ASSIGNMENT 3

Immersive Technologies

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INTRODUCTION

In this assignment, an application has been developed to simulate "Effect of Artificial Light on Insects". Artificial light at night is a widespread and growing form of environmental pollution, with profound impacts on wildlife. Insects are highly sensitive to light and are attracted to it from long distances. However, the effects of artificial light on insect populations are not well understood and this could be because of the diurnal bias of the researchers (Owens, 2020). Light has been used to attract/trap insects for ages and hence can be considered to have a significant impact on the declining insect populations.

This simulation offers a unique opportunity for users to observe and understand the movements and behaviors of insects in the simulated habitat, with the added ability to observe changes in behavior during the day and night, as well as in the presence of artificial light at night. As such, it has the potential to be a valuable tool for urban planners seeking to mitigate the impacts of artificial light on insect populations. The flexibility to choose from different types of lighting further enhances its applicability in this regard. Additionally, this application has great potential for educational purposes, as it can help raise awareness about the impacts of artificial light on other species and their ecosystems. By providing a visually compelling and interactive experience, this simulation can foster greater understanding and appreciation for the role that insects play in maintaining a healthy planet. The simulation has been implemented using virtual Reality technology (Meta quest2) to provide a more immersive experience for the user.

Assumptions:

To ensure simplicity and usability of the application, a few assumptions have been made regarding the behavior of insects within the simulated environment:

- The scene starts with a few insects randomly moving around in the simulated environment. Insect behavior is based on the paper published by Craig Reynolds called "*Flocks, herds and schools: A distributed behavioral model"* (Reynolds, 1987).

- Insects are naturally attracted to food only during the night. However, the presence of artificial light will distract them and cause them to become trapped near light poles until the light is turned off at the end of the night or they die.
- Insects only seek food during the night and will move randomly during the day without interacting with food or light sources.
- Insects will die after spending a certain amount of time around the light source.
- Insects will only be attracted to light sources when they are within a certain distance, which has been determined to show the effects of different types of lights on insect behavior.
- Different light sources have different impacts on insects. Here it is represented by the number of insects attracted to a light source.
- Buildings and other structures are for visual purposes only. Insects can fly through buildings and other solid structures.

Features:

The application has been developed specifically for the Meta Quest2 VR headset and offers several interactive features for users to explore:

Scene:

Users can experience the simulation as if they were physically present within it, viewing the entire environment from a human perspective. This allows them to fully immerse themselves in the simulation and gain a better understanding of insect behavior.

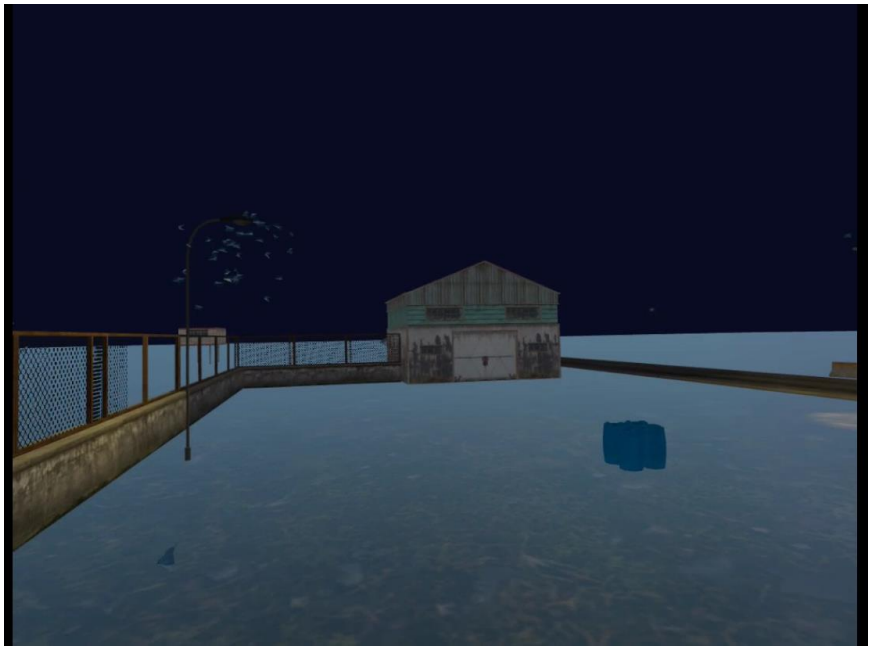


Figure 1User view of scene inhuman perspective

User Movement:

