北京邮电大学 本科毕业设计（论文）中期进度报告

Project Mid-term Progress Report

学院 **School**	International School	专业 **Programme**	e-Commerce Engineering with Law		
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论文题目 **Project Title**	Large-scale scene simulation of games in cold-temperate deciduous coniferous forest area based on UE				

是否完成任务书中所定的中期目标？ **Targets met (as set in the Specification)?**
[YES/NO] YES

已完成工作 Finished work:

• **Targets met?**
  Successfully completed the mid-term assignments.
• **Can finish on time or not?**
  True
• **Finished Work: Write a summary of the work you have completed so far.**

1. **Information collection: vegetation, soil, landform, plant groups, tree species, etc.**
   During this period, I first spent one to two days collecting data from most of the cold regions of China, and determined that the research scope was the Greater Khingan Mountains. The geographic coordinates range from 43°N to 53°30′N, and 117°20′E to 126°E.

   After establishing the goal, I began to collect vegetation and soil information in the Greater Khingan Mountains. The final collection is as follows:

   ● Determining the characteristics of the main vegetation groups in the Greater Khingan Mountains: The Greater Khingan Mountains has rich vegetation groups, such as forests, shrubs, grasslands, meadows, swamps and grass ponds. My main research targets are coniferous, mixed coniferous and broad-leaved forests and broad-leaved forests in forests; thickets and grasslands.
   ● From this, I started to select my target vegetation based on the characteristics of each vegetation biome.
   ● Vegetation information (vertical and horizontal distribution of plants):
   ● Forest: I chose 4 representative tree species, namely: Birch (Betula platyphylla), Larch (Larix gmelinii), Black Alder (Alnus cremastogyne Burk) and Spruce (Picea asperata Mast), covered with needles Leaf forest, mixed coniferous and broad-leaved forest and broad-leaved forest.
   ● Shrubs: There is one vegetation subtype, coniferous shrubs, in the primeval forest area in

Species	Latin Name	Forest Type
Birch	Betula platyphylla	broadleaf forest
Larch	Larix gmelinii	Coniferous forest, mixed coniferous and broad-leaved forest
Black Alder	Alnus cremastogyne Burk	broad-leaved forest, mixed coniferous and broad-leaved forest
Spruce	Picea asperata Mast	broad-leaved forest, mixed coniferous and broad-leaved forest

the northern part of the Greater Khingan Mountains. The most representative pine shrub

(Pinuspumila) was selected. In addition, forest saplings also constitute an important part of the shrub vegetation, including pine saplings, black saplings, and spruce saplings.

- Grassland: The distribution of meadow grassland in this area is not very common, and there is little change in composition. There are two groups of groups and two groups. I chose Filifolium sibiricum. The specific plants are as follows: Filifolium sibiricum, Chrysanthemum chanetii, Stipa baicalensis, Spodiopogonsibiricus, Platycodonggrandiflorum and Bellis perennis L, etc.

Species	Latin Name	Phylogeny
Pine bushes	Pinuspumila	Coniferous bush
Xeryl daisy	Filifolium sibiricum	Prairie (Clematis prairie)
Red chrysanthemum	*Chrysanthemum chanetii*	Prairie (Clematis prairie)
Baikal Stipa	Stipa baicalensis	Prairie (Clematis prairie)
Big oil awn	Spodiopogonsibiricus	Prairie (Clematis prairie)
Bellflower	Platycodongrandiflorum	Prairie (Clematis prairie)
Daisy	Bellis perennis L	Prairie (Clematis prairie)

2. **Regional terrain selection, terrain accuracy selection, and import into UE5**
   - Regional terrain selection: To better show the richness of the terrain, I chose a terrain of 8129x8129 pixels (8129mx8129m), including mountains, plains, and two rivers.

   - Area accuracy selection: At the beginning, I selected a terrain source with poor accuracy (1 pixel every 8 meters, terrain source: https://terrain.party/), then I changed the terrain source to select a high accuracy (every 8 meters). 1 pixel 1 meter, terrain source: https://portal.opentopography.org). This greatly increases the realism of the terrain.

