

**BScCM Final Year Project 2017 – 2018**  
**Phase II Final Report of SM4701(LA2) Graduation**  
**Thesis/Project (BScCM FYP Implementation - Phase II)**

**<< Group No. 13 | Duo >>**

# Check the group no. here when it is available: <https://sm4602.wordpress.com/appendix-i-check-list-for-bsccm-fyp/>

**<< False Awakening >>**

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# FALSE AWAKENING

**BSC FYP 2018**

*Final Report by:*

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*May 18, 2018*

LUCID  
DREAMING  
IN  
VR



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# 1. INTRODUCTION

False Awakening is an immersive and interactive art installation, which recreates Andrew's surrealistic and symbolic lucid dreaming experience, harnessing virtual reality (VR) and electroencephalography (EEG) technology.

# 2. OBJECTIVE/DESCRIPTION

The audiences will be invited to put on the "Dream Machine", which is a generic helmet, incorporated an Oculus Rift virtual reality headset and a NeuroSky MindWave brainwave-sensing headset. They sit on a rocking chair placed in the room decorated with concept arts, objects related to Andrew's fantasy and reference photos.

The audiences experience lucid dreaming by 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.

The content of the dream world, which is created based on Andrew's dream, imagination, and the mergence of his unconscious thoughts and conscious ideas, involves three themes: memories, fantasy and sex. It is also greatly influenced by theories of dreams proposed by Sigmund Freud, Surrealism and Symbolism.

This project has been developed by my partner and I for 10 months. I am in charge of the technical side: software and hardware coding, while Andrew is responsible for building the dream world. It ultimately fulfils the objectives of preserving and expressing my precious memory, wild imagination, perspectives and personalities, inspiring others to break through the constraint of logic and reason we have in a modern society, explore the possibility of embracing the emotional, intuitive, creative thinking, and express their ideas without boundaries. In addition, the VR experience serves the purpose of recreating a dream which is true to reality with semi-realistic physics, meanwhile providing intriguing interactivity.

### 3. DELIVERABLES

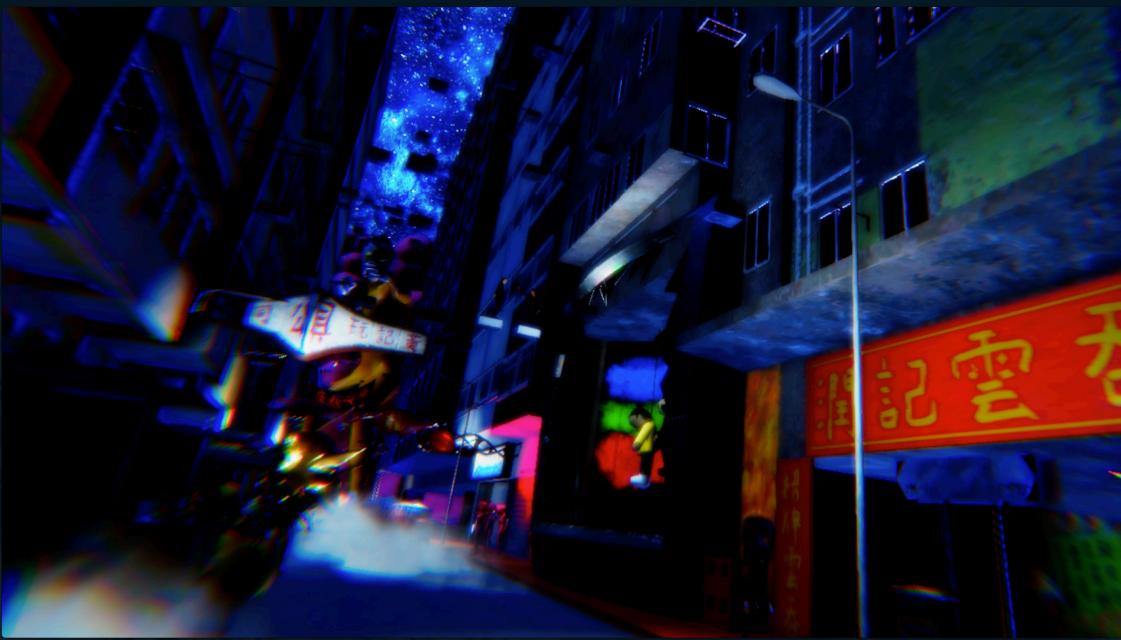
Installation location setup



Dream Machine (Oculus Rift & MindWave)

