False Awakening

Graduation Thesis
Final Private Presentation, Demonstration and Critique
From Duo

Table of Content

Introduction

False Awakening is an immersive and interactive installation art, which recreates *Andrew's surrealistic and symbolic* ***lucid dreaming experience***, harnessing **Virtual Reality** (VR) and **EEG** (Electroencephalography) technology.

Description

- put on the “Dream Machine”
    - generic helmet
    - Oculus Rift virtual reality headset
    - MindWave brainwave-sensing headset

Description

- sit on a rocking chair placed
- room decorated with concept arts, objects related to Andrew’s fantasy and reference photos.
- experience lucid dreaming actively manipulating the dream with their own brain power, immersively witnessing the wonder in the exquisite world in 3D, and interacting with dream world objects with physical gestures in firsthand.

Description

- experience lucid dreaming
  - actively manipulating the dream with their own brain power
  - immersively witnessing the wonder in the exquisite world in 3D
  - interacting with dream world objects with physical gestures in firsthand.

Abstract

- unconscious ideas with conscious imagination
- surrealistic and symbolic style

Abstract

- Sex
- Memories
- Imagination & Fantasy

Deliverables

Deliverables

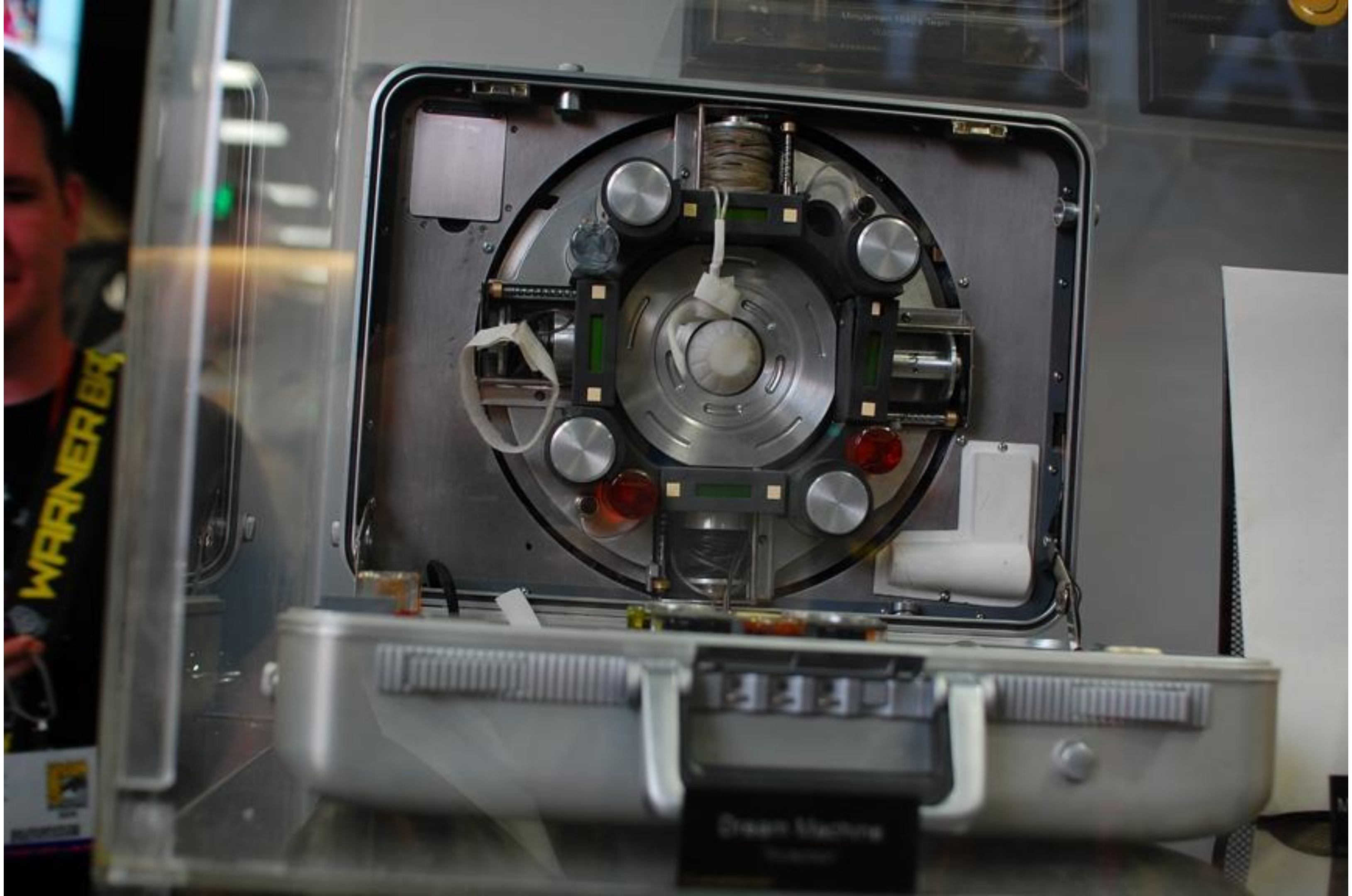
Deliverables

Motives - Technical perspective

- Technical WOW, extraordinary factor
- Human Computer Interfaces beyond ordinary VR
- Idea came, in a sudden when I was sleeping
- EEG

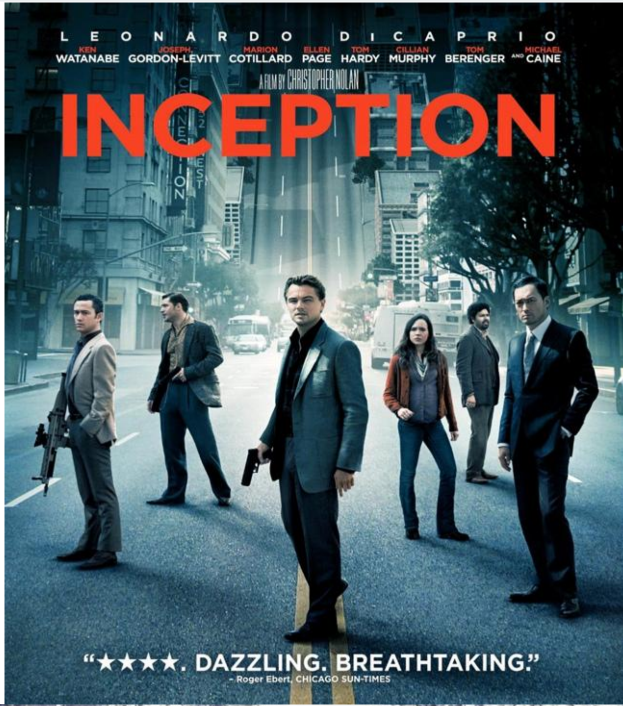
Motives - Technical perspective

- Preference of hardware setup
- Helmet / HMD device (VR + EEG)
- Met Andrew, converge and blend perfectly
    - Idea of Lucid Dreaming
    - Suitable technology
    - Personal skill set


WARNER BR
Dream Machine

Motives - Artistic perspective

- Movie “Inception”
  - Profound Science
  - Wildly creative Fiction
- Curious and interest in Lucid Dreaming
- Science and Psychology behind dreaming

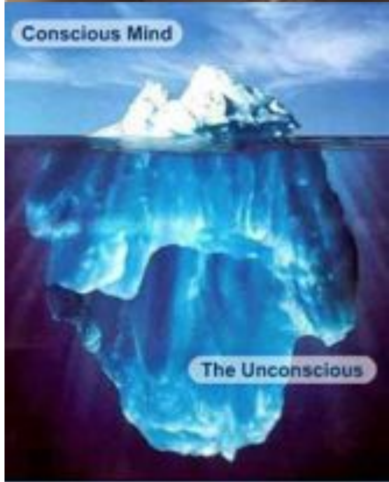

LEONARDO DICAPRIO
KEN WATANABE JOSEPH GORDON-LEVITT MARION COTILLARD ELLEN PAGE TOM HARDY CILLIAN MURPHY TOM BERENGER AND MICHAEL CAINE
A FILM BY CHRISTOPHER NOLAN
INCEPTION
“★★★★. DAZZLING. BREATHTAKING.”
- Roger Ebert, CHICAGO SUN-TIMES

Background research/survey

- Dream
  - *The Unconscious*
  - *The Dream Work*
  - *Active Imagination*

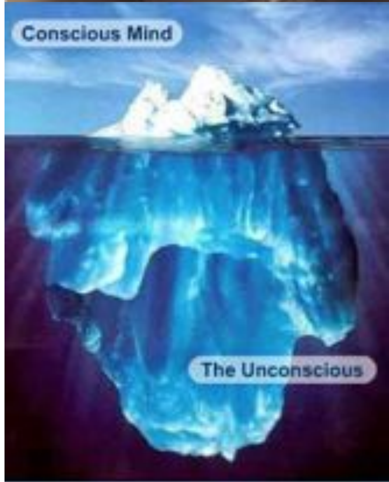
Background research/survey

- The Unconscious
  - Sigmund Freud, neurologist and the founder of psychoanalysis
  - usually illustrated via a metaphor of Iceberg.
  - aka “Libido”
  - repressed due to socialisation
  - But present in the bottom of mind
  - only reappears in consciousness under certain circumstances. The circumstance would be sleeping
  - Therefore, the contents in dreams are the result of unconsciousness.