   - Import into UE5: Using Terre Sculptor software, first import the. geotiff file downloaded from the terrain source, after opening, select 32-bit grayscale float (32-bit grayscale float), and modify the Y-order attributes after importing to observe the degree of mountain undulation. Finally, choose the best quality output. The final output 16-bit grayscale output (16-bit grayscale) generates a .png file.

3. **Construction of vegetation model:**

   During the construction of the vegetation model, to facilitate the model construction, the vegetation is divided into two categories: trees and other plants.

   Trees include 4 types of trees, each type of tree contains several sub-species, including trees of different age groups, such as large trees, medium trees, small trees, and young trees. Among them, large trees and medium trees constitute the forest part of the vegetation model, while small trees and young trees belong to the shrub part.

   Other plants include shrubs and angiosperms, which together constitute the shrub and grassland parts of the vegetation model.
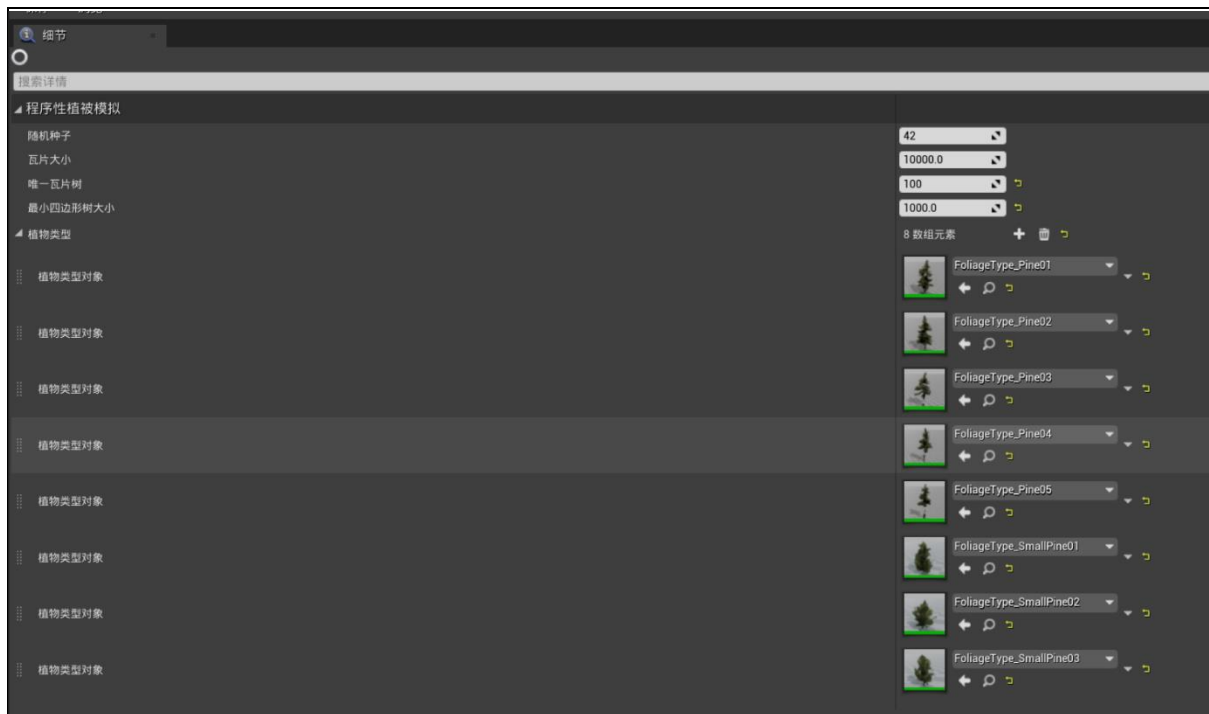
Tree Generation: Procedural Foliage Spawner (PFS)