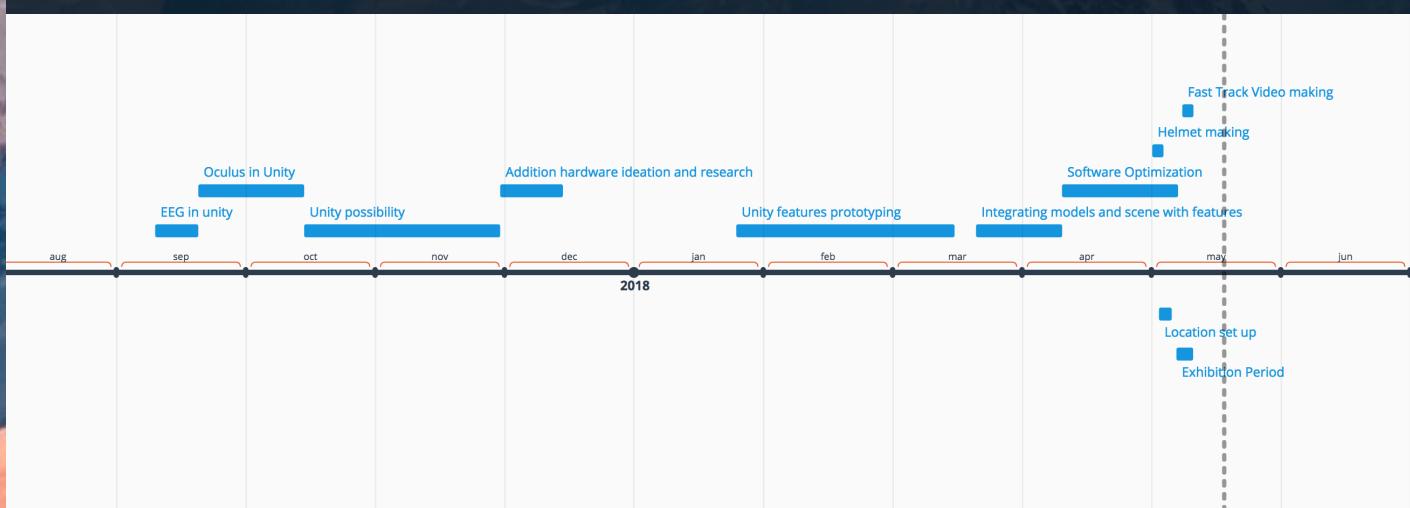


Executable software (developed in Unity3D)



3D in-game assets

## 4. WORK PLAN/MILESTONES/GANTT CHART



## 5. INSPIRATION

### EEG

I commence ideation from the technical aspect. It seems quite boring for every past FYP students to develop projects that does not include a WOW factor. There has been a lot of pure VR games, and pure interactive projects employing stereotypical interfaces like Kinect and LeapMotion. Therefore I have been trying to discover new possibilities of human computer interfaces for a while and I found brainwave interesting. After a thorough research, Electroencephalography (EEG) devices would be the perfect input devices, which can obtain brainwave data from a human being, that I have been looking for.

### VIRTUAL REALITY

For EEG headset, such a high-tech and intuitive device, I would like to use something which can provide immersive experience to compliment that. Thereby, I think the only answer would still be VR, considering the technology available at this moment. At least it wouldn't be conservative and mediocre like pure VR. The initial idea was mind controlling objects in a VR environment, meanwhile try my best to get rid of the pro

### LUCID DREAMING & PARTNER

A friend of mine, Andrew, from BA wanted to do VR for his FYP as well. He introduced "lucid dreaming" as the main theme. I did resonate to it since I love the movie "Inception" by Christopher Nolan, and I have watched documentaries which analyse the science behind the movie, which is super intriguing.

Coincidentally lucid dreaming is closely related to human's brain activity. Brainwave can reflect consciousness, concentration, sleep and meditation state of a person. What is even more a coincident is VR headsets and the EEG devices are both head-mounted devices, which will be great to be combined into one single unibody but multi-functional device.

### DREAM BUILDING

After a bit of discussion, we found his creative skills, especially 3D skills should generate a very good chemistry with my technical implementation, like programming. Hence we decided to team up, with Andrew in charge of the art, and I in charge of the science.

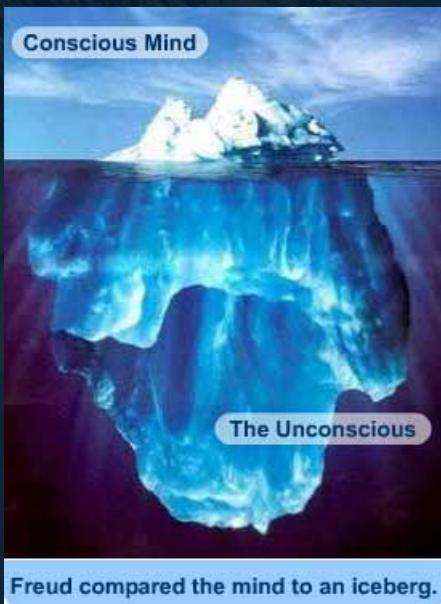
# 6. BACKGROUND RESEARCH/SURVEY

## DREAM

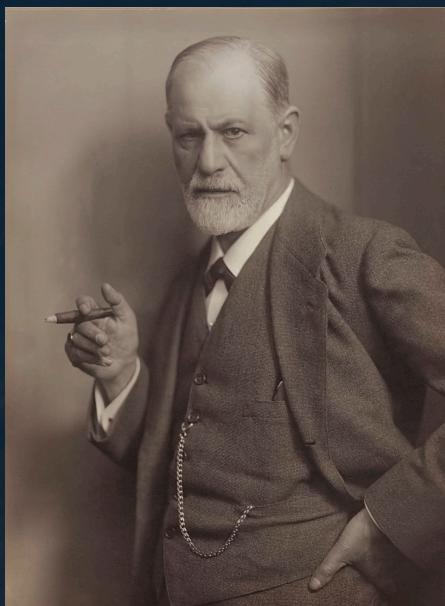
### ***The Unconscious***

Conscious defences is loosened up during sleep. Which is a concept introduced by Sigmund Freud's: The Unconscious.<sup>1</sup>

People sometimes lapse unconsciously, which justify there is in fact another force interfering our conscious.



Freud compared the mind to an iceberg.



Sigmund Freud's idea is usually illustrated via a metaphor of Iceberg. The Unconscious, which also known as "Libido", is repressed due to socialisation, but it is actually present in the bottom of mind, it only reappears in consciousness under certain circumstances. The circumstance would be sleeping. Therefore, the contents in dreams are the result of unconsciousness. Meanwhile, It feels vivid in our dreams as it is in real life which can be explained with the physiological mechanism when we dream.

Rapid eye movement sleep (REM sleep, REMS) is a unique phase of sleep in mammals and birds, distinguishable by random/rapid movement of the eyes<sup>2</sup>. During REM, brain's motor cortex remains active and most importantly, the brainwave looks very similar to that of awake, which justify why it is hardly distinguishable from dreams to realities.

