Assignment # 3

Effect of Street Light on Commuting Bats

IE501914 - Immersive Technologies

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Introduction & Motivation

The main idea of this project is to develop an immersive experience for lighting infrastructure designers in context of NORDARK Project to visualize the behavior of bats effecting from artificial light pollution.

The lesser horseshoe bats, also known as Rhinolophus hipposideros, are a small bat species (weighs only 5-9 grams, approximately 19-25 cm long) found mostly in Europe and parts of Asia. They are famous for their horseshoe-shaped nose leaf, which helps in echolocation.

These bat species are facing several threats, the same as many other bat species because of human activities, habitat loss and pesticides use.

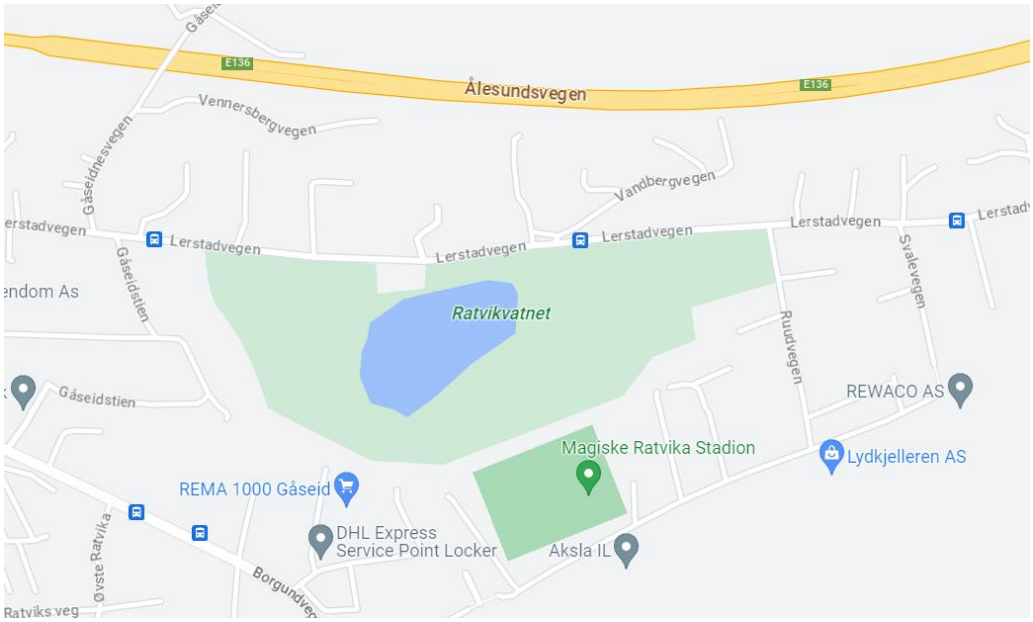
Artificial streetlights can have negative impacts on these species of bats. This specific species rarely flies more than ***five meters*** above the ground, so they are more affected by the light pollution. Like many bat species including lesser horseshoe are nocturnal and use echolocation to find the prey in the dark, so street lighting can disrupt their echolocation and in result making it more difficult to find the food. Street lighting can also disrupt the natural day-night cycles of bats, which can impact their feeding and mating behaviors.

The motivational idea of this project implementation in virtual reality was taken from the paper [1]. In this paper, the researchers specifically studied the endangered Rhinolophus hipposideros bat species commute affected by artificial light pollution.

We assumed that only Rhinolophus hipposideros species of bat exists in the virtual environment. Also, these bat species' behavior is not affected by the weather conditions (rain or dust storm). To create a more immersive experience, we assume that the bat will move randomly without any specific movement speed and angle.