Use the PFS tool that comes with UE to add a PFS volume within the selected range, and the specified trees will be generated within the volume by the algorithm. To use PFS, the Foliage Type of each tree must be added to the PFS. Important parameters for each tree type in PFS are as follows:

| Parameter Name	Value	Effect
AlignToNormal (Boolean)	False	Controls whether the plant is perpendicular to the growing surface.
Ground inclination angle (float)	Birch [0,15] Black Adler [21,25] Spruce [0,5] + [25,30] Pine [12,23]	Plant instances are only placed on slopes that form a special angle from vertical. Control where plants grow, control the degree of mixing between plants.
Number of steps (integer)	[5,8]	The number of times a species is given age and made to spread seeds
Initial seed density (float)	0.1	Number of seeds sown within 10*10 meters
Average Diffusion Distance (float)	[50,500]	Average distance between walk instances and their seeds
Diffusion variance (float)	[20,150]	Specifies the difference between the shot distance and the average
Step by step (integer)	[1,5]	The number of seeds the instance propagates in a single step of the simulation
Distribution seed (integer)	[50,500]	Determine initial placement of seeds
Can grow in shadows (Boolean)	True	Seeds of this type ignore shadow radius when spawned with other plant types
Maximum initial age (float)	[0,1]	Allow new seeds to be created with age greater than 0

Max age (float)	[50,500]	Specifies the maximum age of a seed, after which the instance can continue to scatter seeds, but cannot grow any more.

Shrub Generation: Landscape Grass Type - LGT.

Grass generation is controlled by LGT. Adding LGT to the automatic material function can make vegetation automatically generated on the surface.

Parameter Name	Value	Effect
Grass Density (float)	[2,50]	Number of instances per 10 square meters
Cull Distance (float)	[5000,50000]	The distance at which the instance begins to fade out of the camera
Random Rotation (Boolean)	True	Random rotation of grass instances
Align to Surface (Boolean)	True	Whether the grass instance should be tilted to the terrain's normal

4. UE5 Material Function(Material, Texture and Shader)
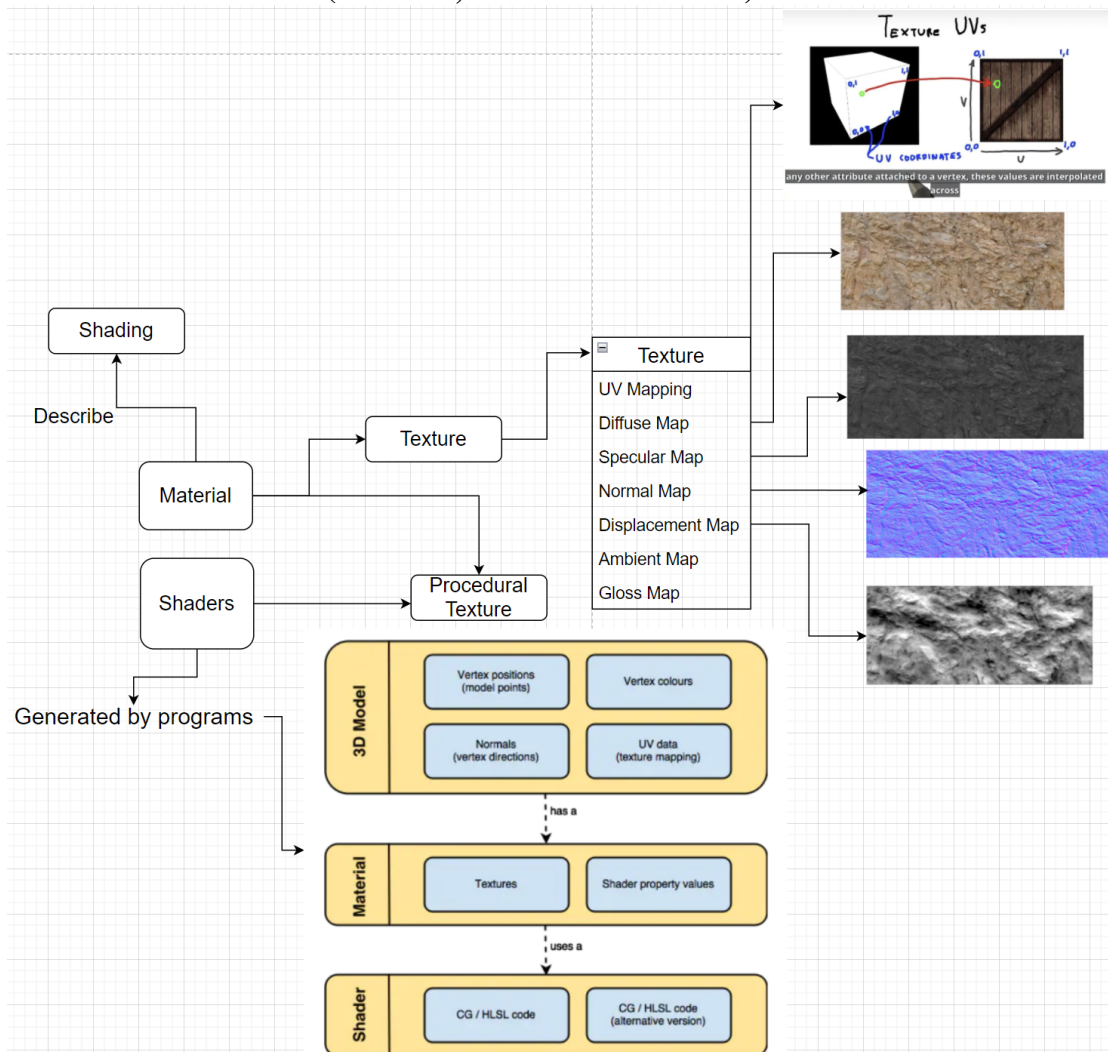
In addition to the material mixing function made before the mid-term, this material was modified in the mid-term, adding 2 layers, 1 new instance, and several important parameters for the material.