In dreams, our mind continuously create and perceive our world simultaneously, and it does this very well that we cannot even notice it's happening. A new "interpretation" is consciously created by the mind. Then, we experience the result of that "new interpretation", forming a reciprocal causation. These scenarios help in delaying wake, just like the guardian of sleep<sup>3</sup>.

But it is only a subsidiary function of dreams.

Main function for dreams is fulfil the repressed wish<sup>4</sup>. In our dreams, wishes can always be fulfilled no matter how hard they are in reality.

### ***The Dream Work***

Often in the dreams, we see irrelevant or even ridiculous combinations of objects, people, time, places and events. This is because when producing a dream, the unconscious tends to combine multiple elements into a sole element. Such a process is called "Condensation", and it further inspires Surrealism artists<sup>5</sup>. Usually, unconscious visualises abstract feelings and ideas in the dreams with materials from what we see in day time and major childhood memories.

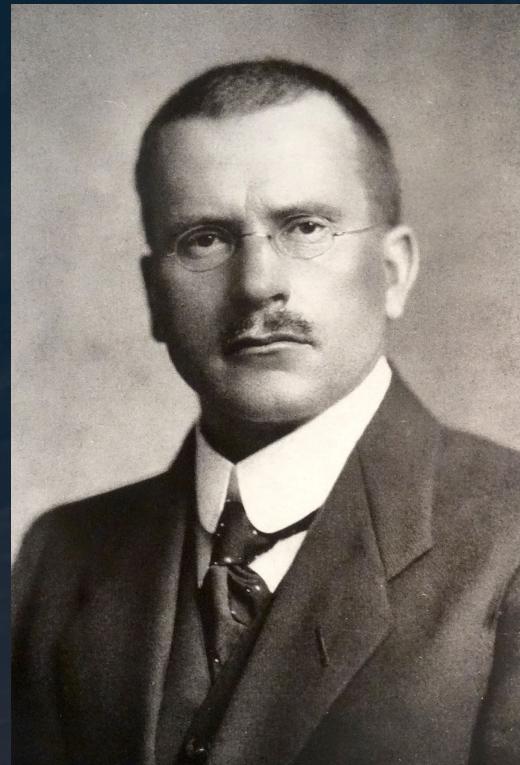
### ***Active Imagination***

In the purpose of bridging the gap between the conscious and unconscious by inspiration, the contents of the unconscious are allowed to get into the conscious actively. This is the process of "Active Imagination"<sup>6</sup>.

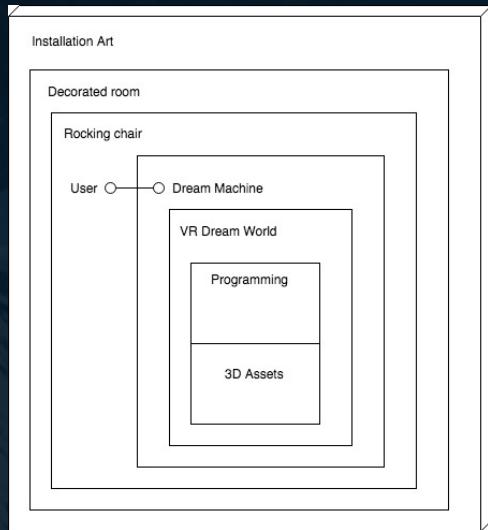
Jung found that, if a person cannot explain or even recall his/her own dream, he/she could try to stop thinking in language and rationality, instead create an unconfined world with imagination. This would help bringing the unconscious contents up to the conscious. Hence, imagining actively in day time is dreaming with eyes open, while dreaming at night is imagining actively with eyes close.

According to "The typical dreams of Canadian university students", 73% falling, 76% sex. The psychologists have studies the most common theme in dreams<sup>7</sup>. Study shows most people have dreamed about sexual experience (76%) and falling(73%).

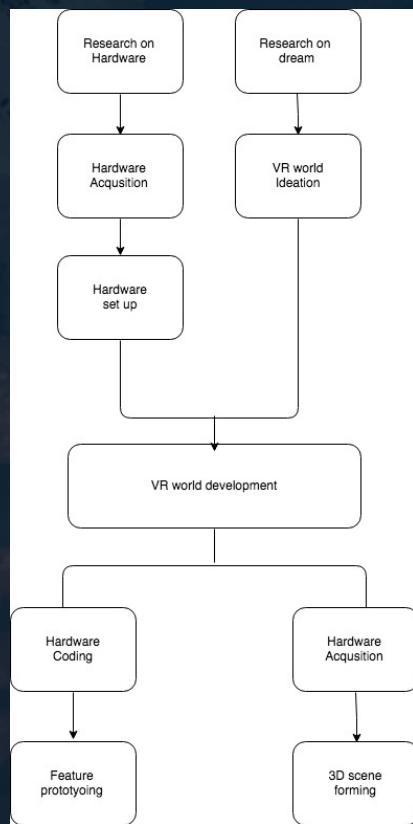
Jung claims, under the personal unconscious, there lies a deeper collective unconscious shared by all human beings. Collective unconscious transcend all individuals, and it is an adaptation strategy of the evolution of human psyche. Experiencing falling is highly possibly engendered from our primate ancestor's experience of falling from high spot, like trees. This falling sense embeds into human collective unconscious after millions years of evolution.



## 7. FRAMEWORK



## 8. METHODOLOGY



# 9. IMPLEMENTATION AND EVALUATION (WITH TECHNICAL MERITS)

## A. HARDWARE

### 1. *Oculus Rift*

The whole bundle of Oculus Rift (the VR headset), a pair of Touch (the controller) and a pair of sensor has been purchased in the late August.