With the help of VR controllers, users are free to move around on the ground within the scene, allowing them to observe different aspects of insect behavior. For example, they can view the difference in behavior of insects during the day and night, as well as the effects of different light sources.

Figure 2Picture showing user movement 1.

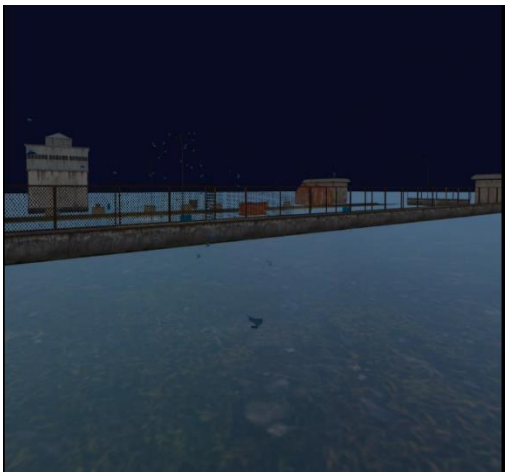


Figure 3Picture showing user movement 2.

Switch perspective:

Users can switch between human and insect perspectives to gain a more complete understanding of insect behavior. The insect perspective provides a unique view of the scene, allowing users to see how insects are drawn to food and how they become trapped near light poles.

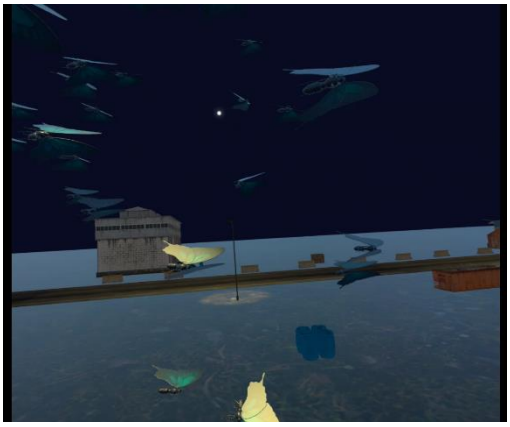


Figure 5Picture showing insect perspective when stuck at light pole.

Figure 4Picture showing insect perspective while moving towards food.

Add/remove light poles:

Using the VR controllers, users can add or remove light poles from the scene. This feature allows them to observe how insects react to different types of light sources and how these sources impact their behavior. However, it's important to note that only one type of light pole should be used at a time to accurately observe the effects of different light sources.

Figure 6Picture showing scene with light poles.

Figure 7Picture showing scene without light poles.

Add insects to scene:

Users can also add insects to the simulation using the VR controllers. The insects are generated at a specific location within the scene, representing their breeding location. However, users should be careful not to add too many insects, as this can affect the overall experience.

Figure 8Picture showing insects being instantiated.

Day and Night

The application simulates both day and night, as this has a significant impact on insect behavior. For example, insects are active during the day but do not engage in foraging, while they actively seek food during the night. The lights are disabled during the day, but users can still add and remove light poles from the scene to see how insects react to different light sources.

Figure 9Picture showing daytime in the scene.