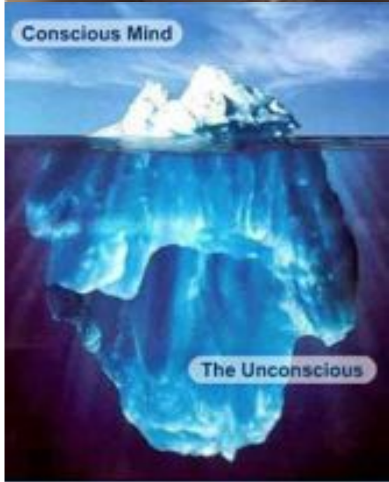
Background research/survey

- The Unconscious
  - vivid in our dreams as it is in real life which
  - explained with the physiological mechanism
  - Rapid eye movement sleep (REM)
    - unique phase of sleep
    - brain’s motor cortex remains active
    - **brainwave** looks **very similar** to that of awake



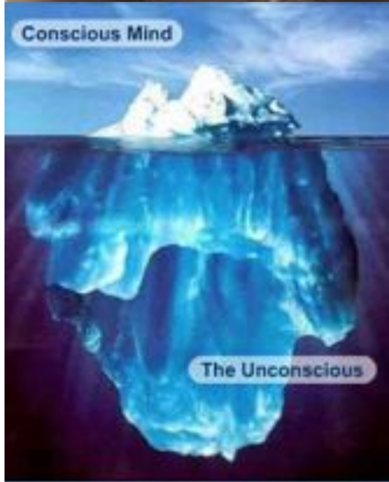
Background research/survey

- The Unconscious
    - mind continuously create and perceive our world simultaneously
    - cannot even notice it's happening
    - A new "interpretation" is consciously created by the mind
    - experience the result of that "new interpretation"
    - forming a **reciprocal causation**
    - help in delaying wake, just like the **guardian of sleep**



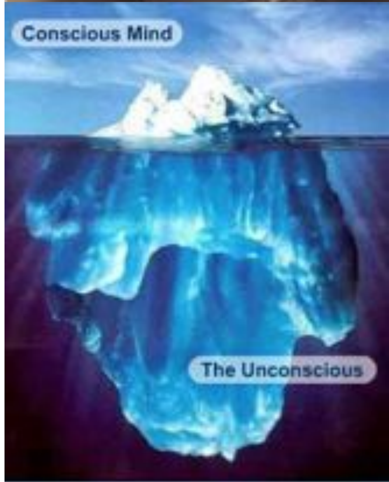
Background research/survey

- The Dream Work
  - see irrelevant or even ridiculous combinations of objects, people, time, places and events
  - the unconscious tends to combine multiple elements into a sole element
  - called "**Condensation**"
  - inspires Surrealism artists



Background research/survey

- The Dream Work
  - Usually, unconscious visualises abstract feelings and ideas in the dreams with materials
  - from what we see in day time and major childhood memories.



Background research/survey

- Active Imagination
  - bridging the gap between the conscious and unconscious by inspiration
  - contents of the unconscious are allowed to **get into** the conscious actively
  - process of “**Active Imagination**” .
  - Carl Jung, psychiatrist and psychoanalyst

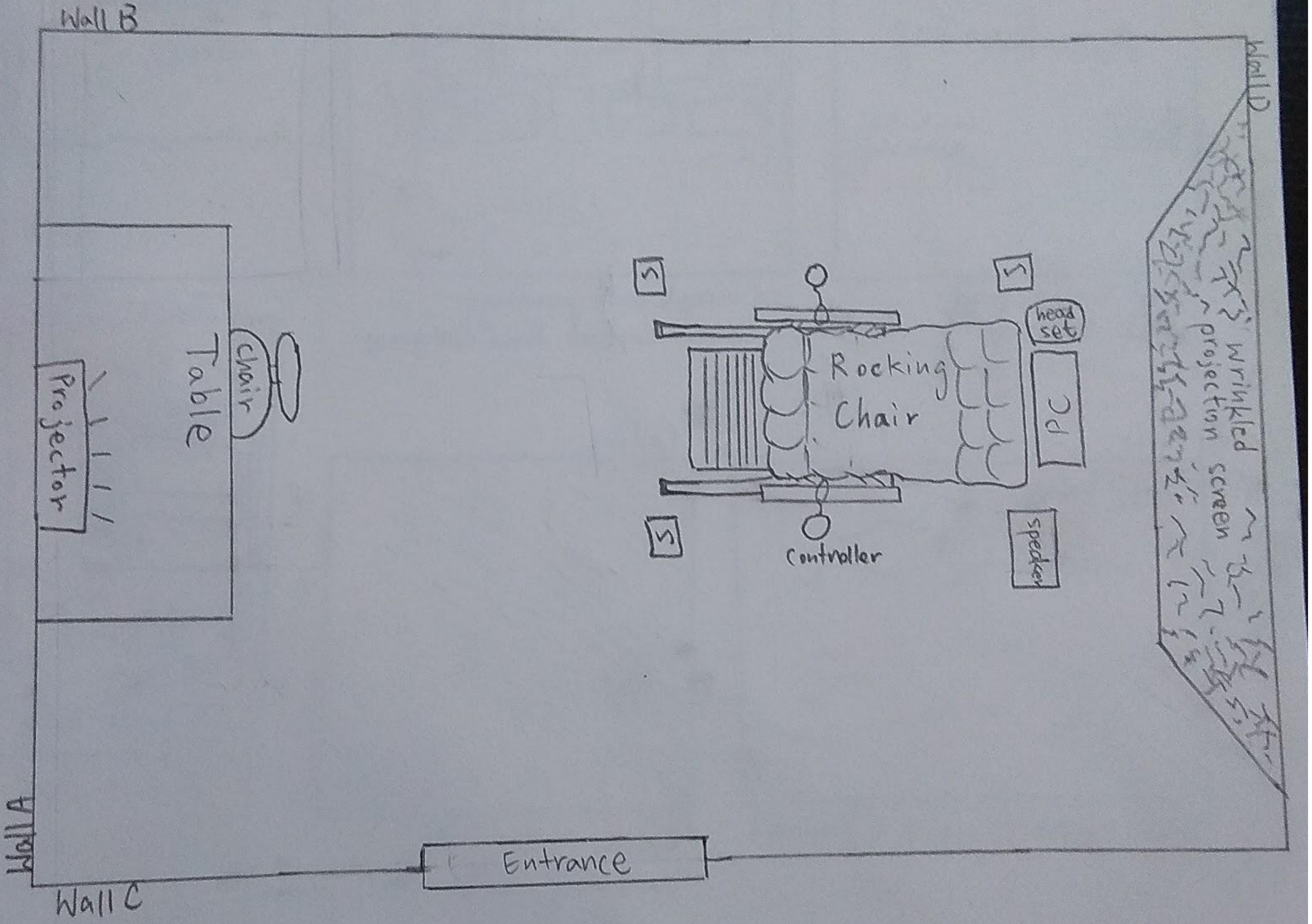
Background research/survey

- Active Imagination
  - if cannot explain or even recall dream
  - try to stop thinking in language and rationality
  - instead create an unconfined world with imagination
  - help bringing the unconscious contents up to the conscious
  - imagining actively in day time is dreaming with eyes open, while dreaming at night is imagining actively with eyes close.

Installation Setup Design

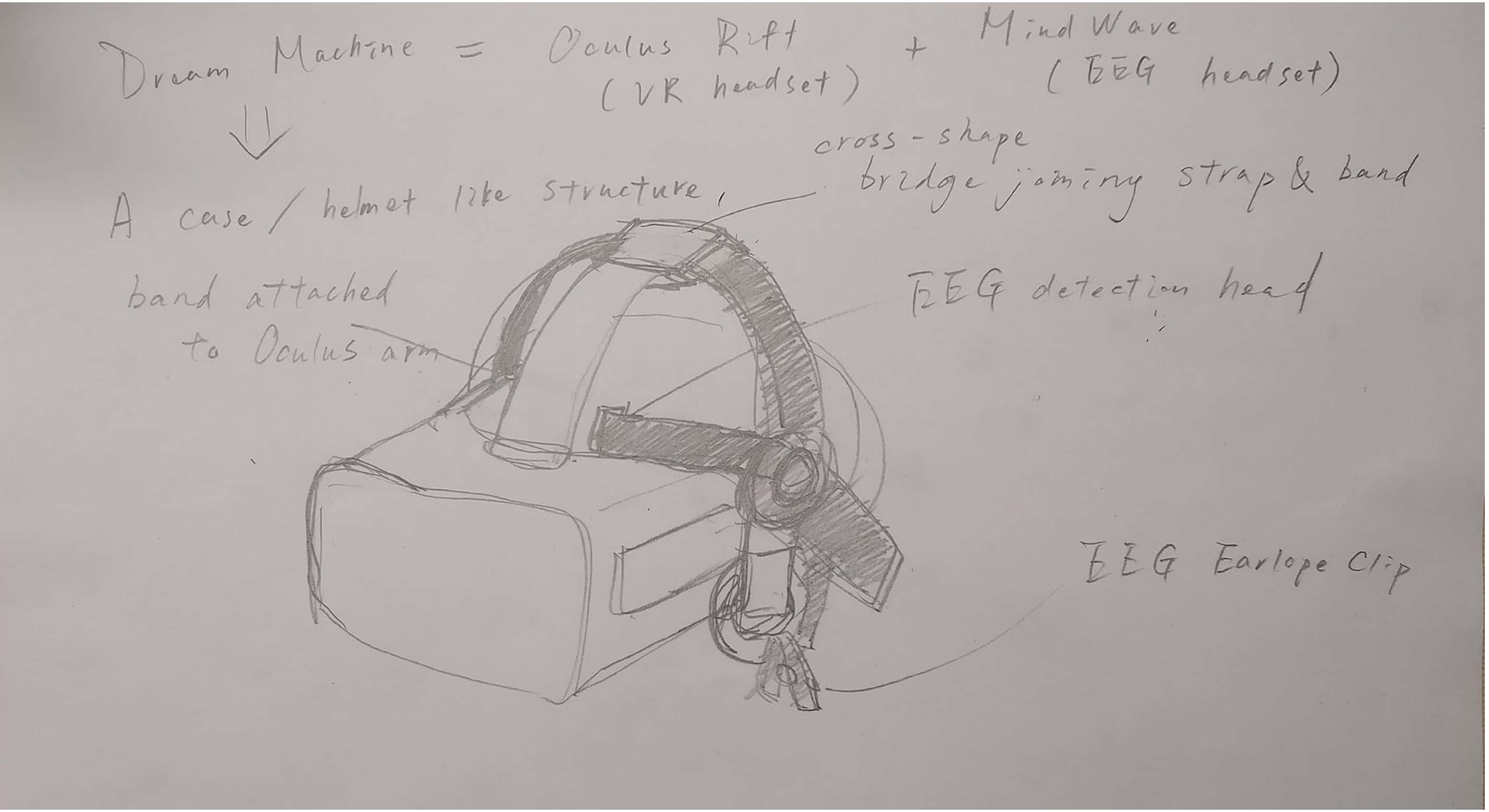
“Andrew’s imaginary bedroom in childhood”