With this bundle, a full on Virtual Reality System can be created. With two sensors, the system can perform accurate, room scale head position and orientation tracking, and also controller tracker.



### 2. *MindWave Mobile*

The MindWave Mobile EEG headset is also purchased all the way from the States.

Mobile is essentially the bluetooth version. I was told that the readings from the headset is not the reliable. In fact, the am able to control the concentration and meditation readings as the instruction told and as I want.



### 3. VR PC

We have upgraded an existing i7 computer with an Nvidia GTX 1070 graphics card. Prior to actual development, we have used the machine to play with some VR demo and games. The machine works perfectly fine, and we believe there will not be hardware limitation upon the gaming hardware.



### 4. The Dream Machine

With the coincident that VR and MindWave Mobile are all head mounted device, we merge the two with a generic skateboarding helmet to form a "Dream Machine". Referencing the film "Inception", which the characters use a machine in a suitcase form to bring them to sleep, it makes sense utilise some sort of machine, for our case wearing a helmet, to do the same purpose.



## B. SOFTWARE

### I. EEG (electroencephalogram)

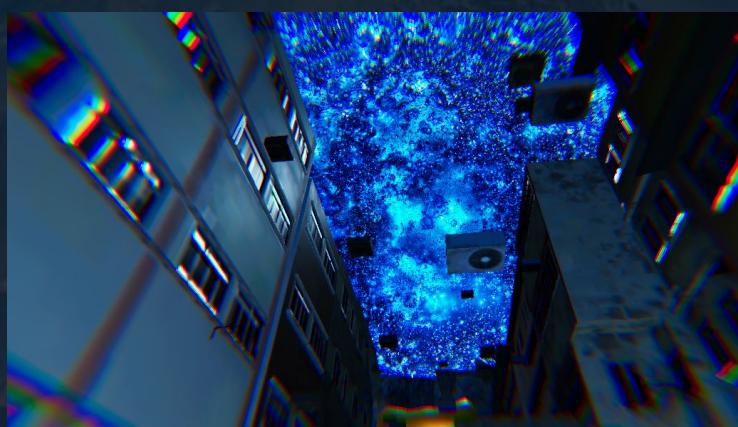
The MindWave headset, which is one of the components of the Dream Machine, can detect electroencephalogram (frankly brainwave) with the sensor placed on user's forehead. With Neurosky's (the headset manufacturer) proprietary algorithm, "attention" and "meditation" values can be obtained from the headset and the signal is sent back to the computer via bluetooth technology.

Each reading is designated with its own purpose.

The "attention" level is bound with the clarity of users' vision in the VR environment. Whenever the user pay more attention and focus, the eyes in the VR environment try to focus and the image becomes sharper and clearer. If the attention level is low, the user will simply perceive a blurry and washed out image.



On the other hand, the "meditation" level is relating with the revolution of the custom skybox. Whenever the user is calm and meditating, the revolution of the starry sky remains low, which is essentially a metaphoric image of a tranquil sky without sparkling stars, reminiscing a peaceful mind with serenity. Contrarily, stars glitters and shine immensely, representing an unsettled state of mind.



## Techical Merit

### TCPCClient Connection

```
1.  public void Connect() {
2.      if(!IsInvoking("ParseData")){
3.          client = new TcpClient("127.0.0.1", 13854)
4.          stream = client.GetStream();
5.          buffer = new byte[1024];
6.          byte[] myWriteBuffer =
7.             Encoding.ASCII.GetBytes(@"{""enableRawOutput"": true, ""format"": ""Json""}");
8.          stream.Write(myWriteBuffer, 0, myWriteBuffer.Length);
9.          InvokeRepeating("ParseData",0.01f,0.05f);
10.     }
11. }
```

A TCP Socket is setup for the MindWave EEG headset, via Bluetooth. A byte of acknowledge message is converted into byte and send back to MindWave to ask for further data.

```
1.  void ParseData(){
2.      if(stream.CanRead){
3.          connected = true;
4.          try {
5.              int bytesRead = stream.Read(buffer, 0, buffer.Length);
6.              string[] packets = Encoding.ASCII.GetString(buffer, 0, bytesRead).Split('\r');
7.              foreach(string packet in packets){
8.                  if(packet.Length == 0)
9.                      continue;
10.                 IDictionary primary = (IDictionary)JsonConvert.Import(typeof(IDictionary), packet);
11.                 if(primary.Contains("eSense")){
12.                     IDictionary eSense = (IDictionary)primary["eSense"];
13.                     if(UpdateAttentionEvent != null){
14.                         UpdateAttentionEvent(int.Parse(eSense["attention"].ToString()));
15.                     }
16.                     if(UpdateMeditationEvent != null){
17.                         UpdateMeditationEvent(int.Parse(eSense["meditation"].ToString()));
18.                     }
19.                 }
20.             }
21.             catch(IOException e){ Debug.Log("IOException " + e); }
22.             catch(System.Exception e){ Debug.Log("Exception " + e); }
23.         }
24.     }
```

The byte is split with "\r", converted to string and stored in a general iDictionary called "primary", then shrink down to another iDictionary which only contains the value of "eSence" (a keyword for retrieving useful data from MindWave), then get the "attention" and "meditation" value and update the value via 2 update event listener.

### Exponential Smoothing Algorithm

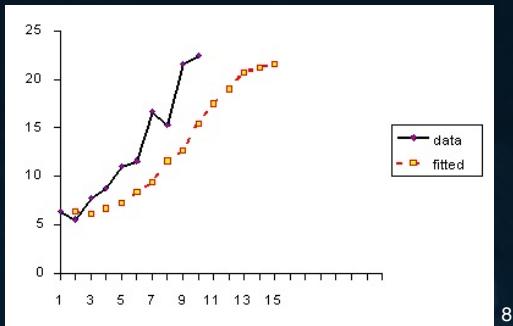
```
1.  void smoothValue(float rawValue) {
2.      smoothed = smoothed + (rawValue - smoothed) / alpha;
3.  }
```

As  $\alpha$  is a constant, where  $0 < \alpha < 1$ , alpha value is converted into a fraction instead.

