Visualizing Geoengineering Data on Mixed and Virtual Reality Devices

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Purpose

- Geoengineers need a way to visualize large-scale environmental changes and environments.
- Difficult to visualize large environments in 2D on paper or a computer monitor.
- Difficult to convey full scale and scope of environmental projects on 2D mediums.
- Utilize mixed and virtual reality platforms like the Microsoft HoloLens to render realistic 3D environments.

The Microsoft HoloLens, a mixed-reality headset. (https://www.microsoft.com/en-us/hololens)

Objectives

- Pipeline system for ingesting multiple types of Geographic Information Systems (GIS) data such as height map, soil type map, vegetation map, hydrography map and reclamation data.
- Realistic 3D terrain generation in Unity after GIS data ingestion of pipeline system, including placement of vegetation, ground texture and water features.
- Options to customize 3D terrain with preferred datasets.
- ViewPoint Generator to view environments anywhere on terrain using Microsoft HoloLens.
- High-performance 60fps rendering of environment on Microsoft HoloLens.

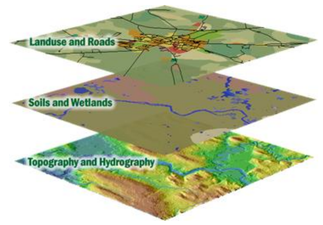
Powered By:

Visual Studio HoloLens unity

Methods

Components

- **GIS Pipeline**
  - System for ingesting GIS data and maps and rendering a 1:1 3D version of the environment.

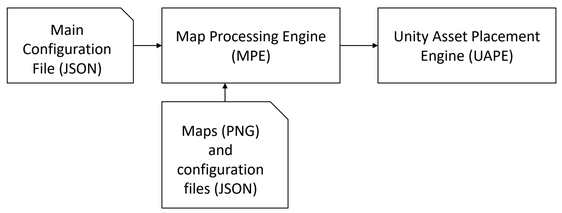


- **Viewpoint Generator**
  - System for modifying and optimizing the 3D environment for viewing on the Microsoft HoloLens.

GIS Pipeline

The GIS pipeline ingests each layer of data and renders the data in 3D.

- Takes as inputs PNG maps and JSON configuration files.
- Utilizes Unity and C#.



ViewPoint Generator

Use modified HoloLens shaders.

- Contain algorithms for calculating pixel color.
- Minimum 60fps rendering.
- Lighting baked into terrain and textures.

Reduce mesh vertices based on distance.

- Vertices compose all 3D objects.
- More vertices, more complex to render.
- Condense faraway objects into 2D quad.

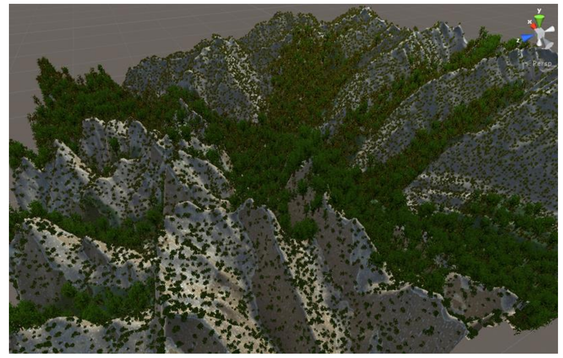
Results

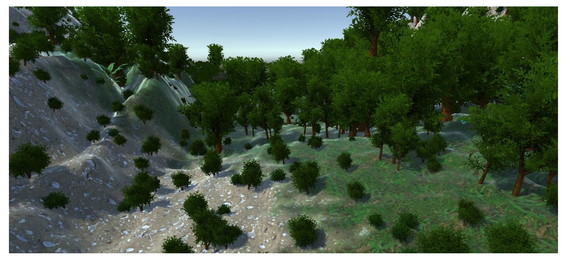
GIS Pipeline

Height Map

Soil Map
#FF0000 : grass_plain
#00FF00 : sand
#0000FF : mountain_rock

Vegetation Map
#FF0000 : boreal
#00FF00 : marsh
#0000FF : alpine





Pipeline Heuristics

- **Vegetation Placement**
  - Type of vegetation depends on biome and prefabs.
  - Variable density, scale, and position for realism.
  - Accounts for terrain characteristics such as slope for appropriate vegetation placement.
- **Soil and Terrain Rendering**
  - Utilize Unity layered splatmaps.
  - Blend soil using randomly generated noise.
  - Adjust terrain height based on height map.
- **Water Placement**
  - Modify water meshes based on connected-components algorithm to match vertex points of hydrology map.

Results cont.

Scene Comparison

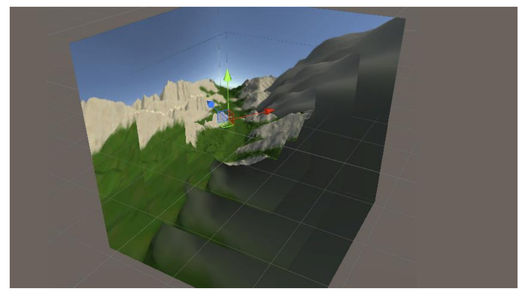
The figures below show the same scene. One is hand-built, and the other is generated automatically using the GIS Pipeline.

Hand-built Scene

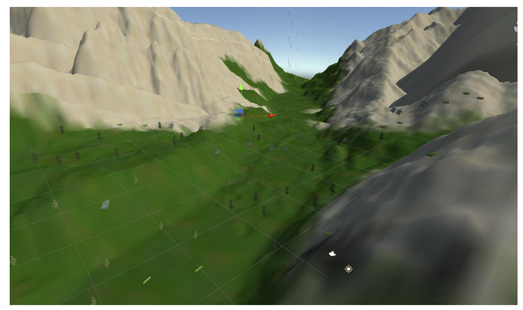
Automatically Generated Scene

ViewPoint Generator

Only render a single piece of terrain to reduce calculations. Outer objects and terrain are rendered as a 2D images but appear 3D to viewer.



Scene using 2D images



Scene as it appears to the viewer