Material (Material) layered, 6 layers in total.

Name of the Layer	Description
Planar	The texture responsible for generating grass, which is generated on flat land with a slope of fewer than 10 degrees. There is blending with the Slope layer between 10 and 15 degrees. It is also responsible for the automatic generation of vegetation and rocks (based on Landscape Grass Type). Important parameters that can be adjusted: <table><tr><th>Parameter</th><th>Effect</th></tr><tr><td>Texture</td><td>Specify the corresponding Texture to be placed on this layer (Albedo, Normal and Roughness)</td></tr><tr><td>BaseColor</td><td>Specifies the base color for this layer. Used to input the initial material blend function.</td></tr><tr><td>Metallic</td><td>Specifies the degree of metallization of the layer, the larger the value, the closer the texture is to the metal.</td></tr><tr><td>Roughness</td><td>Specifies the roughness of the layer. The larger the value, the rougher the texture and the less reflected light.</td></tr><tr><td>Specular</td><td>Specifies the specular reflection strength of this layer. The larger the value, the greater the specular reflection strength.</td></tr><tr><td>UV_Scale</td><td>Specifies the UV scaling degree of the texture of this layer. The larger the value, the smaller the image of the layer will be, and it will be tiled in the entire terrain; otherwise, the smaller the value, the larger the image of the layer will be. Used to adjust the degree of material repetition</td></tr></table>
Slope	The texture responsible for generating cobblestones, which is generated on slopes with a slope greater than 10 degrees and less than 30 degrees and is mixed with the Side layer between 30 degrees and 43 degrees. There is blending with the Slope layer between 10 and 15 degrees. (It has the same type of parameters as in Planar)
Side	The texture responsible for generating the cliff, which is generated on slopes with a slope greater than 30 degrees, and blends with the Side layer between 30 degrees and 43 degrees. Reserved with an excuse (It has the same type of parameters as in Planar)
Foliage Eraser	Responsible for eliminating grass generated by LGT, this layer only supports manual elimination.
Caustics	The erosion layer is responsible for giving the rain erosion effect to the automatically generated material, which is closer to the real landform.
Auto	The Auto layer mixes all the above layers and sets several parameters to adjust the automatic generation effect, including the mixing strength, mixing distance, generation slope, plant growth slope, plant growth on the wall, etc. Set two parameters Blend Bias and Blend sharpness to control the blend distance and blend strength. Add two Distance scales to control the material duplication at close and far distances. Added Perlin noise to materials to avoid grass map duplication issues at long distances.

