PROJECT: Temporal 3D Reconstruction of Cultural Heritage using Gaussian Splatting

Project Overview

This project requires students to:

- Utilize Gaussian Splatting (GS) techniques for the 3D reconstruction of a cultural heritage site prone to natural degradation (e.g., a historical cave, cliff, or ancient artifact).
- Explore methods to either:
    - Partially retrain a GS model using new data that captures changes due to time and environmental factors, or
    - Integrate multiple GS models representing the same site at different points in time into a single composite model, highlighting changes.
- Develop a visualization technique that clearly showcases the differences across time, effectively creating a "time capsule" model that allows users to observe and analyze temporal changes.

Project Deliverables

1. **Initial Reconstruction and Data Collection:**
    - Create a high-quality GS model of a chosen cultural heritage site using point cloud data or 3D scans (in .ply format).
    - Identify historical data or scans taken at different times to capture the temporal changes in the site.
2. **Partial Retraining or Model Integration:**
    - Option 1: Partial Retraining Approach
        - Investigate the feasibility of partially retraining the Gaussian Splatting model using updated .ply data that reflects changes over time.
        - Assess the complexity of modifying the GS algorithm for partial updates and identify potential challenges (e.g., data alignment, model stability).
        - Document the process and any modifications made to the retraining pipeline.
    - Option 2: Model Integration Approach
        - If partial retraining is impractical, develop a solution to merge multiple GS models representing the site at different times into a single composite model.

- Implement a method to visualize and highlight differences between the merged models, using color coding or transparency effects to indicate areas of change.

3. **Visualization of Temporal Changes:**
    - Enhance the composite GS model with clear visual indicators that represent changes over time:
        - Use color overlays (e.g., red for erosion, green for new growth) to highlight differences.
        - OPTIONAL: Provide interactive elements (e.g., a timeline slider) for users to switch between different time points and observe the changes dynamically.
4. **Comparative Analysis of Approaches:**
    - Analyze the advantages and limitations of the two methods (partial retraining vs. model integration).
    - Discuss the impact on computational efficiency, ease of implementation, and quality of the final visual output.
5. **Project Report (Max 8 pages):**
    - Detailed explanation of the chosen approach, including any modifications or optimizations made to the GS model or pipeline.
    - Step-by-step process of model reconstruction, temporal analysis, and visualization.
    - Visual documentation of the final model, including screenshots and comparisons between different time points.
    - Discussion on the potential for long-term digital preservation using this approach.

Evaluation Criteria

- Model Quality and Detail: Accuracy of the initial GS reconstruction and fidelity in capturing temporal changes.
- Temporal Analysis and Visualization: Effectiveness of the chosen method (partial retraining or model integration) in highlighting differences over time.
- Tool and Approach Feasibility: Depth of analysis on the feasibility of partial retraining versus model integration, including technical challenges and solutions.
- Innovation in Visualization: Creativity and clarity in representing temporal changes (e.g., use of color coding, interactive timeline features).
- Documentation and Presentation: Quality, clarity, and completeness of the final report and visual materials.

Suggested Tools and Libraries for Exploration:

- Blender (for initial .ply model editing and visualization)
- Open3D (for possible model merging)
- GitHub repositories
- Unreal Engine (**if no custom solutions are developed or no relevant/useful applications are found, create an Unreal Engine level to implement both models and find a way to highlight temporal differences**)

Notes:

- Students should collaborate effectively, with tasks divided among model reconstruction, temporal analysis, and visualization development.