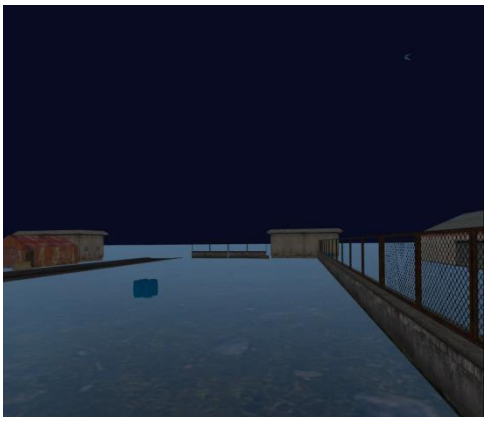
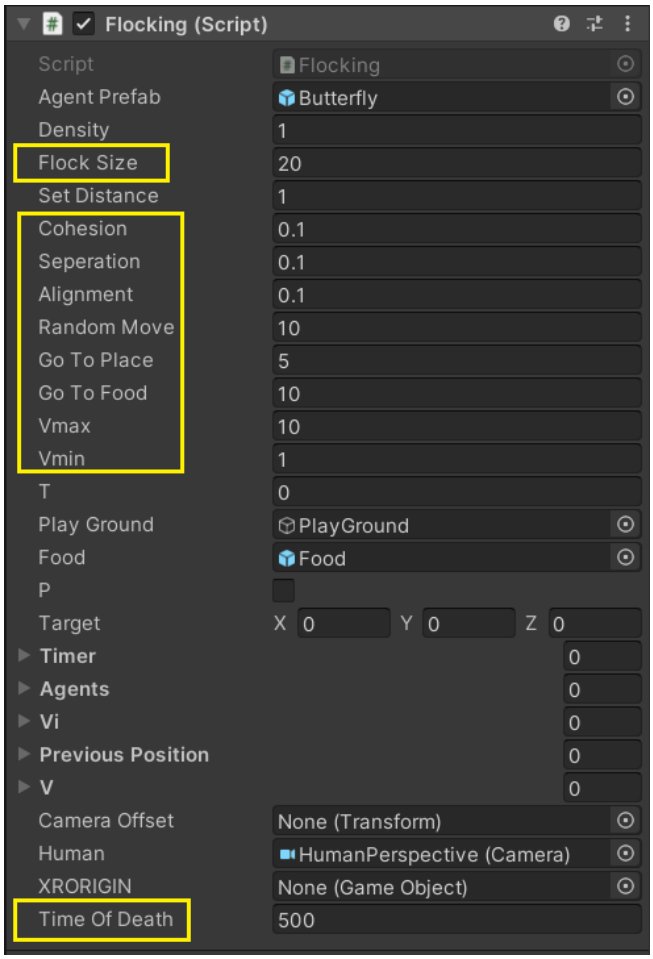


Figure 10Picture showing night in the scene.

Adjustable parameters

Users can adjust a few parameters before running the application to change the behavior of insects. Users can adjust the strength of attraction of insects to the light poles and food to simulate different insect types.



The behavior of insects is based on the boid model. So, the overall behavior is the resultant of different rules followed by the insect. So, the users can change these parameters to simulate the required behavior. These rules are:

Alignment: Makes the insect align with the movement of the group.

Cohesion: Insects fly towards the center of mass of the group

Separation: Avoid colliding with other insects

Follow: Follows a specific target (light and food here) and moves towards that target. Here users can make insects more attracted to food or light by changing the GoToFood and GoToPlace parameters.

Time required for insect death: Users can define time required for the insect after it starts flying around the light source.

More Than Human Perspective

The objective of the project is to demonstrate the effects of artificial light on the behavior and movement patterns of insects. Through the application, users can experience two different perspectives: the human perspective and the insect perspective. The human perspective allows users to observe how insects are attracted to food and light and the negative consequences that follow such as starvation, predation, and heat. On the other hand, the insect perspective provides a view of how the insects themselves perceive the environment and how their behavior changes in response to light. Users can witness how long an insect can endure in the light before dying, thus potentially fostering empathy and compassion for the insects. Additionally, the user can move freely within the simulated environment, allowing them to

explore and observe the surroundings from any desired angle, simulating a real-life experience. Also, the user can move around the scene to get their desired view just as if they were there in real life.