5. **Weather system (Blueprint Component): sunny, cloudy, rain, snow**
The weather system includes a collection of several functions that control the behavior of different actors in the scene, which together constitute the weather system. For example, the

direction and angle of the sunlight controls day and night; the intensity of sunlight, the color of the clouds, and the color of the atmosphere control the sunny day and night, etc. It has the following Features: **Day-Night cycle, Random Thunder, Raining, Snowing, Water, Ice**

- User-based Weather starting randomization
- Curves allowing crossfading weather patterns for minutes, hours or endless
- Particles collide with Scene (all), absorb light (all) & blend background color (snow).

Weather	Sunlight Intensity	Volume Cloud	Sound Effect	Particle Effects FX
Sunny	Warming	Thinned.	Birdsong and wind	Bloom
Cloudy	Weakened	Thicker and moves faster.	Wind	-
Rain	Weakened	Thicker and darken in colour	Wind and Rain	Water drop effects and water drop splash effects
Snow	Remains Unchanged	Remains unchanged	Wind and Snow	Falling snow effects and snow effects

In the weather system, we can adjust the properties of each Actor to achieve the desired effect.

Core: Weather Random Time, Always Rain, Always Snow, Always Sunny, Always Day Time, Always Night, Dark Clouds
Snow: Max Snow Falling, Snow Blend Max, D Snow Color Of Day, D Snow Color Of Night
Rain: Rain Color Of Day, Rain Color Of Night, Max Rain Falling, Max Rain Fog Falling, Rain Drops Blend Max, Get Wet Roughness, Get Wet Specular, Thunder Waiting Time, Thunder Min Volume, Thunder Max Volume
Sun: Sun Intensity, Sun Intensity Of Rain or Snow. Sun Temperature of Daytime, Sun Temperature of Night
Fog: Fog Density Of Sunny, Fog Density Of Rain or Snow, Fog Height Falloff Of Sunny, Fog Height Falloff Rain or Snow
Wind: Wind Speed Of Snow or Rain, Wind Speed Of Sunny, Wind Weight Of Snow or Rain, Wind Weight Of Sunny
SkyLight: Sky Light Intensity Of Day, Sky Light Intensity Of Night

