demoConstruct: Democratizing Scene Construction for Digital Twins through Progressive Reconstruction

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ABSTRACT

We introduce demoConstruct, an open-source project aimed at developing an accessible collaborative scene authoring tool for immersive applications, catering to both professional and untrained users. The tool employs progressive reconstruction, enabling simultaneous near real-time scene acquisition and editing tasks, including editing in Virtual Reality (VR). And, can be applied to multiple use cases, such as reconstructing disaster struck areas in near real-time for remote responders to plan and simulate operations. Participants will have the opportunity to experience an alpha version of demoConstruct, allowing them to construct their immersive environments during the lab. This experience aims to foster academic discourse and stimulate discussions to collectively advance this research area through an open-source initiative.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative content creation**; **Computer supported cooperative work**; • **Applied computing** → *Computer-aided design.*

KEYWORDS

3D Reconstruction, Collaborative Scene Authoring

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1 INTRODUCTION

Creating high-fidelity digital twins traditionally involves technically complex practices performed by trained technical artists and computer vision researchers. These processes typically require expertise and resources that are not readily accessible to the average consumer, often necessitating the use of expensive 3D software on high-performance workstations. This complexity and lack of accessibility inhibit the broader adoption of digital twinning technologies, particularly in sectors without deep technological expertise, such as manufacturing and education.

We hence present demoConstruct, an open-source initiative designed to democratize digital twin creation. demoConstruct enables a novel collaborative scene authoring workflow, anchored in the concept of progressive 3D reconstruction [Foo et al. 2023]. This methodology allows for incremental model creation and editing simultaneously, significantly reducing the duration of scene construction and facilitating near real-time collaboration among users.

Our SIGGRAPH Labs session will feature a demonstration of the demoConstruct tool with hands-on experience for attendees. The session is structured to show both demoConstruct's capabilities and facilitate an interactive exploration of its practical applications. This will foster academic discourse, stimulate discussions, and collectively advance this research area through an open-source initiative.

2 THE DEMOCONSTRUCT SYSTEM

demoConstruct is designed to be a collaborative scene authoring tool that is accessible to both professional and untrained users using different devices. In the current alpha version, the front-end client interfaces are built using React and Babylon.js, while the back-end services are built using Python server libraries (e.g., fastAPI).

The current tool is built on prior work that described the use of progressive reconstruction to enable near real-time scene authoring workflows [Foo et al. 2023]. The system architecture has 3 main components - *Capture Client*, *Editing Client*, and *Edge Server* (Fig. 1).

The **Capture Client** is designed for simplicity of data capturing and enables users to efficiently capture real-world imagery and initiate the 3D model creation process. Utilizing simple mobile phone cameras, users can scan objects or environments, which are

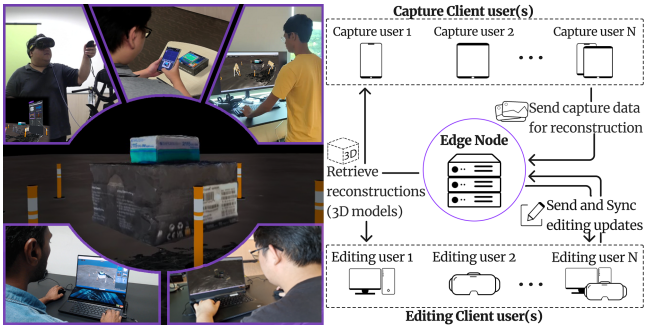

Figure 1: The left image shows screenshots of multiple Capture Clients and Editing Clients collaborating in the shared scene in the middle. The right image shows the architecture of the demoConstruct system.

then sent to the Edge Server for progressive 3D reconstruction. This offloading architecture allows the Capture Client to leverage the Edge Server's much higher computational resources, ensuring that progressive reconstruction outputs are quickly available to other users.

The **Editing Client** allows users to apply 3D transformations (translation, rotation, scaling) to 3D models and progressively update reconstructed 3D models within a virtual environment. Accessible across multiple platforms (e.g., desktop and VR), the Editing Client enables collaborators, regardless of their physical location or device, access to their shared persistent virtual environment. As the progressive reconstruction unfolds on the Edge Server, updated 3D models are synchronized across Editing Clients, automating the process of incorporating the latest iterations of their designs into the scene. This seamless integration across multi-platform interfaces empowers users to execute precise and immersive edits, fostering a rich collaborative ecosystem for digital twin scene construction.

The Editing Client also enables a highly interactive digital twin environment, users can use VR to test and validate various scenarios in a digital twin that is updated near real-time.

The **Edge Server** represents the core of the demoConstruct system, encompassing the Progressive Reconstruction Module crucial for the platform's real-time, collaborative digital twin creation capabilities. Acting as a central repository and processor, the Edge Server receives reconstruction data from various Capture Clients and provides versioning for reconstruction data and generated 3D models, facilitating the seamless transformation of real-world objects into incrementally refined digital twins.

In this alpha version, the Progressive Reconstruction Module utilizes a batch-based approach to photogrammetry, currently implemented with Meshroom [Griwodz et al. 2021]. As Capture Clients capture imagery from the real world, light pre-processing is performed before being queued within the Edge Server. The Progressive Reconstruction Module within the Edge Server iteratively enhances the fidelity of the 3D model, making progressive improvements with each batch of data processed. It then serves progressively reconstructed models to clients, aligning with the goal of enabling near real-time creation and editing.

In keeping with demoConstruct's open-source ethos and recognizing the dynamic landscape of 3D reconstruction, the Progressive Reconstruction Module is designed to be modular and extensible. For example we are currently exploring the incorporation of other 3D reconstruction methods, such as recent SLAM-based [Labbé and Michaud 2019] and NERF-based [Schwarz et al. 2020] approaches.

3 ATTENDEE EXPERIENCE

This SIGGRAPH Labs session will be an interactive hands-on installation. Attendees will experience a blend of live demonstrations and directly interaction with demoConstruct through any of the following roles:

- A *Capture Client* user using a mobile phone to capture reconstruction data
- A *VR Editing Client* user using a VR headset and controllers to manipulate reconstructed models to create a virtual scene
- A *Desktop Editing Client* user using a laptop computer to perform scene authoring tasks similar to the above.

Attendees in all roles will be experiencing demoConstruct's capabilities and functionalities in a single collaborative environment.

Intended Audience. This experience will benefit researchers and practitioners in computer graphics and vision, and those creating 3D environments (e.g., game and VR developers, etc.). Non-technical industry stakeholders interested in digital twins will also benefit.

Takeaways. Attendees will gain comprehensive insights into a new kind of collaborative tools for addressing complex problems in digital twinning and immersive content creation. The hands-on experience will show how such tools can be integrated into and enhance a project or workflow, offering a practical perspective on applying these innovative solutions in their work. The session will emphasize the value of continued contributions to the demoConstruct project via its GitHub repository (https://singaporetech.github.io/immersification-demoConstruct/). Attendees are invited to partake in this open-source initiative, fostering an ongoing dialogue and collaboration opportunity that will both aid their own projects and help shape the trajectory of applied 3D reconstruction technologies.

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