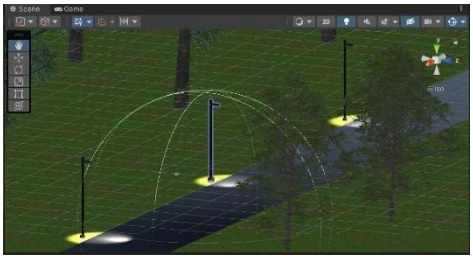
Study Area

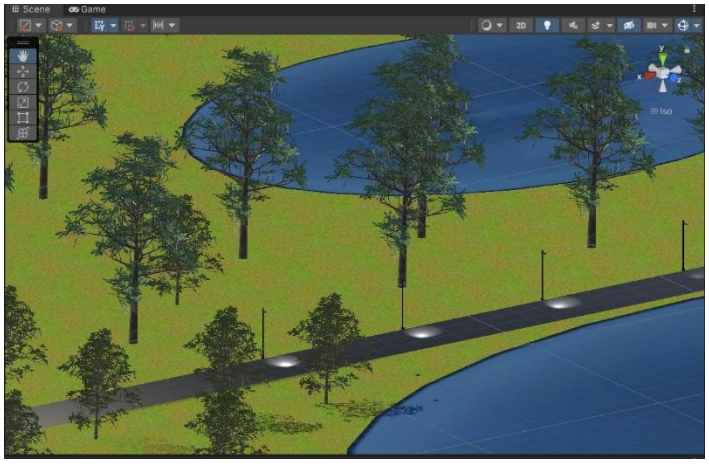
To study the behavior of these lesser horseshoe bats specie effected by light pollution, we got inspired from the site scale area of Ratvikvatnet which is a freshwater lake situated in Aalesund, More & Romsdal (Norway). The reason behind choosing this area was that there is already research regarding the effect of lighting species on different species is going on in this area in context of NORDARK project.



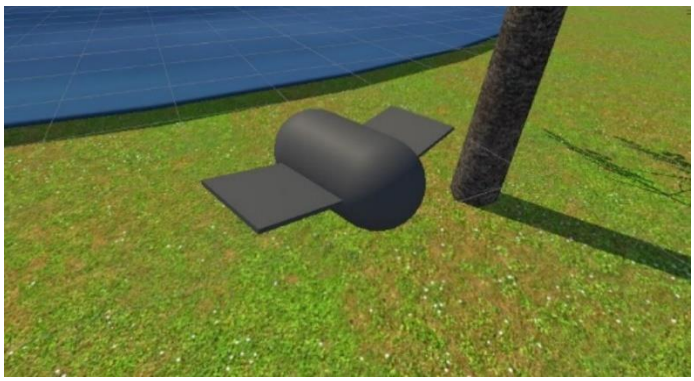
Virtual Environment

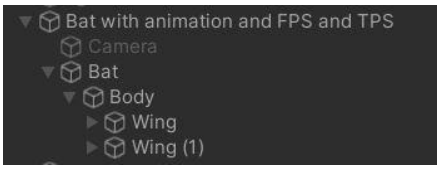
A virtual environment consisting of lake, trees, street lights & moving bats was created in Unity 3D that is a digital replica of the area around Ratvikvatnet Lake. 3D model of street light containing spot light and 3D collider were developed in the scene to study the change in commuting behavior of bats as they pass through the light zone.





To create a more immersive experience, a 3D model of bat was developed in Unity 3D from scratch and two animations were attached with it. Every bat in the immersive environment has a camera to track its movement through FPS (First Person) & TPS (Third Person) perspective.





Instantiating of Bats

Bats were instantiated in the scene using the unity 3D method. The number of bats can be changed by the user at different spawn points during runtime of immersive environment.

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```
1   using System.Collections;
2   using System.Collections.Generic;
3   using UnityEngine;
4
5   public class BatsInstantiate : MonoBehaviour
6   {
7       public GameObject bat;
8       public Transform[] spawnPoints;
9       public int numberofbats = 0;
10      public float seperationfactor = 5;
11
12      void Start()  // Start is called before the first frame update
13      {
14          instantiatebat();
15      }
16
17      void Update() // Update is called once per frame
18      {
19
20      }
21      void instantiatebat()
22      {
23          for (int i = 0; i < spawnPoints.Length; i++)
24          {
25              for (int x = 0; x < numberofbats; x++)
26              {
27                  Vector3 offset = spawnPoints[i].forward * seperationfactor;
28                  Instantiate(bat, spawnPoints[i].position + offset, Quaternion.identity);
29              }
30          }
31      }
32  }
33
```

Bats behavior in light

For implementation of this part, a script named “Behaviourchange” was created in unity 3D to detect whether the bat is in light zone or not by changing the bool ‘batIsInLight’ to ‘true’ when a bat enters the trigger zone associated with a streetlight, and to ‘false’ when it exits. This can be used to change the behavior of the bats in response to the presence or absence of streetlights in the virtual environment.

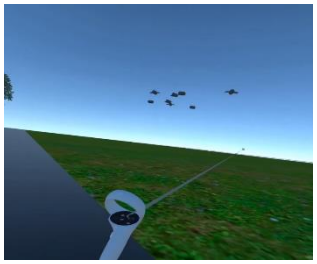
```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class Behaviourchange : MonoBehaviour
{
    public static bool batIsInLight;
    void Start()  // Start is called before the first frame update
    {
        batIsInLight = false;
    }