6. **Snow effect: Material blend function.**
This project mainly studies boreal landforms, so one of the key points of the project is the production of snow effects. Until the mid-term, making snow effects were mainly about adding falling snow FXs, sound effects, and snow effects. The snow effect is a complex blueprint function, this function contains snow function and a subfunction. The snow function controls parameters such as the snowfall curve, and controls the occurrence of the entire snowfall behaviour; at the same time, the subfunction needs to be linked to the output node of each material in advance to achieve the effect of controlling the colour (grass material, leaf material, cobblestone material, etc.).
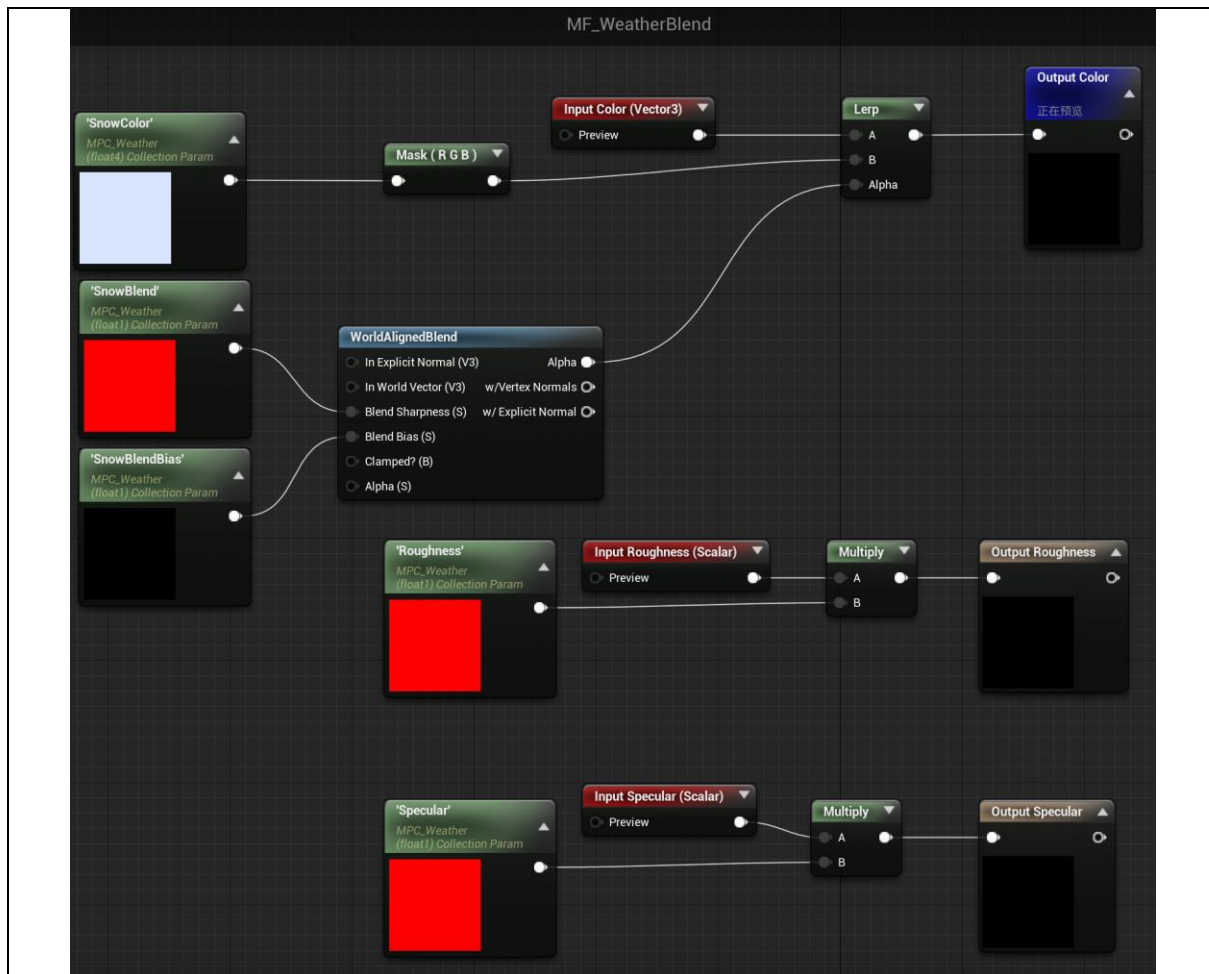
In the middle of the work, I used the WorldAlignedBlend method to blend the white directly to the surface of the material to create the snow effect. This approach can be adapted to most materials. Compared with the snow effect in 3D, this kind of texture saves a lot of computing resources, which is beneficial to the fluency of the scene.

7. **Atmospheric effects: light, volumetric clouds, volumetric fog, particle effects, and sun effects.**

Creating a good atmospheric effect can add beauty to the scene, and lighting constitutes the most important part of the scene design. Several atmospheric effects were used in the scene to add the unique climate effect of the Greater Khingan Mountains.

Weather System Master	
Directional Light	定向光源组件
Sky Light	天空光源组件
Sky Atmosphere	天空大气组件
Post Process Comp	后期处理组件
Volumetric Cloud	体积云组件
Exponential Height Fog	指数级高度雾组件
Sky Sphere	静态网格体组件
Rain FX	Niagara粒子系统
Snow FX	Niagara粒子系统
Rain Audio	音频组件
Thunder Audio	音频组件
Snow Audio	音频组件
Birds Audio	音频组件
Wind Audio	音频组件
Cicada Audio	音频组件
Is Night Time Line	时间轴组件
Sun Time Line	时间轴组件
Snow or Rain Falling Time Line	时间轴组件
Rain Falling Time Line	时间轴组件
Snow Falling Time Line	时间轴组件
Get Wet Time Line	时间轴组件
Frozen Time Line	时间轴组件

