Digital Twin Forest

Yichen Jiang: jiany34@mcmaster.ca
Junhong Chen: chenj297@mcmaster.ca
Jiacheng Wu: wuj187@mcmaster.ca
Bowen Zhang: zhangb82@mcmaster.ca
Tingyu Shi: shit19@mcmaster.ca
Department of Computing and Software, Faculty of Engineering

Problem Statement

A Digital Twin Forest represents a virtual emulation of the natural environment, particularly focusing on an actual forest ecosystem.

By incorporating the spatial distribution, ages, average tree height, and leaf area index of the forest, it is possible to construct a model based on the collected data, facilitating remote monitoring and data acquisition pertaining to wildfires, deforestation, climatic factors, and more.

Consequently, this enables the prediction of the impacts that such events exert on the forest ecosystem.

The purpose of this project holds potential benefits for both commercial and scientific applications. Commercially, the product can aid forest owners in making informed decisions, while scientifically, it can serve as a valuable tool for researchers investigating environmental problems.

Technology

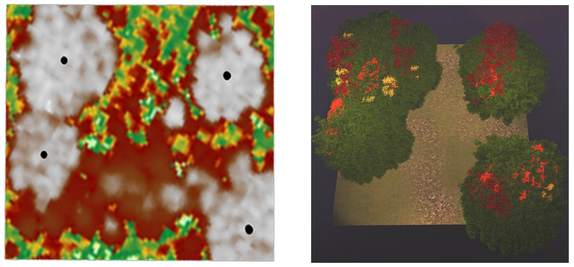
Digital Twin Forest seeks to generate a precise and concise virtual representation of real-world forest data by employing advanced parametric modeling and data visualization methodologies.

The environmental science lab collects various forest data to construct a comprehensive digital forest ecosystem model.

Subsequently, data visualization techniques facilitate an immersive, interactive digital environment, enabling users to engage with the forest ecosystem through 3D models for real-time exploration.

Utilizing Unity, a game engine that incorporates robust tools for user interface design and 3D model processing, the team employed the C# programming language for implementation.

Solution



Tree Distribution

Parametric Modeling

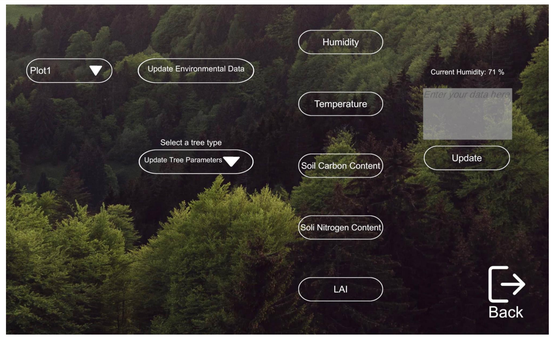
Parametric modeling involves governing 3D models through the utilization of features and constraints, thereby enabling users to automate repetitive alterations instead of manually manipulating the geometry within 3D modeling software.

In Digital Twin Forest, the team optimized the Unity terrain tool and tree editor by developing scripts to manage them. The original tools provided limited functionality, supporting only manual planting of trees. However, following the implementation of coding and mathematical solutions, the team achieved complete control over the forest simulation.

Consequently, various parameters, such as materials, locations, scale, and even leaf quantity, can now be customized. All trees can be automatically generated based on authentic forest data. As depicted in the figure, the distribution of the virtual forest accurately mirrors the satellite imagery.

Moreover, since all models can be generated from a single parent tree, there is no need to store thousands of trees for the entire forest. By retaining only 7 different tree prefabs, the project's size has been reduced by half.

Seasonal Change



Update Data Page

Data Model Synchronization

Contrary to urban digital twins, which necessitate only a static model of the city, Digital Twin Forest encompass a vast array of parameters due to the dynamic growth of forest ecosystems.

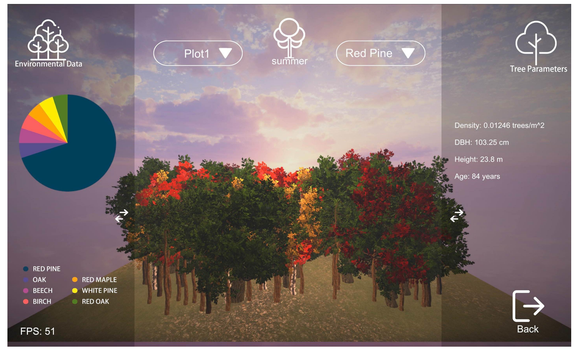
For instance, when the average height of birch trees is altered, the birch tree models correspondingly adjust. This adaptation employs the technology of parametric modeling.

In this manner, forest data can be refreshed in real time via the interface, with the resulting model modifications being displayed.

Data Model Sync

Results

- Modeled 14 plots of Turkey Point
- Environmental data: humidity, temperature, LAI, soil C content, and soil N content
- Tree parameters: densities, DBH, height, and age
- Seasonal transition
- Update data and models



Data Visualization

Prospect

Digital Twin Forest holds the potential to revolutionize the comprehension of forest ecosystems and furnish valuable insights for improved management and protection of these crucial resources.

Employing parametric modeling and data visualization techniques, the project strives to generate a precise virtual representation of real-world forest ecosystems, equipping researchers and conservationists with an influential tool to safeguard these vital habitats.

As an emerging industry, digital twin technology exhibits promising market value, and this project may serve as a steppingstone toward a Digital Twin Earth—a virtual duplicate of our planet.

In future developments, sensors may be deployed within the forest, and the application may establish internet connectivity to obtain the latest forest data, enabling real-time responses and automatic data updates.