The paper "Light pollution is a driver of insect declines" by (Owens, 2020) discusses various reasons why artificial light can be detrimental to insect populations. Some of the reasons include the attraction of insects to light sources, which can lead to them being preyed upon, exposed to high temperatures, and susceptible to collisions with artificial structures. Additionally, the disruption of natural light cycles can negatively impact the insect's ability to navigate and reproduce, ultimately affecting their survival. The paper also highlights the cascading effects of insect population declines, such as decreased food availability for other organisms and reduced pollination services. Overall, the paper emphasizes the urgent need to address light pollution as a serious threat to insect populations and ecosystem health.

Knowledge gained and difficulties faced:

We encountered difficulties in representing the insect perspective in VR due to the risk of cyber sickness caused by the rapid and unpredictable movement of the insects in real time. To address this issue, we attempted to modify the behavior model of the insects by adjusting the parameters to create smoother, more comfortable movement for the user (Doerner, 2022). It was hard to replicate the insects' haphazard movements until we opted for the Swarm model, which allows us to regulate the behavior of the group while retaining the individual-level randomness.

While working on the application development we learned more about working with Unity3d as well as converting a Unity 3d project to a VR compatible project. It was a great opportunity for us to learn more on using classes and functions in coding considering we do not come from a coding background. The insights from guest lectures on more than human perspective helped us understand the importance of holistic development while being considerate to other species. It was especially a great learning on the factors that affect the insect population like climate change, habitat loss, pesticide use and artificial light. We followed tutorial videos provided during the course along with some online resources to implement the VR integration with the 3D project.

Future work:

- It is possible to improve the lights in the simulation by incorporating additional characteristics and enhancing the modeling, such as light cones, light intensity, etc. To achieve greater realism, these enhancements can be based on the real light poles present in the area.

- A more advanced behavior model can be introduced for insects to account for their response to factors such as heat, light, and predators. Since insect behavior is a complex subject, a simplistic random movement approach is inadequate for obtaining meaningful outcomes from the simulation.

- In addition, the model can be applied on a broader scale by including insects in ecosystem simulations. This would allow us to observe how artificial light impacts not only the insects but also their predators and other animals in the ecosystem. Moreover, once a realistic ecosystem is established, a more intricate behavior model can be developed to simulate the event of insect mortality.

In this project we seek the impact of artificial light on insect behavior and well-being. By taking a more-than-human perspective, we can ensure that the project is not only technically sound but also ethically responsible and environmentally sustainable. For example, in the context of the project, an immersive technology that enables users to see the world from the perspective of insects can help build empathy for these creatures and promote awareness about the impact of light pollution on their well-being. Furthermore, immersive technologies have the potential to create new ways of interacting with and understanding the natural world. By using immersive technologies, users can experience environments and creatures in ways that are not possible in real life, allowing for a deeper understanding and appreciation of the complexity and diversity of the natural world.

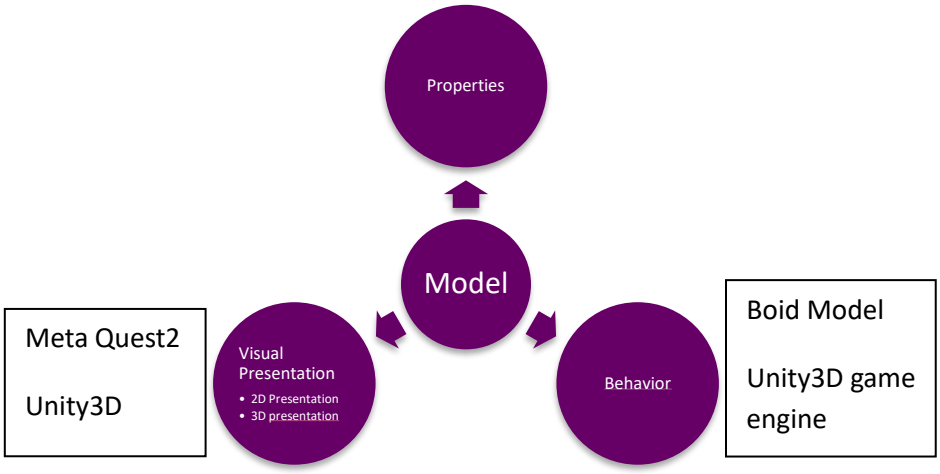
Overall, combining more-than-human and immersive technology can lead to more inclusive, ethical, and sustainable interactions with the world around us. It can help us to develop a deeper understanding of the impact of our actions on non-human entities and ecosystems and inspire us to take action to protect and preserve the natural world.