Light Source	Effect
Directional Light	A directional light source simulates light coming from an infinite source. The shadows cast by this light source are parallel, so it is suitable for simulating sunlight.
Sky light	Sky light collects the distant part of the level and applies it to the scene as a light source. Even if the sky comes from the atmosphere, clouds at the top of the sky box or distant mountains, the appearance of the sky and its illumination / reflection will match
Volumetric Cloud	Using a two-dimensional volume cloud map, a volume cloud is generated by connecting Perlin noise nodes.
Exponential Height Fog	The density of exponential height fog is higher at the lower position on the map, while the density is lower at the higher position. Its transition is very smooth, and there will be no obvious switching with the increase of altitude. Can highlight the altitude effect.
Niagara FX	Use niagarafx to write special effects of rain and snow.
Post Process Component	Add lens flares, add lens effects, add volumetric effects, and add lens effects bloom and exposure

8. Scene performance optimization: increase the smoothness.

Scene performance optimization is the top priority of the entire project, and it is also the most difficult part of the project. In UE5, using a large number of expensive plant assets in the same scene will make the scene FPS (frame per second) very low. Use several effective optimization methods to stabilize the frame rate above 30fps to ensure the basic scene browsing experience is the project pursuit. Since this project needs to use a large number of plant assets, if the scene performance optimization is not set, the scene fluency will be poor. After starting to optimize the scene, until the mid-term, the overall performance optimization of the scene has made gratifying progress:
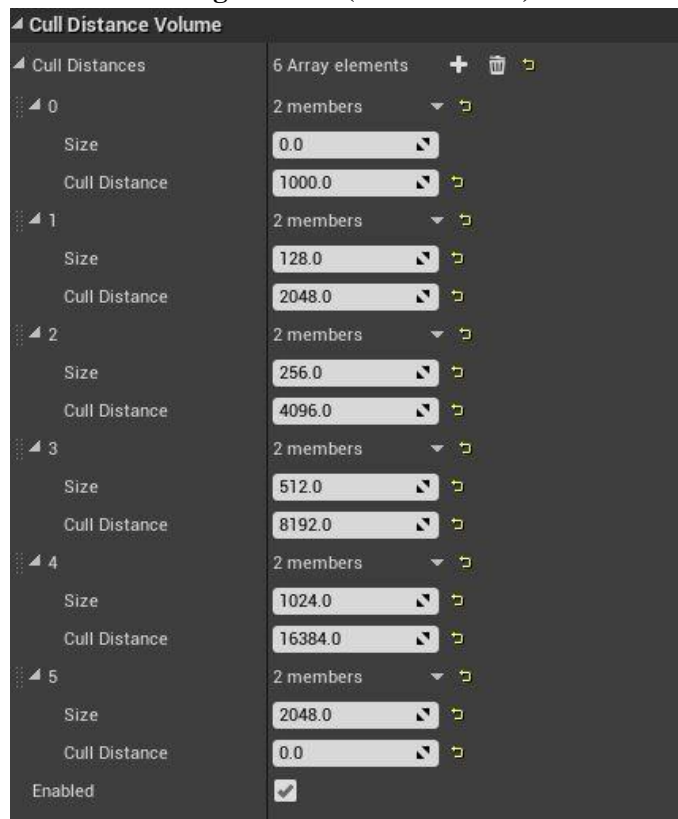
Set mesh LOD (Levels of Detail)

Set LOD for plant materials that appear in a large number of scenes. Set the position and importance of the nodes of the plant asset model in the display environment, determine the resource allocation for object rendering, and reduce non-important objects. The number of faces and the degree of detail is high, to obtain efficient rendering operations. Take the Black Alder plant asset as an example:

LOD Layers	Screen Size	Triangles	Vertices
LOD 0	(0.99,5]	423,509	439,689
LOD 1	(0.8,0.99]	203,065	259,446
LOD 2	(0.4,0.6]	143,457	204,793
LOD 3	(0.3,0.4]	50,491	59,268
LOD 4	(0.15,0.3]	28,020	37,956
LOD 5	(0.15,0.3]	7,111	9,054
LOD 6	(0,0.15]	9	9

It can be seen that as the proportion of objects on the screen decreases, the number of LOD layers increases, and the number of triangles and vertices decreases rapidly. Scene computing resources are optimized. After adding LODs, the FPS of the same scene was significantly improved.