The next smoothed value is sum of the existing smoothed value and the difference of the incoming raw value.

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

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



PLOT DEMONSTRATING INADEQUACY OF SINGLE EXPONENTIAL SMOOTHING WHEN THERE IS TREND

In the **simple moving average algorithm**, the past observations are weighted equally, while exponential functions are used to assign **exponentially decreasing weights over time**. Simple moving average is not applicable for my case, but exponential smoothing suits my case as I need to **forecast** the value base on just previous actual value and smoothed value, since the hardware itself limits the refresh rate to a sluggish 1Hz.

## Custom Shader

```

1. //volumetric rendering
2. float s = 0.1, fade = 1.0;
3. float3 v = float3(0, 0, 0);
4. for (int r = 0; r < _Volsteps; r++) {
5.     float3 p = abs(from + s * dir * .5);
6.     p = abs(float3(tile - fmod(p, tile*2)));
7.     float pa,a = pa = 0.;
8.     for (int i = 0; i < _Iterations; i++) {
9.         p = abs(p) / dot(p, p) - formparam;
10.        a += abs(length(p) - pa);
11.        pa = length(p);
12.    }
13.    //Dark matter
14.    float dm = max(0., darkmatter - a * a * .001);
15.    if (r > 6) { fade *= 1. - dm; } // Render distant darkmatter
16.    a *= a * a; //add contrast
17.    v += fade;
18.    // coloring based on distance
19.    v += float3(s, s*s, s*s*s*s) * a * brightness * fade;
20.    // distance fading
21.    fade *= distFade;
22.    s += stepSize;
23. }
```

The shader is a ready made bought from Unity Assets Store. We change the `formparam` with the mapped meditation reading from the headset. The author of the shader explained all the functions of the variables clearly, except the `formparam` variable , that he stated it as a "magical number" without proper reasoning.

With my own understanding, the greater the `formparam` , the lower the `p` & `a` would be. Thereby has more darkmatter rendered, as darkmatter is subtracted by `a`. `dot()` on line 9, means 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.

## **II. Scene Management**

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.

The entire system runs as the following:

1. Software starts
2. EEG headset connects to the computer, and does the setup
  1. Connection cause serious frame drops
  2. connection will be done only once, when the operator setup the location and equipment
  3. Setup will be done every time this "stand-by" scene is being loaded.
  4. 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.
  5. EEG is ready for incoming signal before users putting on the headset
  6. no lag will be experienced by the users
3. Users put on the Dream Machine
  1. The user is in this "stand-by" scene, where the environment is blacked out, what users can see is their bare hands in VR
  2. The VR headset detects that the device is put on, image fades in
4. Users clip the ear clip onto their earlobe
  1. EEG signal can be detected
  2. Once EEG signal is detected, the system enters the "dream" scene without loading
  3. Visuals fade in
  4. Song fade out
5. Users enjoy the lucid dreaming experience
6. Users take off the Dream Machine / remove the earclip
  1. If Dream Machine is take off, the system immediately enter the "stand-by" scene again
  2. Even the ear clip is not removed, the system does the setup processing and load the "dream" scene in the background again
  3. The system is ready for the next user
  4. Go to step 3, and iterate