- Ordinary
- Poor & Crude
- In contrast of the fantasy in dream

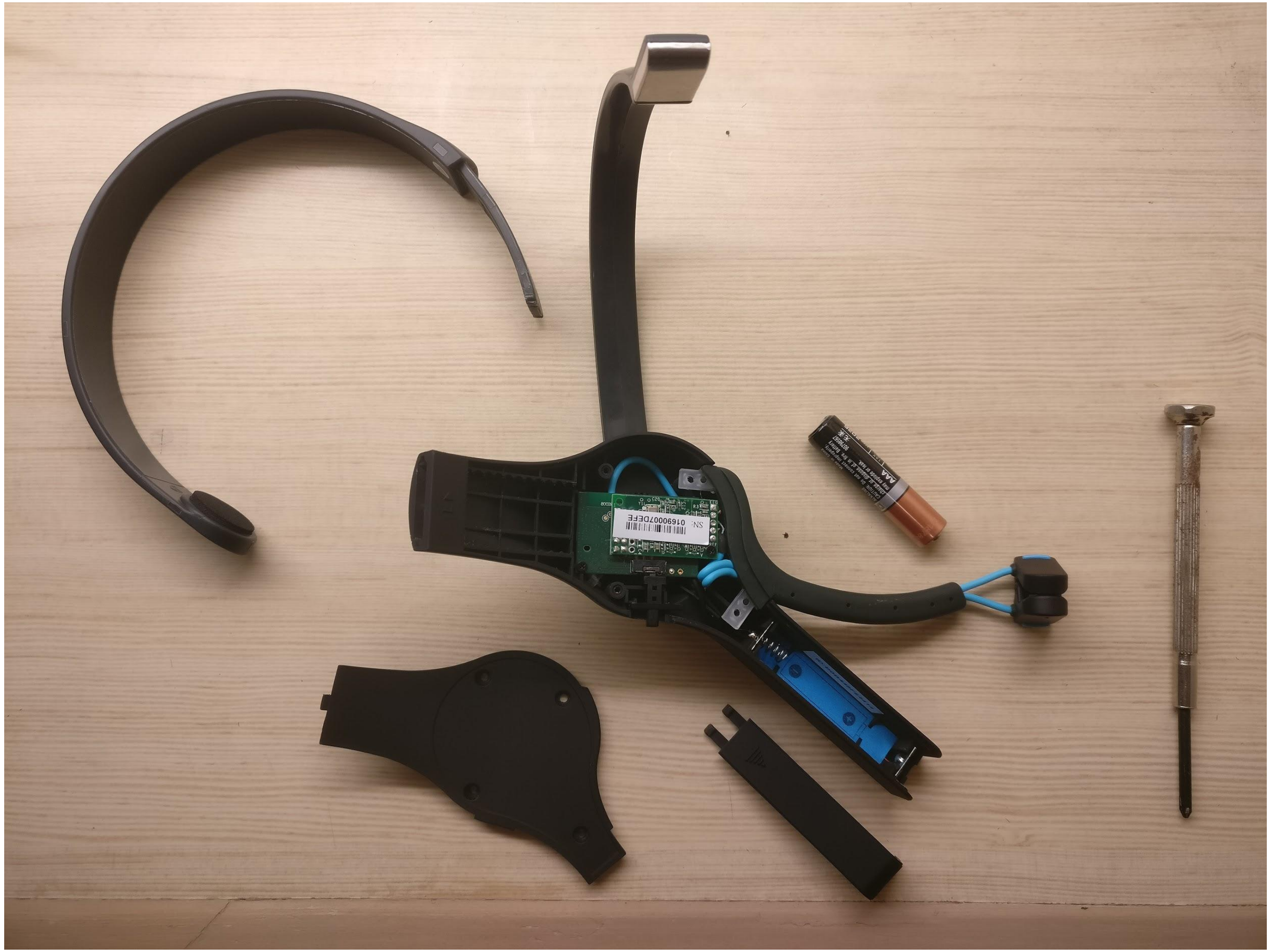

Wall B
Wall D
Wall A
Wall C
Table
chair
Projector
S
S
S
Rocking Chair
head set
PC
Controller
speaker
wrinkled projection screen
Entrance

Hardware Design

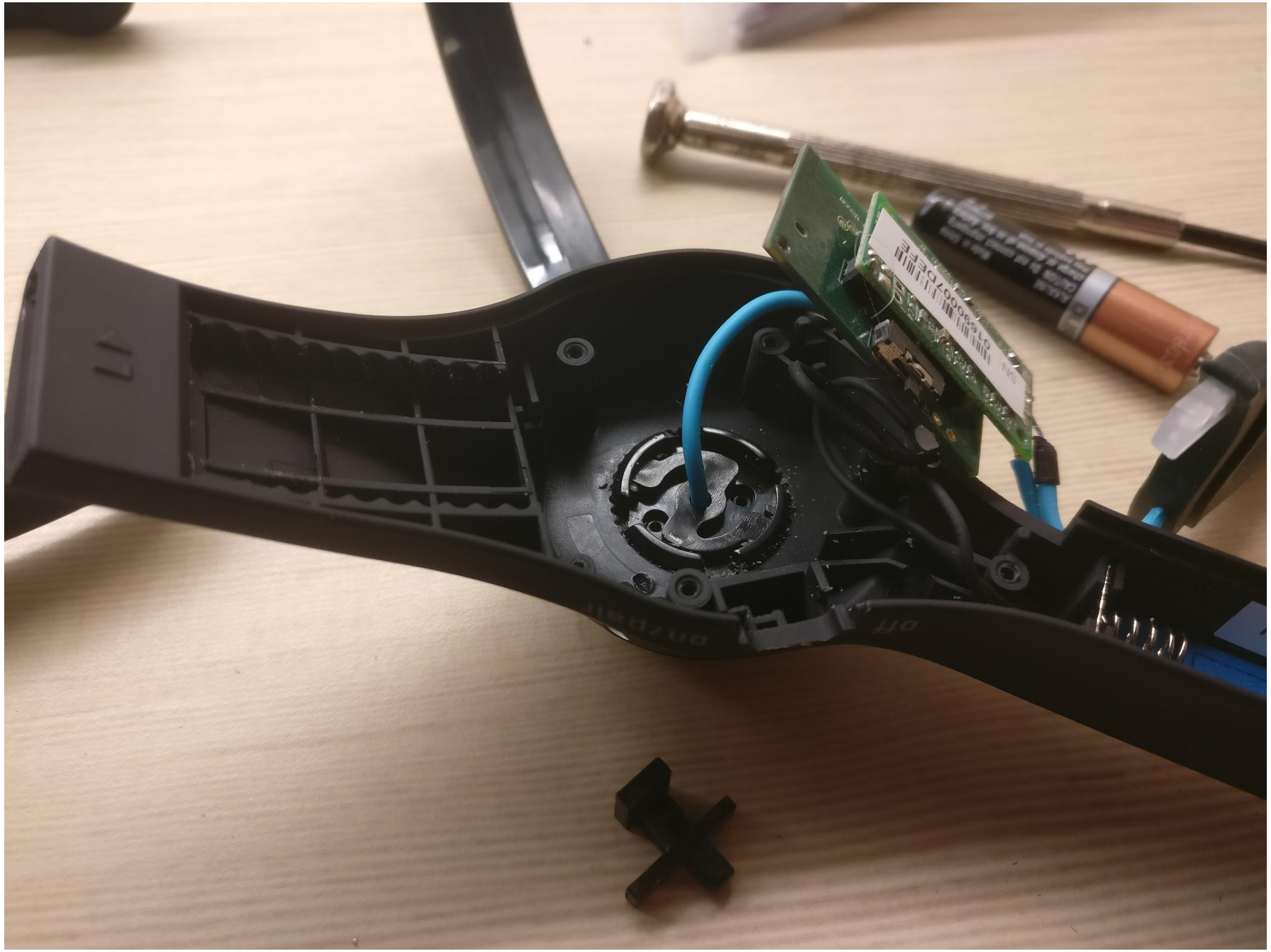
The Dream Machine


Dream Machine = Oculus Rift (VR headset) + Mind Wave (EEG headset)
A case / helmet like structure,
cross-shape bridge joining strap & band
band attached to Oculus arm
EEG detection head
EEG Earlope Clip

