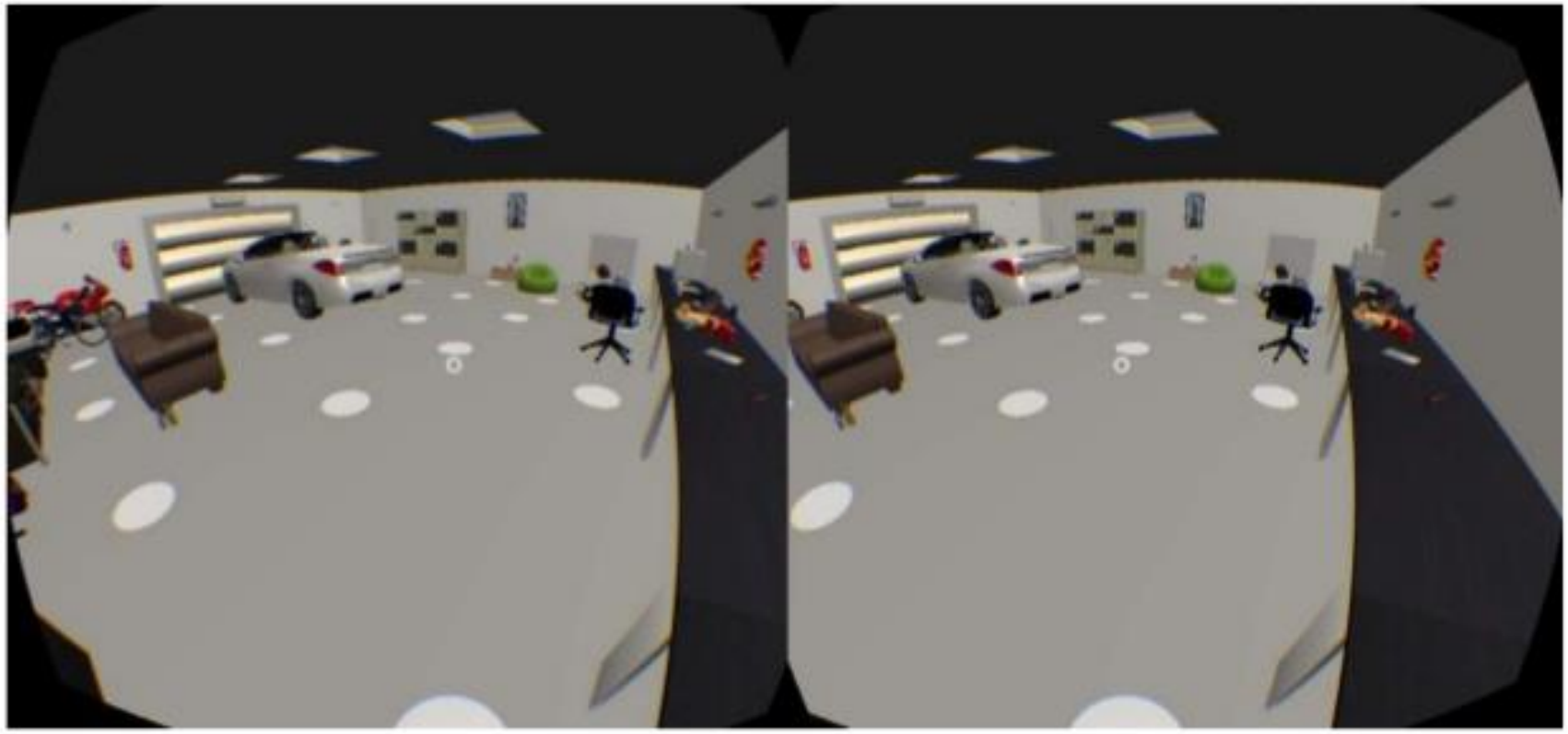
- https://threejs.org/

Visualization

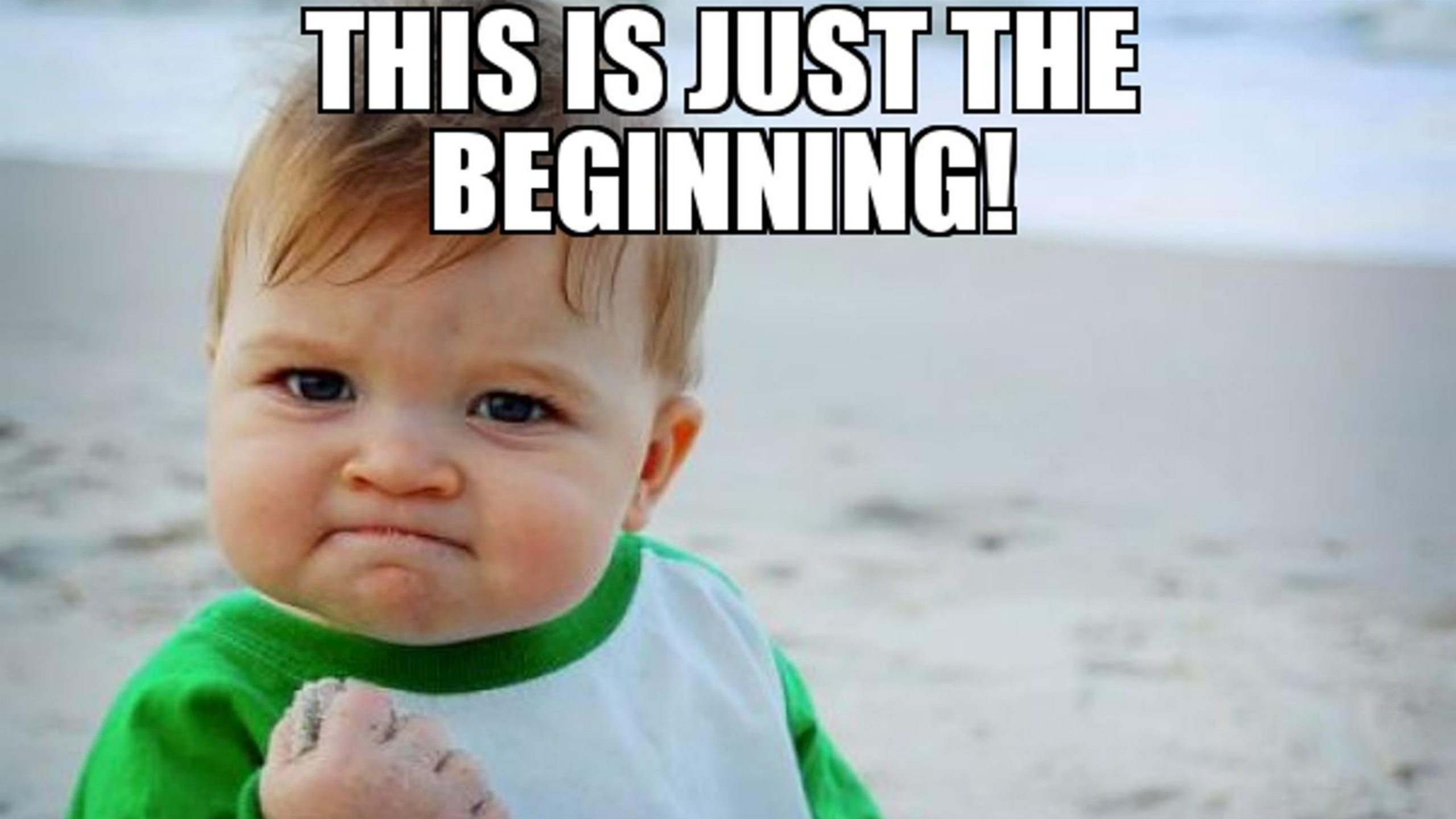
- http://mariovalle.name/visualization/VizArt.html
- https://www.psychologytoday.com/us/blog/flourish/200912/seeing-is-believing-the-power-visualization
- https://www.nature.com/articles/487430a

Virtual Reality
(with Three.js)

```
renderer.vr.enabled = true;
```



Learning to script and debug is initially hard work
Scary and daunting – but it is a valuable tool for communicating your ideas


THIS IS JUST THE
BEGINNING!


Questions & Discussion

Q&A

- Do you need to be connected to the internet to use Three.js

No, Three.js runs in the browser

- Should you learn WebGL before you learn Three.js?

Learn Three.js, and then if your interest wants to go deeper, the internals of Three.js are a fantastic learning resource for how they accomplish everything on top of raw WebGL

How to run things locally (browser/debugging)

File access blocked by CORS policy

One solution (Python)

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