    void Update()   // Update is called once per frame
    {

    }

    public void OnTriggerEnter(Collider other)
    {
        if (other.gameObject.tag == "Light")
        {
            batIsInLight = true;
        }
    }

    public void OnTriggerExit(Collider other)
    {
        if (other.gameObject.tag == "Light")
        {
            batIsInLight = false;
        }
    }
}

```

A script “FlyingBat” is attached to every instantiated bat in the immersive scene and is responsible for the control of flight behavior of bats. The bat's movement speed and rotation angle changes randomly over time and respond differently depending on whether the bat is in the light or not. The FlyingBat object's movement speed and rotation angle are controlled by two sets of coroutines which depicts the normal and the aggressive behavior of the bat: changemovespeedN () and changerotationN() for normal behavior, and changemovespeedA () and changerotationA () for behavior under the influence of streetlights.

C: > Users > Zeshan Mubshir > Desktop > Batdemo > Assets > FlyingBat.cs

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class FlyingBat : MonoBehaviour
{
    public float moveafterseconds = 0.0f;
    public float moveSpeed = 0;
    public float rotateAngle = 0;
    Quaternion target
    void Start()
    {
        rotateAngle = 6;
        moveafterseconds = 2.0f;
        StartCoroutine(changemovespeedN());
        StartCoroutine(changerotationN());
    }
    void Update()
    {
        transform.Translate(Vector3.forward * Time.deltaTime * moveSpeed, Space.Self);

        if (Behaviourchange.batIsInLight == true)
        {
            StopCoroutine(changemovespeedN());
            StopCoroutine(changerotationN());

            StartCoroutine(changemovespeedA());
            StartCoroutine(changerotationA());
        }
        else if(Behaviourchange.batIsInLight == false)
        {
            StopCoroutine(changemovespeedA());
            StopCoroutine(changerotationA());

            StartCoroutine(changemovespeedN());
            StartCoroutine(changerotationN());
        }
    }
    IEnumerator changemovespeedN()
    {
        moveSpeed = Random.Range(4, 6);
        moveafterseconds = Random.Range(8, 10);
        yield return new WaitForSeconds(moveafterseconds);
        StartCoroutine(changemovespeedN());
    }
    IEnumerator changemovespeedA()
    {
        moveSpeed = Random.Range(10, 12);
        moveafterseconds = Random.Range(6, 9);
        yield return new WaitForSeconds(moveafterseconds);
        StartCoroutine(changemovespeedA());
    }
    IEnumerator changerotationN()
    {
        rotateAngle = Random.Range(-60, 60);
        transform.eulerAngles = new Vector3(0, (rotateAngle), 0);
        moveafterseconds = Random.Range(8, 10);
        yield return new WaitForSeconds(moveafterseconds);
        StartCoroutine(changerotationN());
    }
    IEnumerator changerotationA()
    {
        rotateAngle = Random.Range(-60, 60);
        transform.eulerAngles = new Vector3(0, (rotateAngle), 0);
        moveafterseconds = Random.Range(3, 4);
        yield return new WaitForSeconds(moveafterseconds);
        StartCoroutine(changerotationA());
    }
}
```

Oculus Integration package v15_0 was imported into the application which was connected with Meta Quest 2 device.



A teleportation technique was applied with the help of Oculus Right controller button “A” to allow the user to move to a specific location in the scene during runtime while wearing the VR headset. The below script checks with the if statement if the user has pressed the A button of the right controller of the Oculus. In result a ray cast will be generated from the controller in the scene toward the position where the user is pointing which will in turn change the position of the user.

```
void Update()
{
    RaycastHit hit;

    if(OVRInput.Get(OVRInput.Button.One))
    {
        if(Physics.Raycast(transform.position,transform.forward, out hit, raylenght*10))
        {
            //// press A
            if (hit.collider.gameObject.tag == "Ground")
            {
                // press A
                aboutToTeleport = true;
                teleportPos = hit.point;

                GameObject myLine = new GameObject();
                myLine.transform.position = transform.position;
                myLine.AddComponent<LineRenderer>();

                LineRenderer lr = myLine.GetComponent<LineRenderer>();
                lr.material = tMat;

                lr.startWidth = 0.01f;
                lr.endWidth = 0.01f;
                lr.SetPosition(0, transform.position);
                lr.SetPosition(1, hit.point);
                GameObject.Destroy(myLine, delay);

                pointer.transform.position = hit.point;

            }
            else

if(OVRInput.GetUp(OVRInput.Button.One) && aboutToTeleport == true)
{
    // Setting player position to teleport position
    aboutToTeleport = false;
    player.transform.position = teleportPos;
}
}
```

More than Human Design Perspective

More than human design perspective was the core consideration in the implementation of this immersive project. The main purpose of the project implementation was to allow a user to have an inclusive experience for an immersive environment to experience the behavioral change of bats passing through artificial lighting.