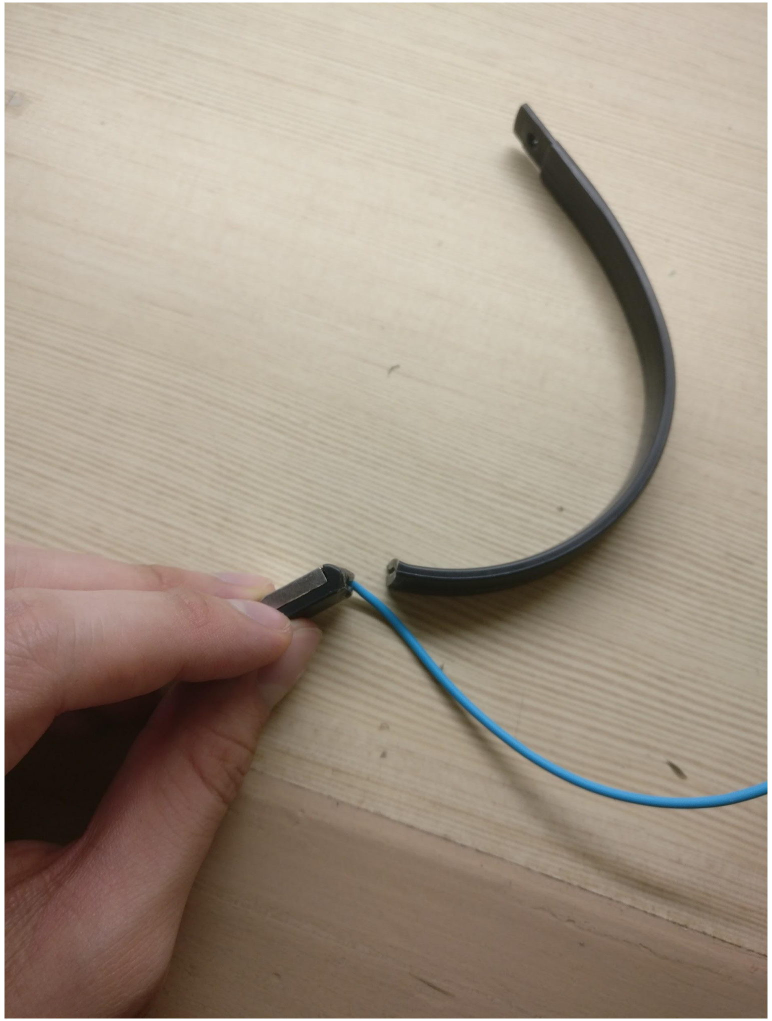
Original Concept Design



MindWave Disassembly



MindWave Disassembly

t can prevent all head injuries.Even in very low speed accid
n occur. For best protection,follow manual fitting instructions:Hel
chin strap comfortably tight against throat.Fasten buckle securely.Des
helmet after impact.Protection may not be adequate in future impacts.Damag
sible.Don 't modify anything on this helmet.It could reduce the helmet 's ability of pr
Do not clean with solvents,bleaches and strong detergents.They can damage helmet,
sometimes invisibly.Use mild soap and water only,Read manual.
MADE IN CHINA
Manufactured Date:06/2014
Serial No.:09


https://youtu.be/bzOnoPETeYA

Storytelling driven features

1. EEG Focus to Focus & EEG Still Sky
2. Scene Management
3. Chicken Finite State Machine
4. Pacman
5. Beyblade Battle
6. Pedestrians System
7. CCTV
8. VR Nuance

EEG Focus to Focus

01

Attention level is obtained from the EEG headset, then mapped and smooth to create “Focus to Focus” effect. Turns out that the experience is very intuitive and interactive. Really need to concentrate to read clearly.

Implementation:

Requires audience/user to get certain message from detail images & text, particularly with concentration

EEG Focus to Focus

01

Attention level is obtained from the EEG headset, then mapped and smooth to create “Focus to Focus” effect. Turns out that the experience is very intuitive and interactive. Really need to concentrate to read clearly.

Achieve and optimised with:

1. EEG Serial data parsing
2. Analog input exponential smoothing algorithm
3. Camera post-processing

EEG Focus to Focus

EEG Serial data parsing

```
public void Connect(){
        if(!IsInvoking("ParseData")){
                client = new TcpClient("127.0.0.1", 13854);
                stream = client.GetStream();
                buffer = new byte[1024];
                byte[] myWriteBuffer =
                Encoding.ASCII.GetBytes(@"{""enableRawOutput"": true, ""format"":
""Json""}");
                stream.Write(myWriteBuffer, 0, myWriteBuffer.Length;
                InvokeRepeating("ParseData",0.01f,0.05f);
        }
}
```

EEG Focus to Focus

EEG Serial data parsing

```
void ParseData(){
     if(stream.CanRead){
          connected = true;
          try {
               int bytesRead = stream.Read(buffer, 0, buffer.Length);
               string[] packets = Encoding.ASCII.GetString(buffer, 0, bytesRead).Split('\r');
               foreach(string packet in packets){
                    if(packet.Length == 0)
                    continue;
          IDictionary primary = (IDictionary)JsonConvert.Import(typeof(IDictionary), packet);
```

EEG Focus to Focus

EEG Serial data parsing

```
                    if(primary.Contains("eSense")){
                      IDictionary eSense = (IDictionary)primary["eSense"];
                          if(UpdateAttentionEvent != null){
                              UpdateAttentionEvent(int.Parse(eSense["attention"].ToString()));
                           }
                          if(UpdateMeditationEvent != null){
                              UpdateMeditationEvent(int.Parse(eSense["meditation"].ToString()));
                           }
                    }
                  }
              }
              catch(IOException e){ Debug.Log("IOException " + e); }
              catch(System.Exception e){ Debug.Log("Exception " + e); }
            }
```

EEG Focus to Focus

Exponential Smoothing Algo

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

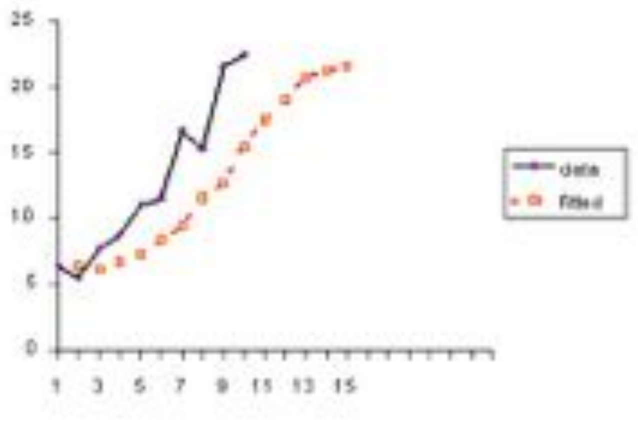
where: F_t = new forecast
F_{t-1} = previous period forecast
A_{t-1} = previous period *actual* demand
α = smoothing (weighting) constant

```
void smoothValue(float rawValue) {
        smoothed = smoothed + (rawValue - smoothed) / alpha;
    }
```

Exponential smoothing:

smoothing **time series data** using the **exponential** window function. Whereas in the simple moving average the **past observations** are weighted equally.

EEG Focus to Focus
Exponential Smoothing Algo

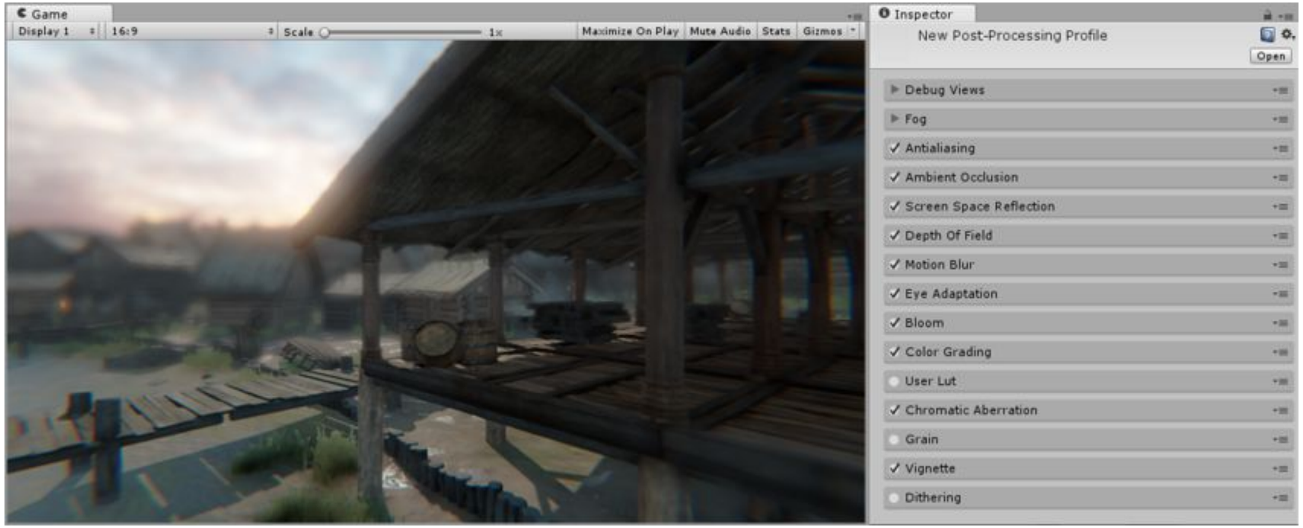


Exponential smoothing:

- **simple moving average algorithm,** the past observations are weighted equally
  - Not applicable
- **exponential** functions are used to assign **exponentially decreasing weights over time**.
  - exponential smoothing suits my case
  - **forecast** the value base on just previous actual value and smoothed value
  - hardware itself limits refresh rate to a sluggish 1Hz.