## **Techical Merit**

### **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
        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;
}
}
}

```

An AsyncOperation loads the level asynchronously in the background. Unity completely loads the entire scene in a background loading thread, which allows the next scene to be loaded while still playing the current one, and switch seamlessly to the next without delay. It is essential that a normal loading scene operation will show a loading wheel on Oculus's screen, which destroys the entire realistic "dreaming" experience. On top of the instant scene switching, a "dip to black" fade in is added to provide smooth transition experience.

### **III. VR Grabbable objects**

One of the main reason why VR is immersive is VR involves players' physical interaction with virtual objects in the VR environment, which is perceived as realistic as we do in real life. In order to trick audiences to think the dream is real, we should incorporate natural physical interaction in the dream as much as we can.

#### **Techical Merit**

##### **OVR Grabbable**

Most of the objects in the VR environment are attached with "Rigidbody" and "MeshColliders" components, which are some of the essential Unity3D physics components. Exploiting "OVR Grabbable", from the official Oculus Unity framework, objects can be grabbed, thrown, & involves realistic physics, just like the what we normally experience in the reality.

### **IV. Chicken Wandering**

The attention to details in the VR environment is crucial to establish another reality within this virtual environment. Especially, Non-Player Characters (NPCs) should behave like how they should behave in reality. Hence a flock of wandering chicken should be nuance for this dream environment.



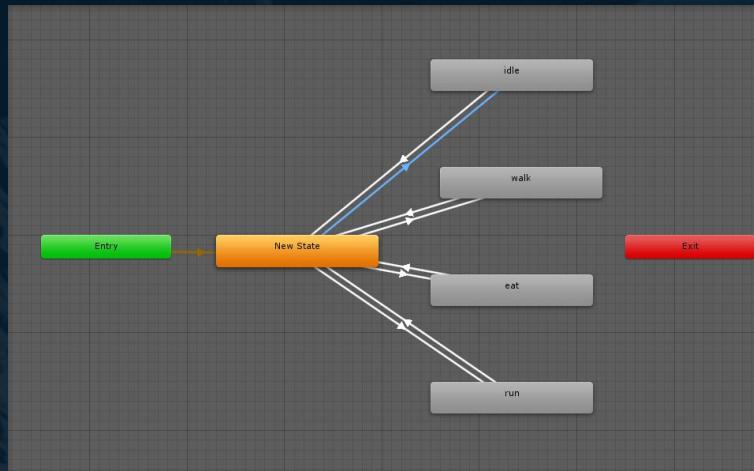
#### **Techical Merit**

##### **Finite State Machine (FSM)**

A Finite State Machines is perfect for creating AI. As it is commonly used for organising an execution flow, and usually goes on and on, it resembles agent's wandering and patrolling

behaviour very well. For this case, the chickens wander with different speed, and realistic animations played on each state correspondingly.

Chickens in this chicken ring are essentially Artificial Intelligences. Harnessing FSM, chicken's movement can fall into 5 states in total. Including "Idle", "Stay", "Eat", "Walk" and "Run". Each chicken get into only one state at a time. After finishing a state, the chicken returns to the "Empty" state, wait for a second, and then switch to another state randomly (1 of 4).



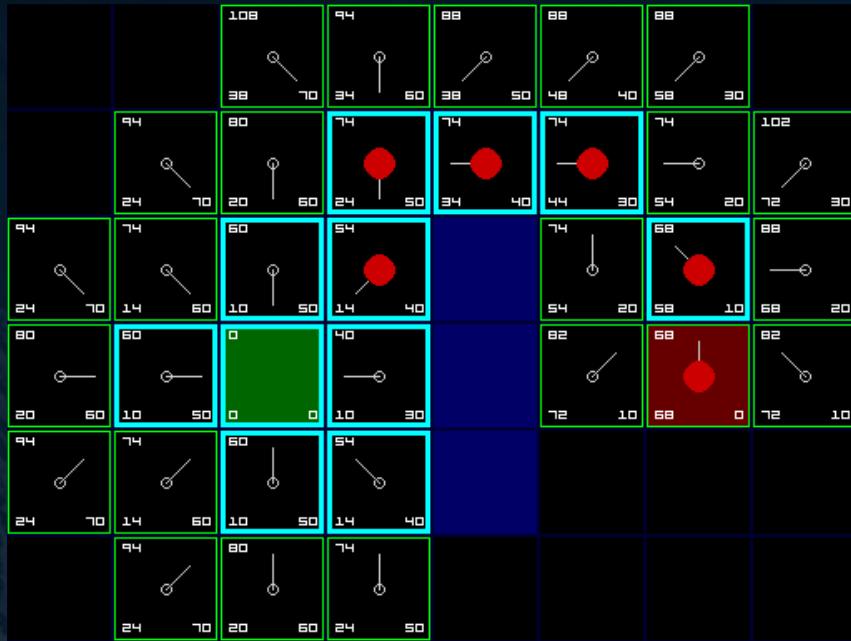
## V. AI pedestrian system

All exotic characters from Andrew's fantasy are walking on the street with their own destinations. These characters are all Artificial Intelligence agents. These agents travel through the map using A\* pathfinding algorithm. A\* algorithm is an effective algorithm which make sure Al's go to the destination in the shortest distance available. These AI agents can walk and run on the NavMesh (Navigation mesh), which is baked beforehand. These AI avatars not only avoid each other, but also the user. Prior to employing A\* pathfinding, a simple and crude straight line movement, from point A to point B, without any obstacle avoidance.



## Techical Merit

### A\* Pathfinding



A\* pathfinding algorithm is one of the most used pathfinding algorithm in game development. It is performant, efficient and accurate. It guarantees to find the best and shortest path between any starting point and any destination.

When performing A\* path 3 costs for each node are considerer.

H cost: Heuristic cost (distance from end node)

G cost: Movement cost (distance from starting node)

F cost: H + G

And 2 lists are maintained.

Open list: with nodes being considered

Close list: with nodes that will not be considered