The major tasks implemented in this immersive experience were to allow the user to have an immersive experience and have an interaction with the created environment. A user can change its location in the immersive scene to a better perspective view to observe the path change of endangered bat species. Also, the user can experience the environment from the

lighting designer perspective to plan and decide the lighting in the urban areas and can have an idea of how it can impact wildlife.

More than human design perspective development was a more challenging part of this application because for us it requires a lot of study about how light pollution impact on commuting behavioral change. To cater to this challenge, scientific research papers were studied to understand the commuting behavior change of bat species.

This immersive application can be extended to study the behavioral change of different kinds of other bat species in different weather conditions also by changing temperature, humidity, and wind. Also, the development of this can be done to different artificial lighting conditions.

More than human design thinking approach have taught us to think from a new perspective. It also allows us to think about how our actions can lead to a drastic effect on our environment because of any activity we perform in this world. So, in return it teaches us to do every action that does not harm the surroundings while it should be for a sustainable environment. This approach also helps us to mitigate the gap between us humans and the nature around us.

Individual Reflection

This immersive project was a good learning opportunity for us to think from a new perspective. Some of the techniques used in this project were those that we had learned in the computer graphics course. Immersive reality techniques like VR, AR and XR were a new fascinating concept for us. The integration of Oculus Quest 2 device with Unity 3D was a bit challenging in the start because of its lots of settings. The perception view and interaction of different immersive objects from the eye of an immersive environment fascinating. Also, this project paved the way for us how we can study the natural behavior of bats effecting by human activities and how we can contribute with the help of immersive technologies to make awareness among other stakeholders to protect these endangered species of bats.

Knowledge Gained

We have gained knowledge in various aspects by the implementation of this immersive project.

- Unity 3D game engine familiarization in terms of VR implementation
- Different Immersive Experiences approach understanding
- Teamwork skills

Immersive Technique Usage

VR based immersive experience has been created with the help of Meta Quest 2 device. In this VR experience, a user is allowed to roam around the immersive scene to interact with the natural replicated scene in a more realistic way.

Simulation & Visualization Techniques Implementation

The following simulation and visualization techniques are used in the development of this immersive application creation.

1. **3D Modeling:** for the creation of a 3D immersive environment showcasing the effect of lights on bats.
2. **Textures Mapping:** to associate textures with ground and lake area.
3. **Animation:** applied for the moving behavior of bats
4. **Interactive Features:** A user can roam in the scene and add new light poles according to development requirement and can see the commuting behavior change of bats.

Challenges Faced

The following challenges were amongst the top in the creation of this immersive experience.

- Unity 3D game engine setup for VR device
- More Realistic environment creation
- UI Design development for user friendly immersive experience

Possible Research Project Ideas for Future

The following research ideas can be implemented as an extension of this immersive project.

Research Topic.1:

Title: How does different kind of streetlights (e.g., LED, fluorescent, Metal halide and induction lights) can have an impact on commuting behavior of multiple bat species? [2]

Research Topic.2:

Title: Comparison of different bat species behavioral change (e.g., feeding, mating, commuting) by the effect of street light pollution. [3]

Motivation & Objective

As with the human development in urban areas, light pollution is increasing. Many species like bats mostly rely on echolocation to find food because of their nocturnal nature. But at the same time, artificial light can have a negative impact and disruption to this natural behavior and in result can endanger the life of these species.

Both above research ideas can be implemented in immersive technologies (VR, AR or XR) to create a stimulating environment with different street lighting conditions to study the impact of lighting pollution on different behavior of different bat species. In this way, wildlife researchers, planners and designers can work collaboratively to plan the environment keeping in mind the wildlife also does not affect because of this human activity.

References

[1] https://www.sciencedirect.com/science/article/pii/S0960982209011932

[2]https://www.researchgate.net/publication/272889669_Impacts_of_artificial_lighting_on_bats_A_review_of_challenges_and_solutions

[3] https://www.sciencedirect.com/science/article/abs/pii/S0269749119315210