EEG Focus to Focus

01



New Post-Processing Profile

- ▶ Debug Views
- ▶ Fog
- ✓ Antialiasing
- ✓ Ambient Occlusion
- ✓ Screen Space Reflection
- ✓ Depth Of Field
- ✓ Motion Blur
- ✓ Eye Adaptation
- ✓ Bloom
- ✓ Color Grading
- ○ User Lut
- ✓ Chromatic Aberration
- ○ Grain
- ✓ Vignette
- ○ Dithering

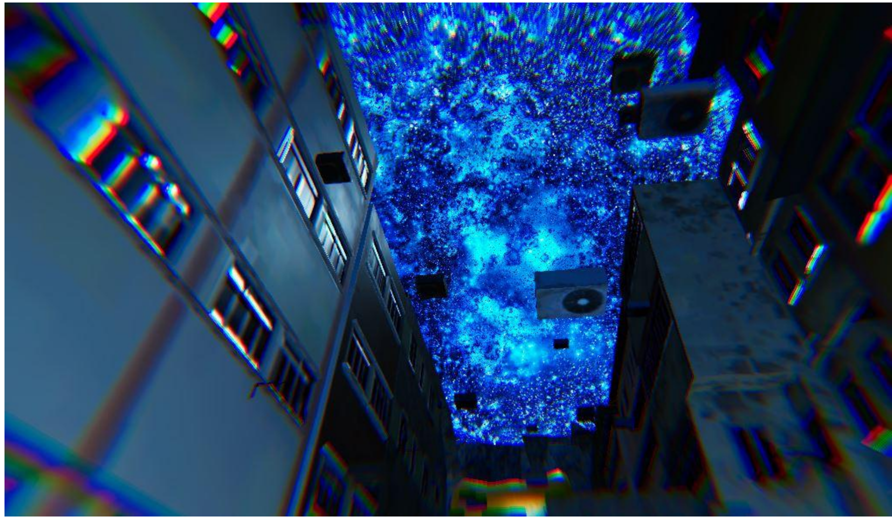
EEG Still Sky

01

Meditation level is obtained from the EEG headset, then mapped and smooth to create such an effect. When mind is calm, the sky stays dark and normal, vice versa.

Implementation:

The sky graphically and artistically represents how relax a person is. Used as a reflection of user's mind. If user's mind is unstable, the sky fluctuates.



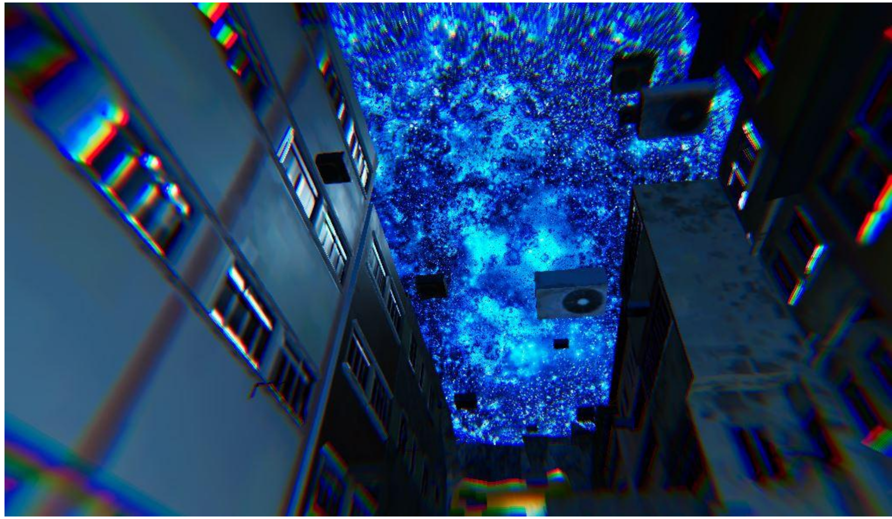
EEG Still Sky

01

Meditation level is obtained from the EEG headset, then mapped and smooth to create such an effect.

Achieve and optimised with:

1. EEG Serial data parsing
2. Analog input exponential smoothing algorithm
3. Custom Shader



EEG Focus to Focus

Custom Shader

```
//volumetric rendering
float s = 0.1, fade = 1.0;
float3 v = float3(0, 0, 0);
for (int r = 0; r < _Volsteps; r++) {
      float3 p = abs(from + s * dir * .5);
      p = abs(float3(tile - fmod(p, tile*2)));
      float pa,a = pa = 0.;
      for (int i = 0; i < _Iterations; i++) {
            p = abs(p) / dot(p, p) - formparam;
            a += abs(length(p) - pa);
            pa = length(p);
      }
```

Dot Product of two vectors.

The dot product is a float value equal to the magnitudes of the two vectors multiplied together and then multiplied by the cosine of the angle between them.

EEG Focus to Focus
Custom Shader

```
        //Dark matter
        float dm = max(0., darkmatter - a * a * .001);
        if (r > 6) { fade *= 1. - dm; } // Render distant darkmatter
        a *= a * a; //add contrast
        v += fade;
        // coloring based on distance
        v += float3(s, s*s, s*s*s*s) * a * brightness * fade;
        // distance fading
        fade *= distFade;
        s += stepSize;
    }
```

Scene Management

02

In order to provide users a pleasant using experience, all the negative impacts of user experience, engendered by the technical operations, are carefully concealed and eliminated.

1. Software starts
2. EEG headset connects to the computer, and does the setup
   a. Connection cause serious frame drops
   b. connection will be done only once, when the operator setup the location and equipment
   c. Setup will be done every time this “stand-by” scene is being loaded.
   d. Right after the laggy EEG connection and setup process are done, the next scene, the actual “dream environment” is being loaded in the background, without any visual feedback in the VR environment.
   e. EEG is ready for incoming signal before users putting on the headset
   f. no lag will be experienced by the users

Scene Management

02

3. Users put on the Dream Machine
    a. The user is in this “stand-by” scene, where the environment is blacked out, what users can see is their bare hands in VR
    b. The VR headset detects that the device is put on, image fades in
4. Users clip the ear clip onto their earlobe
    a. EEG signal can be detected
    b. Once EEG signal is detected, the system enters the “dream” scene without loading
    c. Visuals fade in
    d. Song fade out

Scene Management

Async load

```
IEnumerator LoadScene() {
        yield return null;
        //Begin to load the Scene you specify
        AsyncOperation asyncOperation = SceneManager.LoadSceneAsync(scenename);
        //Don't let the Scene activate until you allow it to
        asyncOperation.allowSceneActivation = false;
        Debug.Log("Pro :" + asyncOperation.progress);
        //When the load is still in progress, output the Text and progress bar
        while (!asyncOperation.isDone) {
            //Output the current progress
            Debug.Log("Loading progress: " + (asyncOperation.progress * 100) + "%");
            // Check if the load has finished
```

Scene Management

Async load

```
            if (asyncOperation.progress >= 0.9f) {
                //Change the Text to show the Scene is ready
                Debug.Log("Press the any button to continue");
                //Wait to you press the space key to activate the Scene
                //if (OVRInput.Get(OVRInput.Button.Any) && !pressed) {
                if (isMounted && DoFocus.connected && !pressed) {
                    //Activate the Scene
                    osf.FadeOutToDream();
                    //playNon.PlayMusic();
                    PlayNon.PlayMusic();
                    Debug.Log("Starting Dream");
                    asyncOperation.allowSceneActivation = true;
                    pressed = true;
                }
            }
            yield return null;
        }
```

Scene Management

02

5. Users enjoy the lucid dreaming experience
6. Users take off the Dream Machine / remove the earclip
    a. If Dream Machine is take off, the system immediately enter the “stand-by” scene again
    b. Even the ear clip is not removed, the system does the setup processing and load the “dream” scene in the background again
    c. The system is ready for the next user
    d. Go to step 3, and iterate

Scene Management

Async load

- Loads level asynchronously the background
- completely loads the entire scene in a background loading thread
  - next scene to be loaded
  - still playing the current one
  - switch seamlessly to the next without delay.
- normal loading scene operation will show a loading wheel on Oculus's screen
  - destroys the entire realistic "dreaming" experience
- a "dip to black" fade in is added to provide smooth transition experience.

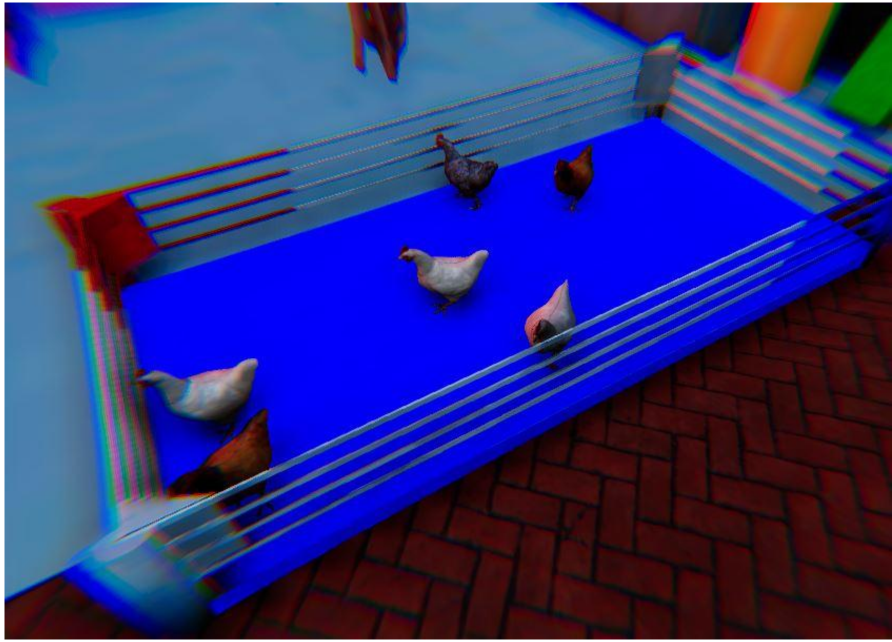
Chicken FSM

03

Chickens are treated as AI in a virtual environment. A Finite State Machine is required to set exactly one of a finite number of states at any given time.