Simulation Concepts:

This application represents a game type simulation since the objects in the scene do not completely obey the physics laws. Further we have used two of the three major components of the Simulation,

1. Behavior Model: The insect behavior is based on the boid model which consists of several rules (as mentioned above). More rules can be added to the behavior model to make more complex behavior of the insects.
2. Visualization: Virtual Reality has been used for the visualization of the simulation for creating an immersive experience for the users. Here, the application has been developed specifically for Meta Quest2 VR headset.

The simulation does not use any external data sources as the behavior is dependent on the existing boid model and hence there is no requirement for property layer in this simulation.



Immersive Technologies concepts:

Virtual reality:

VR technology allows users to experience digital environments in a new and exciting way. In this application, users can experience a sense of immersion when observing the simulated environment as a human or as an insect.

Virtual World:

A virtual location has been generated to simulate the effects of light on insects. The world includes various elements, such as buildings, roads, fences, barricades, dumpsters, and barrels. This has been chosen to make the user feel the location has been abandoned and is a perfect habitat for insects to live.

Presence:

The user can feel physically present in the scene as they can look around and move within the scene using VR controllers.

Simulation:

The application simulates the behavior of insects using a boid model developed by Craig Reynolds. The application also simulates the interaction between light and insects, along with day/night differences.

Tracking:

The VR headset tracks the user's motion and displays the part of the scene corresponding to their rotation.

Cybersickness:

There is a chance that users may experience cybersickness when using the insect perspective as the insect movement is random and fast. To reduce the likelihood of this, the velocity of insects has been moderated, and the rotations have been smoothed to avoid sudden changes in scenes.

Research Project

"Simulation of impact of artificial light on an ecosystem surrounding the light source in Virtual reality."

A research project can be an extension of the application with more complex interactions and more inter dependent agents in the scene. This application is a simulation of different types of agents (insects, frogs, lizards etc.) interacting among each other and with the environment around them (light poles, grass, vegetation etc.). The light poles also have more features like heat, color, frequency of sound emitted etc. and each of these properties having different effect on different species. Possible research questions:

1. Impact of artificial light on population distribution of different species of the landscape
2. Impact of different light sources on the vegetation

Motivation:

Artificial light has a significant impact on population of insects (Owens A. C., 2020). According to (Goulson, 2019), insects play a crucial part in all land-based ecosystems by serving as a source of food for a wide range of creatures, including birds, bats, reptiles, amphibians, and fish. In addition, insects are essential for pollination, pest control, and nutrient cycling. Hence artificial light sources having an impact on insect population will have a ripple effect on the food chain. This could eventually result in ecological imbalance of the surroundings.

Objective:

The objective of this project is to help urban planners to design the infrastructure such that other species are impacted as little as possible. Also, this application can be used to help educate people on the species' behavior under different circumstances. The application can be used to predict the population distribution and impact of these changes on the vegetation of the ecosystem.

This application will be developed using virtual reality technology to make the user experience as immersive possible to generate empathy.

References

Doerner, R. a. (2022). *Virtual and augmented reality (VR/AR): Foundations and methods of extended realities (XR).* Springer Nature.

Goulson, D. (2019). The insect apocalypse, and why it matters. *Current Biology*.

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Reynolds, C. (1987). Flocks, herds and schools: A distributed behavioral model. *SIGGRAPH*.