```

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

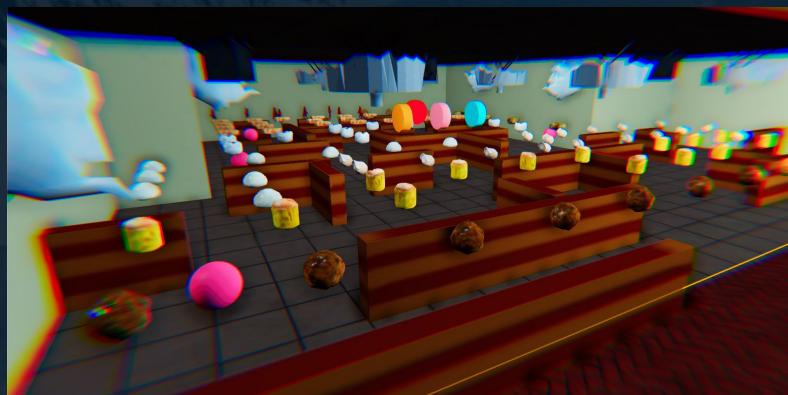
```

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## **VI. Pacman**

This Pacman in Hong Kong style is basically reminiscing the original Pacman arcade game from 1980. There are four unique Als, each behaves uniquely and they all walk inside the maze with baked NavMesh.

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



---

## **VII. Pushable door**

This feature serves the purpose of reality simulation. A hinge component from Unity is attached to the door. While spring is also applied, the door bounce back after impact. The door interacts with Rigidbodies, like player's hands. If the player pushes, the doors open along the pushing motion.



---

## **VIII. Breakable glass**

Breaking glass symbolise a sense of destruction and break through, revealing the truth concealed that is located behind the glass. In this case, users can break the glass to access the forbidden sex space.

The glass plate detects incoming collision. The original glass replace the itself with a pre-segmented glass, formed with individual fragments, at the moment of user's hand colliding with the glass. Simultaneously, the collision add explosion force to the fragmented glass when user smash the it.



---

## **IX. Punching bags**

On top of physical interaction, this kind of punching interaction becomes the fun factor for being in VR environment. Players love to play with certain playful objects in the scene and this would be one of it.

A spring component is attached to punching bags and hanging bigs, alongside Rigidbody and mesh collider. It involves real physics, when users punch these objects, they are punched away and they bounce back to where you hit it from.



---

## X. Respawn system

As mentioned, most of the human beings experience "falling" in a dream, which justify there is indeed a collective subconscious lies beneath one's personal subconscious. We emulate this in the VR environment. When the user falls and drops onto an invisible safety net placed several metres under the ground, user is teleported back to the sky on the same latitude and longitude, but a higher altitude, and drop onto the ground again. Frankly, the user will never "dies" in the dream.

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## XI. Moving vehicles

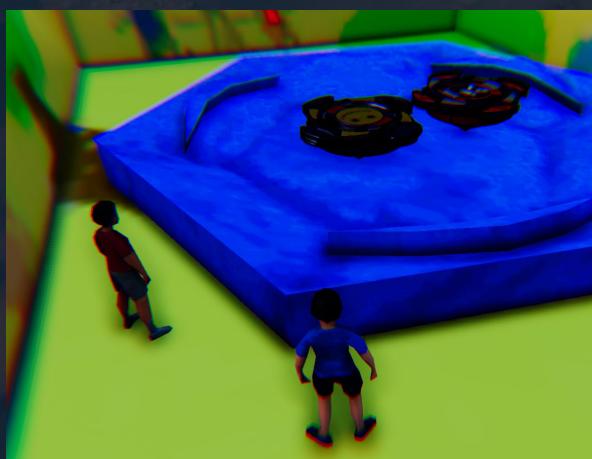
Certain amount of vehicles are being maintained in a system. Vehicles are instantiated at point A, then they translate from point A to B in various speed, and being destroyed at point B.



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## XII. Moving Beyblade

Beyblade is one of the childhood toys which draws a substantial impact on Andrew. While simulating the physics, the two beyblades are programmed to attack each other. Despite of rotation, torque and force are applied, in order to incite intensive crashing and bumping, they might even lifted away from the ground because of the great impact.



### XIII. Surveillance system

Render Texture is the key for this feature. In-game cameras' rendering is captured and placed onto a custom texture. Then texture can be applied on any object, in this case a quad on the monitor. With Kuwahara algorithm, an edge preserving image filter, the image turns into an oil painting.



#### Techical Merit Kuwahara Filter

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

```
float2 start[4] = {_Radius, _Radius}, {_Radius, 0}, {0, -_Radius}, {0, 0};  
float2 pos;  
float3 col;  
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;  
        }  
    }  
}
```

a	a	a/b	b	b
a	a	a/b	b	b
a/c	a/c	a <b>b</b> / c/d	b/d	b/d
c	c	c/d	d	d
c	c	c/d	d	d

A region of an original texture is divided into 4(k) square regions a,b,c,d (NW, NE, SW, SE) with the pixels located on the central row and column belonging to more than one region. For every pixel in the  $_Radius * _Radius$  size region, the colour values and the square of the colour values are being added to the **sum for arithmetic mean** (mean[k]) and **standard deviation σ sigma**(sigma[k]) respectively.