Implementation:

A Unity Animation Controller repurposed as a Finite State Machine.



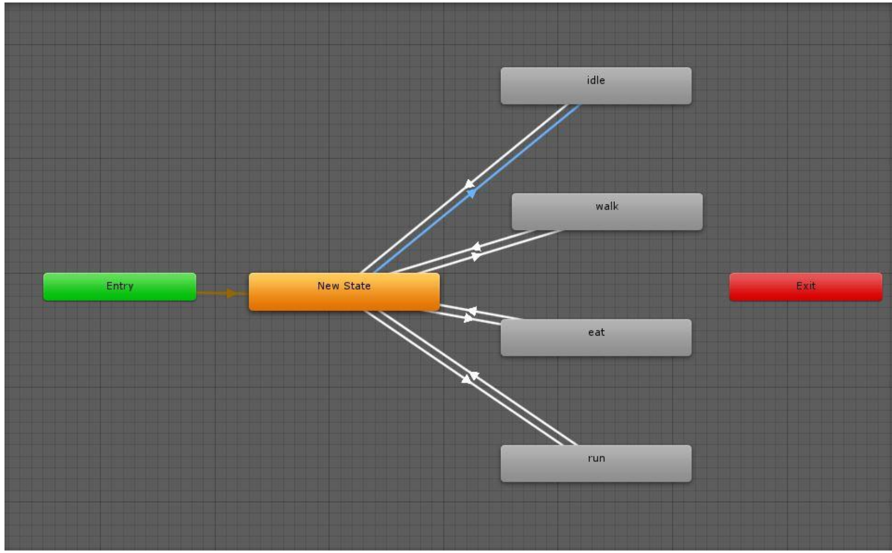
Chicken FSM

03

Chickens are be either in:

1. Idle
2. Eat
3. Walk
4. Run

Totally 4 states, with random number of cycles of each state, the machine switch to the empty state and randomly go to 1 of the 4 states



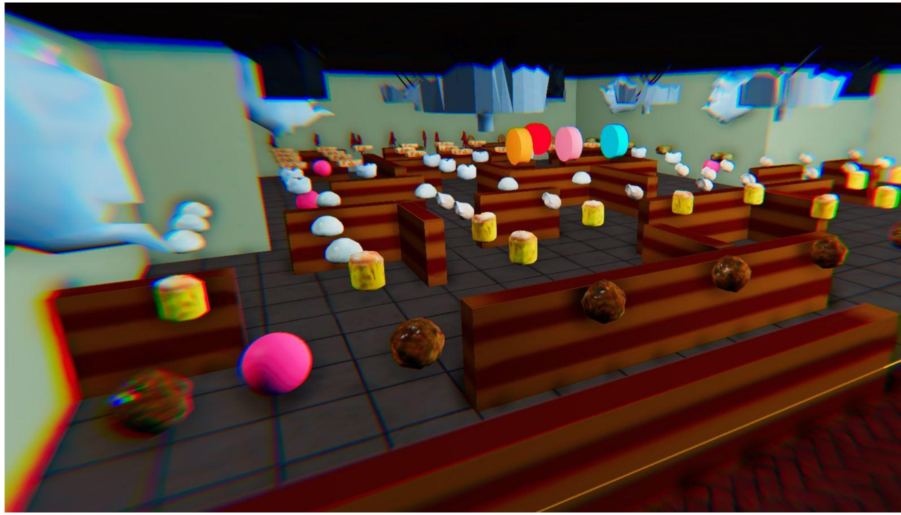
Pacman
04

Implementation

A Pacman mini game with a Hong Kong Style implementation

Achieved with:

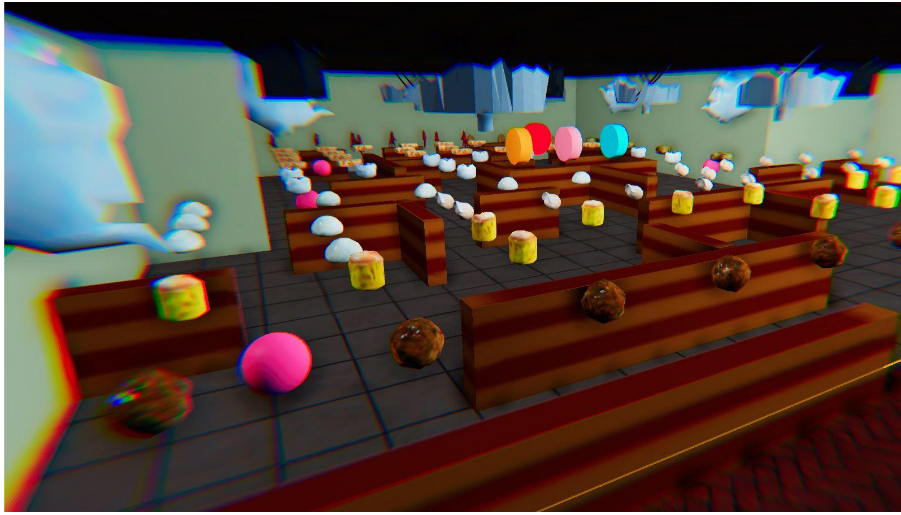
1. 4 unique AIs
   a. Blinky
   b. Inky
   c. Pinky
   d. Clyde
2. Navmesh Baking



Pacman

04

1. Blinky
   a. Chase player as always
   b. When player has power up, run in the opposite direction
2. Pinky
   a. Travel to a random spot and wait, flip-flopping between run and stagger states
   b. If player is nearby, chase
3. Clyde
   a. Go to a random spot
   b. If player is nearby, decelerate and chase
4. Inky
   a. A slowers version of Pinky



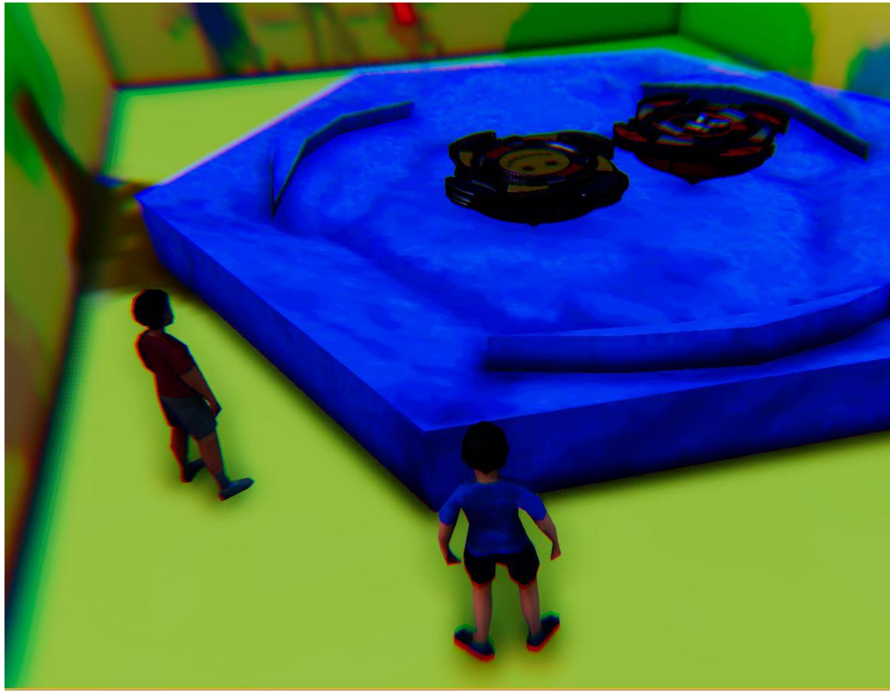
Beyblade Battle

05

Simulating beyblade spinning and crashing into each other requires physics. To mimic an intensive fight, two beyblade always needs to be targeting each other.

Implementation:

- rigidbody.AddForce()
- rigidbody.AddTorque();
- transform.Rotate()



Beyblade Battle

05

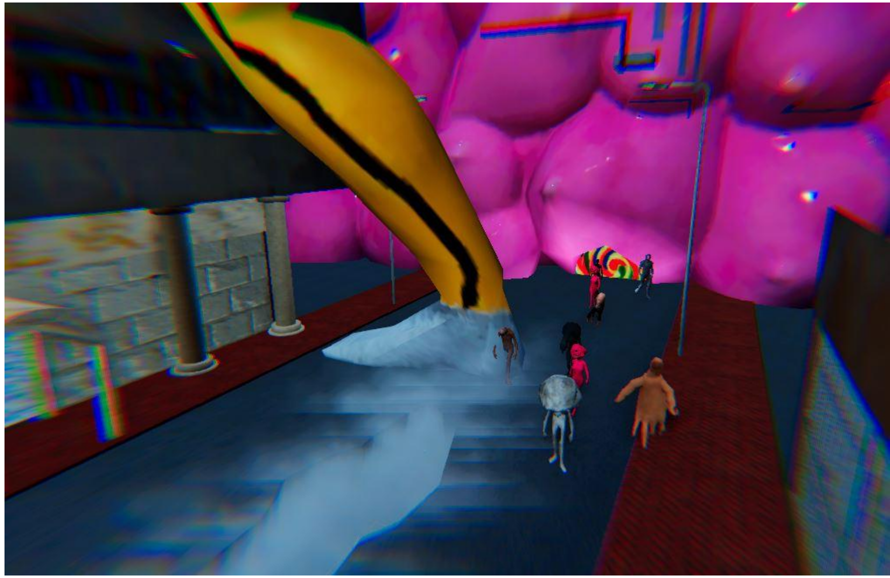
```
Vector3 offset = target.position - this.transform.position;
rb.AddForce(offset * attraction, ForceMode.Acceleration);
float h = 10000 * torque * Time.deltaTime;
rb.AddTorque(transform.forward * h, ForceMode.Acceleration);
transform.Rotate(Vector3.forward, speed * 100 * Time.deltaTime);
```

Pedestrians System 06

Coding moving NPCs can be straightforward, but it can also be complex as more and more can be added to the AI to make it even more realistic, like an actual AI.