Set the mesh culling distance (Cull Distance):

◢ Cull Distance Volume				
◢ Cull Distances	6 Array elements	✚ 🗑 ↺		
⣿ ◢ 0	2 members	▾ ↺		
Size	0.0	↘		
Cull Distance	1000.0	↘ ↺		
⣿ ◢ 1	2 members	▾ ↺		
Size	128.0	↘ ↺		
Cull Distance	2048.0	↘ ↺		
⣿ ◢ 2	2 members	▾ ↺		
Size	256.0	↘ ↺		
Cull Distance	4096.0	↘ ↺		
⣿ ◢ 3	2 members	▾ ↺		
Size	512.0	↘ ↺		
Cull Distance	8192.0	↘ ↺		
⣿ ◢ 4	2 members	▾ ↺		
Size	1024.0	↘ ↺		
Cull Distance	16384.0	↘ ↺		
⣿ ◢ 5	2 members	▾ ↺		
Size	2048.0	↘ ↺		
Cull Distance	0.0	↘ ↺		
Enabled	☑			

When the camera is far enough away from a mesh component, the mesh component can be considered unimportant and therefore culled. By setting Cull Distance, mesh components are automatically culled from the scene after a certain distance from the camera, saving computational performance. Usually, in LGT and PFS, the culling distance can often be set to two values, the start culling distance and the end culling distance. The mesh starts to gradually cull when it reaches the start culling distance and completely culls when it reaches the end culling distance, resulting in a smooth scene gradient.

9. Discuss my progress on the project with Supervisor

My mentor first affirmed my progress, which is in line with the mid-term goal, and is working hard to present the final completion effect. Secondly, the instructor gave suggestions for my project based on my research goal: the geographical location of the Greater Khingan Mountains: add two highlights to the project:

1. Snow effect - interactive snow

2. Season effect - change the colour of leaves with the seasons. I took my mentor's advice and am working on two project highlights.

尚需完成的任务 Work to do:

1. Further increase the richness of shrubs.
2. Thesis writing.
3. Improve scene performance optimization.
4. It is expected to add two scene highlights:
5. Snow effect - interactive snow
6. Seasonal effect - leaf colour changes with the season

存在问题 Problems:

1. The snow material cannot be added to all material layers

2. Scene sound effects cannot be added correctly

3. The scene FPS is lower than 30

拟采取的办法 Solutions:

1. Modify the material blending function so that the snow effect can be added to the material layer

2. Add sound effects

3. Scene performance optimization: set mesh LOD; set mesh culling distance (Cull Distance)

论文结构 Structure of the final report:

Abstract...

Basic Project Objective: Simulation of the Northeast China Frigid Environment

Chapter 1: Introduction...

Introduction: The overall goal of this project is to complete the goal; use software and technology: UE5 and other software; realize the simulation of frigid weather, terrain, and vegetation.

Chapter 2: Background...

Introduce some basic concepts about UE5, such as Material, Texture, Shader, etc., including the ideas and procedures of the overall project presentation.

Chapter 3: Design and Implementation ....

Introduce my work, mainly divided into 6 parts

● Regional terrain selection, terrain accuracy selection, and import into UE5
● Construction of vegetation model
● UE5 Material Function (Material, Texture and Shader)

- Weather system (Blueprint Component): sunny, cloudy, rain, snow
- Snow effect: Material blend function.
- Scene performance optimization: increase the smoothness.

Final results display, the results include UE project engineering files, packaged assets and display videos

Closing, stating my final work, what I accomplished, set out the achievements very crisply.