```
float sigma2;  
float n = pow(_Radius + 1, 2);  
float4 color = tex2D(_MainTex, uv);  
float min = 1;  
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;  
    }  
}
```

After that, all the arithmetic mean and standard deviation  $\sigma$  sigma for the 4 regions are being calculated and compared. According to the Kuwahara algorithm, the central pixel

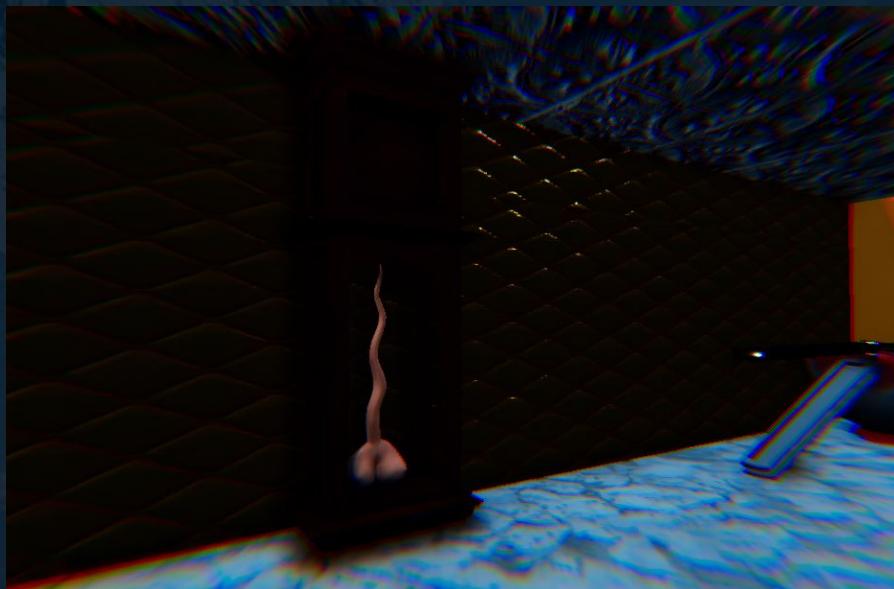
always tends to select the mean colour value which has the least standard deviation, which mean the greatest similarity. For example, the pixel located on a darker side of the edge will most probably take the mean color value of the darker region, vice versa. That said, the edges can be preserved as such principle creates contrast along the edges of objects appeared on the texture.

In a nut shell, the so called "oil paint" effect is essentially achieved through smoothing the pixels and seeing the edges, each chunk of similar pixels are like each stroke of oil paint from a brush.

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#### XIV. *Swinging boobs*

This feature is a physics simulation, recreating a moving pendulum. Hinge component is attached to the boobs. Then the program apply force onto the boobs on each side to push the boobs to the other side, ultimately bounce back and forth.



## 10. DISCUSSION AND ANALYSIS/DATA COLLECTION

After we have set up the installation on site, one major discovery, or a issue is most audiences cannot focus to obtain high attention value from the EEG headset. A relatively low attention reading leads to a blurry image in game, which would incite the problem of audiences not noticing the details of the 3D objects, which is a waste of Andrew's hard work of building these amazing models. Most of them obtain an attention reading of 50. If someone is able to focus, they cannot stay focus for too long, which also means they cannot explore the world with clear image for most of the journey, and it takes us back to the same problem, most of the detailed models are not being seen.

The other point we discovered is, audiences play with the interactive projects a lot that they do not travel and explore the world enough. In other words, these playable objects become the distraction, interfering them from discovering the world. Such meaningless interaction is not the aim of the project.

Last but not least, audiences assume that everything is grabbable then they tried to pick up everything, however it is not. Which leads to another problem: grabbing a non-grabbable object ruins the VR experience, their hands poke through the objects, which looks and feels unrealistic.

## 11. CONCLUDING REMARKS: A CRITICAL APPRAISAL OF THE PROJECT

After 10 months of development, from ideation to on site installation exhibition, I consider this project an above average one. Ignoring the problems discovered and mentioned in the previous section, there are still many to be appreciated.

The selection of theme, and the adaptation to the hardware and software is superb.

First and foremost, selecting the theme of "dreaming" is a great choice that this topic is rarely adopted in previous student's FYP. Dreaming is a very intriguing topic which every one can resonate with it, as everyone dreams. While talking about dream, almost all the ideas we wanted to bring into the artwork are supported by solid science theories, books written by renowned scientist, like Sigmund Freud and Carl Jung. Such scientific support further consolidate the mindset of setting up the artwork, as what we think of and what we do are genuinely reasonable and rational.

It is such a miracle that dreaming can perfectly adapt to the VR environment and EEG can act as the interface. VR provides the immersiveness and genuineness that a realistic dreaming experience requires. Meanwhile, EEG backs the science of dreaming, and it makes the concept of "actively creating/altering the dream" possible, in an intuitive mean, without a traditional physical interaction using a proprietary VR controller as the input. And the implementation makes it moderately subtle that users will not question why the brainwave sensor exist.

I really appreciate what Andrew has created for the entire VR world. It takes a long time to build all the detailed 3D models and incorporate vivid animation. Although, we originally decided to focus on building a building at the ending, instead of spending our effort on the street, it is already time consuming enough for building the street. The visual is the face of this project. If the model, texture and lighting does not look good, audiences would immediately have a bad impression on the entire project. Indeed, the visual wow the audiences, hence the audiences will have the interest to know more or even try out our artwork.

However, there are still much can be done, in the aspect of programming, and adding more details.

Actually, there are still rooms for improvement for the programming part. If there is more time available, I would further develop the pedestrians system. As the AIs (walking avatars) would easily jam in some certain spots. In addition, the not so controlled randomness involved in instantiating the AI, and different moving speed cause unpredictable traffic jam. Honestly, the way of the avatars walking is not as naturally as in reality. More fine tune would be need, to fulfil my own expectation and standard.

## 12. SUMMARY

To conclude, False Awakening has successfully delivered a lucid dreaming experience with a high degree of completion. Employing ideal hardware, like the Oculus Rift and MindWave, they provided the possibility of immersiveness. Creating and gathering detailed and exotic 3D assets to form a scene guarantee the aesthetic and impression of the artwork, and also the visual expression we want to convey. The software coding provides the interactivity and genuineness of a dream should have, altogether with CS technical merits. Overall, every nuance packed and decision made for the work is backed with comprehensive and solid science. In a nut shell, False Awakening accomplished what we expect and serve the intended purpose.

## 13. ACKNOWLEDGMENTS

In the accomplishment of this project, I would like to thank all the people who have been concerned with this project.

Primarily I would thank Andrew, my partner for cooperating with me, even he was on exchange in semester A. Without your brilliant ideas and fascinating assets, the project would not be finished by my own.

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Then I would like to thank my uncle for getting me all the required hardware I need, all the way from the USA to Hong Kong. Last but not least, my loved ones and friends who have helped me with their valuable care and suggestions during the development period.

## 14. APPENDICES: RELEVANT INFORMATION LISTING ALL SUPPORT MATERIAL

<sup>1</sup> Freud, S. (2015) *The Unconscious*. London: Penguin Books Ltd.

<sup>2</sup> Alan, W (2017) *Sleep, Dream & Consciousness*. Hong Kong: CUHK

<sup>3</sup> Freud, S. (2015) *The Unconscious*. London: Penguin Books Ltd.

<sup>4</sup> Freud, S. (2015) *A General Introduction to Psychoanalysis*. Herts: Wordsworth Editions Ltd.

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<sup>7</sup> Tore A. Nielsen, Antonio L. Zadra, Valérie Simard, Sébastien Saucier, Philippe Stenstrom, Carlyle Smith, Don Kuiken. (2003). The Typical Dreams of Canadian University Students . Retrieved from <https://link.springer.com/article/10.1023/B:DREM.0000003144.40929.0b>

<sup>8</sup> Forecasting with Single Exponential Smoothing. <https://www.itl.nist.gov/div898/handbook/pmc/section4/pmc432.htm>