Implementation:

Imaginary avatars walk and run on the street. Symbolising the characters in dreams are always you day time reality’s projection.

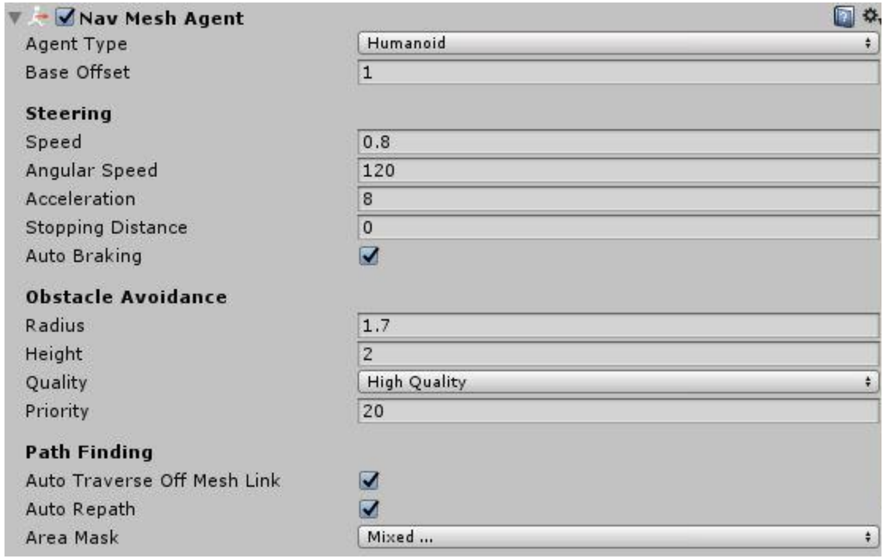


Pedestrians System

06

Achieved with:

- Unity AI (A* pathfinding algorithm)
  - NavMesh
  - NavMeshAgent
  - NavMeshObstacle
- NavMeshAgent.SetDestination
- Instantiate()



Nav Mesh Agent

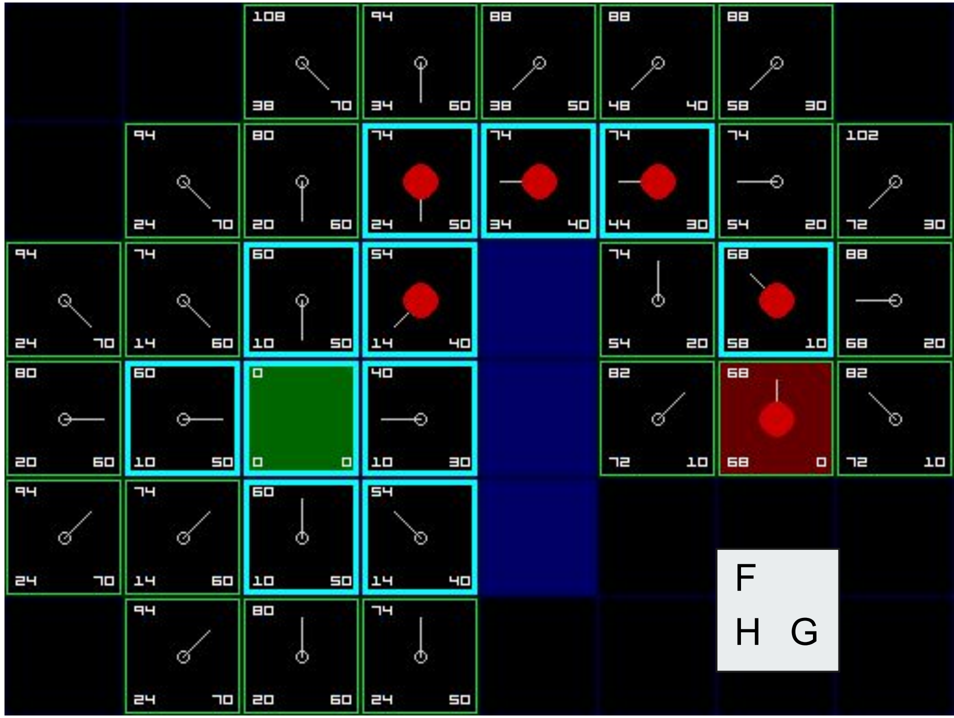
Agent Type	Humanoid
Base Offset	1
Steering	
Speed	0.8
Angular Speed	120
Acceleration	8
Stopping Distance	0
Auto Braking	✓
Obstacle Avoidance	
Radius	1.7
Height	2
Quality	High Quality
Priority	20
Path Finding	
Auto Traverse Off Mesh Link	✓
Auto Repath	✓
Area Mask	Mixed ...

Pedestrians System
A* Pathfinding

Finds shortest path from particular start-to-end points

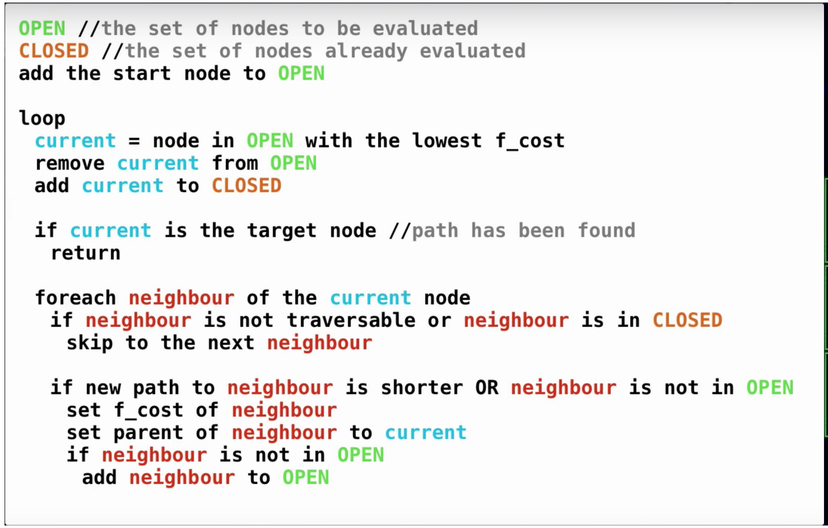
Good performance and accuracy

- **H cost: Heuristic cost** (distance from end node)
- **G cost: Movement cost** (distance from starting node)
- **F cost: H + G**
- **Open list:** being considered
- **Close list:** will not be considered



Pedestrians System

A* Pathfinding (Pseudo-code)



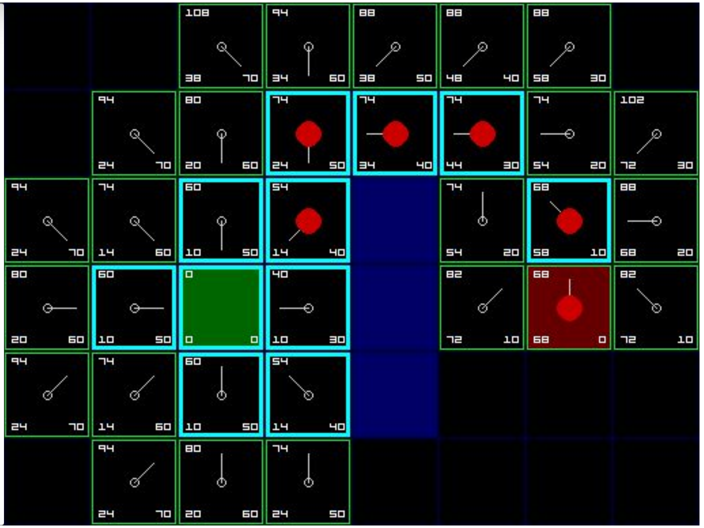
```
OPEN //the set of nodes to be evaluated
CLOSED //the set of nodes already evaluated
add the start node to OPEN

loop
 current = node in OPEN with the lowest f_cost
 remove current from OPEN
 add current to CLOSED

 if current is the target node //path has been found
  return

 foreach neighbour of the current node
  if neighbour is not traversable or neighbour is in CLOSED
   skip to the next neighbour

  if new path to neighbour is shorter OR neighbour is not in OPEN
   set f_cost of neighbour
   set parent of neighbour to current
   if neighbour is not in OPEN
    add neighbour to OPEN
```



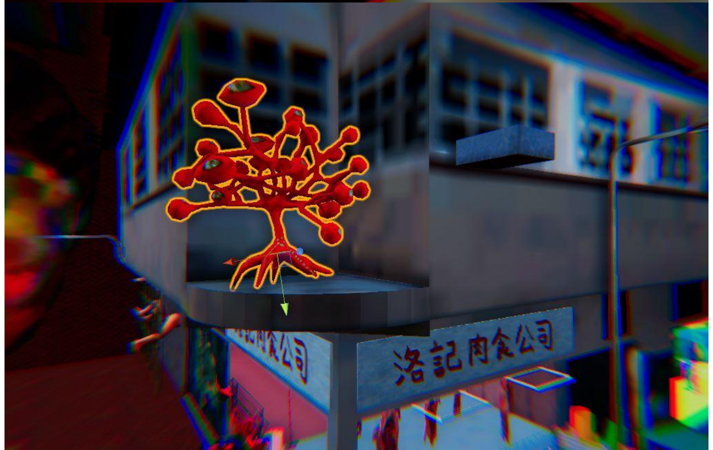
CCTV

07

There are always CCTVs on the street, surveilling.

Achieved with:

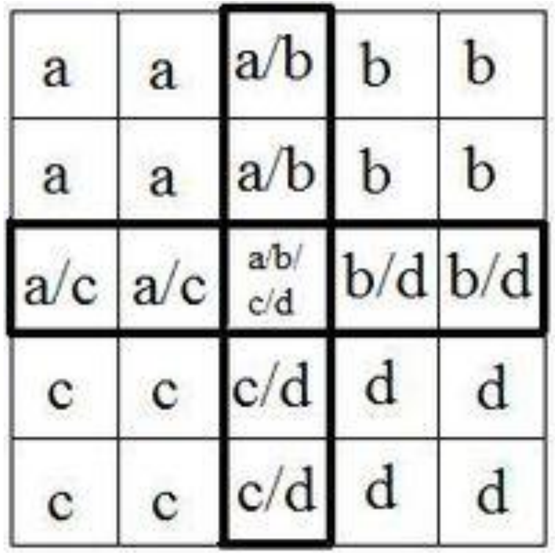
- Render Texture
- Kuwahara Filter



Abstract Oil Paint

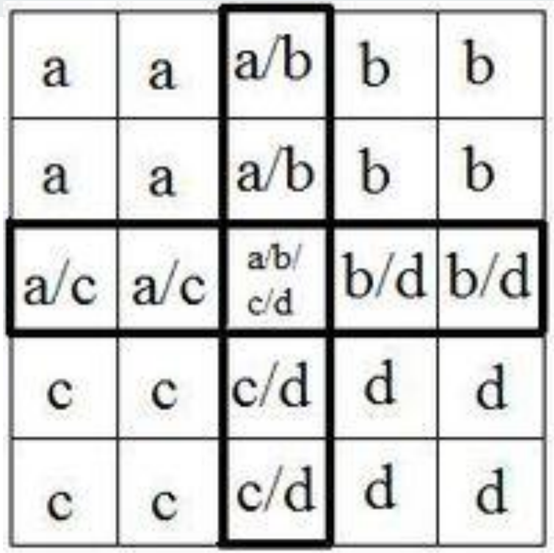
Kuwahara filter

- non-linear smoothing, noise reduction filter.
- Unlike other smoothie filters, Kuwahara filter is able to smooth the image while preserving the edges.



a	a	a/b	b	b
a	a	a/b	b	b
a/c	a/c	a/b/ c/d	b/d	b/d
c	c	c/d	d	d
c	c	c/d	d	d

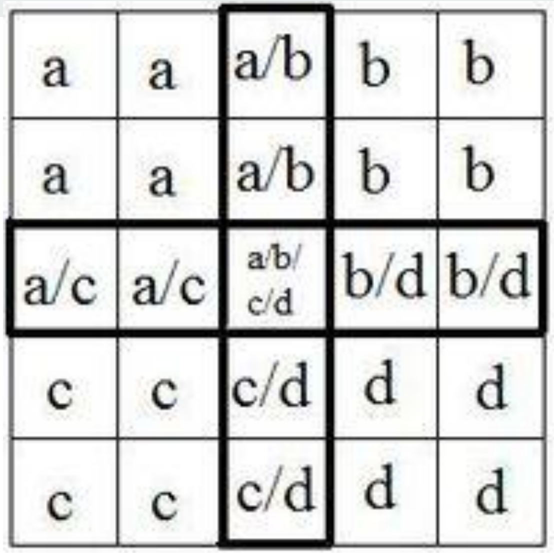
Abstract Oil Paint
Kuwahara filter



```
for (int k = 0; k < 4; k++) {
    for (int i = 0; i <= _Radius; i++) {
        for (int j = 0; j <= _Radius; j++) {
            pos = float2(i, j) + start[k];
            col = tex2Dlod(_MainTex, float4(uv + float2(pos.x * _MainTex_TexelSize.x, pos.y * _MainTex_TexelSize.y), 0., 0.)).rgb;
            mean[k] += col;
            sigma[k] += col * col;
        }
    }
}
```

Abstract Oil Paint
Kuwahara filter

```
for (int l = 0; l < 4; l++) {
        mean[l] /= n;
        sigma[l] = abs(sigma[l] / n - mean[l] * mean[l]);
        sigma2 = sigma[l].r + sigma[l].g + sigma[l].b;
        if (sigma2 < min) {
                min = sigma2;
                color.rgb = mean[l].rgb;
        }
}
```



a	a	a/b	b	b
a	a	a/b	b	b
a/c	a/c	a/b/ c/d	b/d	b/d
c	c	c/d	d	d
c	c	c/d	d	d

VR Nuance
08

To recreate reality in a virtual space, realistic physics are essential to trick users perception.

Springs, hinge, bounce components can simulate realistic experience.

VR Nuances
08

To recreate reality in a virtual space, realistic physics are essential to trick users perception.

Using:

Instantiate()

Rigidbody.AddExplosionForce()

VR Nuances
08

To recreate reality in a virtual space, realistic physics are essential to trick users perception.

Using:

Spring component

VR Nuances

08

To recreate reality in a virtual space, realistic physics are essential to trick users perception.

Using:

Spring component

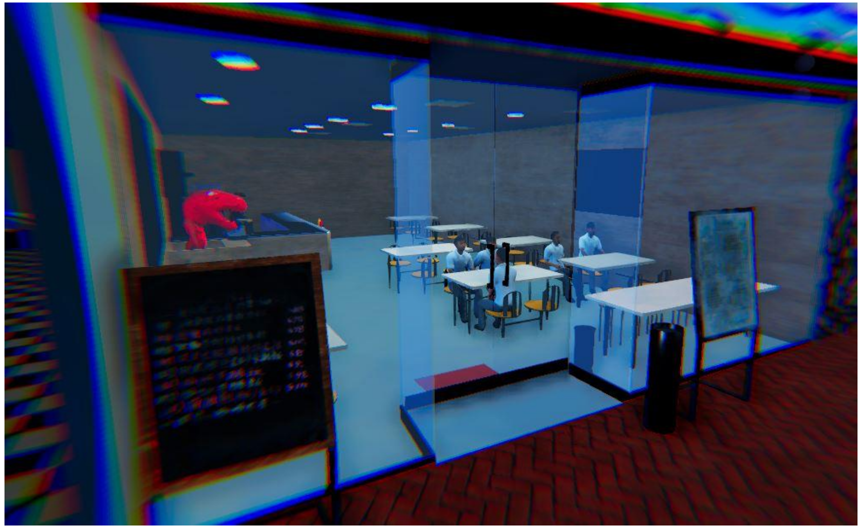
VR Nuances

08

To recreate reality in a virtual space, realistic physics are essential to trick users perception.

Using:

Hinge



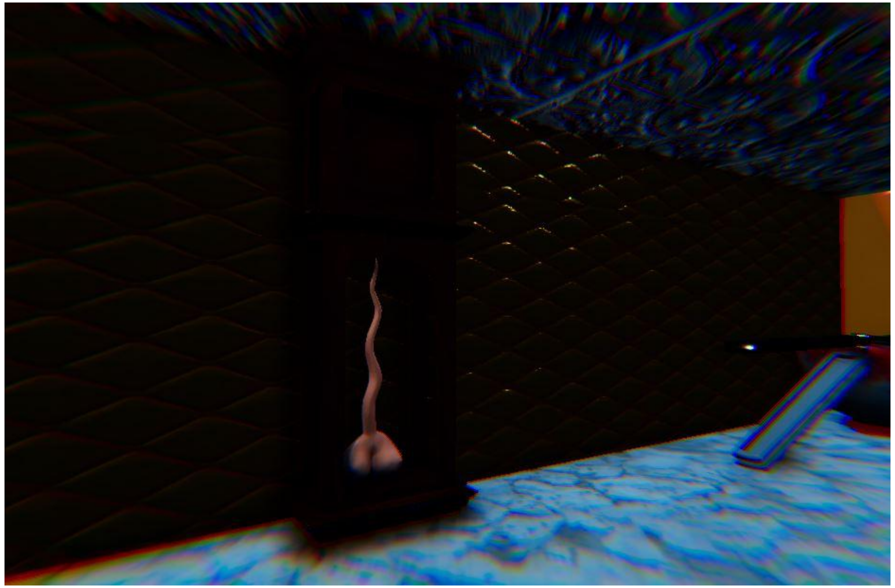
VR Nuances

08

To recreate reality in a virtual space, realistic physics are essential to trick users perception.

Using:

Hinge, with force (Pendulum)



Discussion and analysis/Data collection

- audiences cannot focus
- cannot obtain high attention value from EEG
- cannot stay focus for too long
  - blurry image in game
  - audiences not noticing the beauty of 3D objects

Discussion and analysis/Data collection

- audiences play with the interactive projects a lot
- do not travel and explore the world enough
  - distraction, interfering them from discovering the world
  - the aim is discovering and experiencing

Discussion and analysis/Data collection

- audiences assume that everything is grabbable
- tried to pick up everything
- even not grabbable
  - ruins the VR experience
  - hands poke through the objects
  - looks and feels unrealistic.

Possible improvement

- Dynamic floor and ceiling for attention value
    - Adapt to audience’s ability to focus
- VR, realistic simulations
    - Beverage Dispenser
    - Rotating Kebab machine
    - Water tap

Conclusion

“Successfully delivered a lucid dreaming experience with a high degree of completion”

Conclusion

Oculus Rift and MindWave: provided the possibility of immersiveness

Assets & scene: guarantee the aesthetic and impression of the artwork + the visual expression we want to convey.

Software: provides the interactivity and genuineness of a dream should have, + CS technical merits

Overall: every nuance packed backed with comprehensive & solid science

Thank you.