CoBranchMR: Supporting Parallel Design and Conflict Resolution in Mixed Reality

NILOOFAR SAYADI, University of Notre Dame, USA
KAIYUAN TANG, University of Notre Dame, USA
YUNHAO XING, University of Notre Dame, USA
SIMRET GEBREEGZIABHER, University of Notre Dame, USA
CHAOLI WANG, University of Notre Dame, USA
DIEGO GÓMEZ-ZARÁ, University of Notre Dame, USA

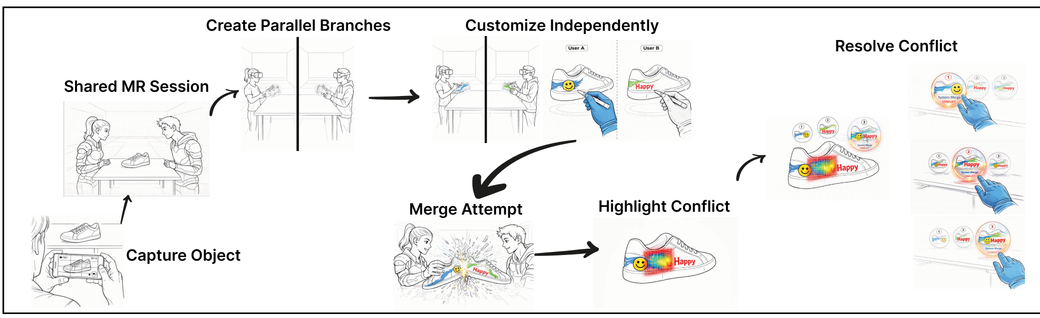

Fig. 1. From capture to conflict resolution: **CoBranchMR** lets collaborators branch a shared 3D object, customize in parallel, and merge their edits, highlighting spatial conflicts and supporting hands-on resolution.

We present **CoBranchMR**, a mixed reality (MR) system that enables distributed collaborators to work on the same digital representation of a physical object in parallel while working at different locations. **CoBranchMR** lets users branch an object into editable virtual copies, customize them independently, and then merge their work back into a shared object. When merging copies, the system displays potential conflicts on the object's surfaces and provides several resolution options. By adopting branch-and-merge workflows for embodied spatial collaboration, **CoBranchMR** provides a new collaborative interaction model to support parallel design, conflict resolution, and negotiation in remote creative work.

CCS Concepts: • **Human-centered computing → Mixed / augmented reality**; *Collaborative interaction*; *Computer supported cooperative work.*

Additional Key Words and Phrases: Mixed Reality; Collaborative Design, Branch-and-Merge; Conflict Resolution; 3D Painting; Gaussian Splatting

Authors' Contact Information: Niloofar Sayadi, University of Notre Dame, Notre Dame, USA, nsayadi2@nd.edu; Kaiyuan Tang, University of Notre Dame, Notre Dame, USA, ktang2@nd.edu; Yunhao Xing, University of Notre Dame, Notre Dame, USA, xyunhao@nd.edu; Simret Gebreegziabher, University of Notre Dame, Notre Dame, USA, sgebreeg@nd.edu; Chaoli Wang, University of Notre Dame, Notre Dame, USA, chaoli.wang@nd.edu; Diego Gómez-Zará, University of Notre Dame, Notre Dame, USA, dgomezara@nd.edu.

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1 Introduction

Collaborative work around artifacts often requires people to coordinate how their individual contributions should be aligned, combined, and reconciled. CSCW research has studied how socio-technical systems can support the additional efforts required to articulate individual actions into a shared, single object [11, 12]. For distributed collaborators, this articulation work becomes harder because physical objects are situated in only one place, are not easily viewable or editable by multiple users, and require users to establish common ground [2, 4].

Prior CSCW and MR systems have supported remote collaboration around digital workspaces by providing shared virtual context, spatial awareness, and opportunities for joint manipulation [1, 10, 15]. These systems are valuable for helping collaborators see and discuss the same workspace, but they do not allow them to explore different possibilities in parallel before deciding what to preserve, combine, or discard. Requiring all edits to happen on a single shared object can force premature negotiation and limit individual exploration, making it difficult to compare alternative designs.

Version control systems address this coordination problem by allowing collaborators to branch from a shared source, work independently, and merge their changes later. When edits overlap, the system highlights conflicts and requires collaborators to resolve them through negotiation. Recent work has explored version-control concepts for immersive content creation, including VRGit for collaborative VR scenes [16], and non-linear revision control has examined conflict resolution for overlapping edits in images [3]. However, less is known about how branch-and-merge workflows support distributed collaboration around digital artifacts represented in MR, where conflicts are spatial, embodied, and tied to the surface of an object.

We present **CoBranchMR**, an MR system that supports parallel design and conflict resolution around a shared digital artifact. It employs 3D Gaussian Splatting [5] to reconstruct a photorealistic virtual representation of a physical object, which collaborators can branch into separate editable virtual copies. Users customize these copies independently and then merge their work back into a single shared version through an embodied interaction in mixed reality. When collaborators make overlapping edits, the system visualizes the conflict directly on the object surface and provides options to keep one version, keep the other, blend both, or undo the merge.

Through this demo, we show how branch-and-merge interaction can support a collaborative process that moves between individual exploration and joint decision-making. **CoBranchMR** contributes to CSCW by demonstrating a novel interaction model for coordinating parallel work, maintaining conflict awareness, and negotiating shared outcomes in distributed creative work.

2 System Description

The system runs on two MR headsets connected over a local network for real-time multiplayer sync. A physical object is captured once using 3D Gaussian Splatting and imported into the system as a photorealistic object. An AI-generated invisible proxy mesh sits over the splat to handle physics and painting detection.

Branch: Independent Painting. Once the physical object is in the environment, each user starts by pressing a button with a virtual brush to spawn their own copy of the object. The object can be grabbed, moved, and rotated freely using hand tracking. To paint, the user dips the brush into a colored cube and then draws on the object surface. To erase, they dip the brush into a white eraser.

The application enables painting to draw smooth, continuous strokes directly on the object surface. A raycast fires from the brush tip in all six directions to find the exact surface contact point. Strokes are stored in the object's local space, so they stay attached to the object when it is moved. The eraser can remove parts of strokes by splitting them at the erased section, similar to how erasing works in drawing apps. Each stroke is labeled with the user's ID (`UserA` or `UserB`) when it is created. This identity tag is used later by the conflict detection system.

Merge: Bringing Copies Together. When both users agree on their designs, they physically carry their object copies toward each other in MR space until the copies touch. A confirmation panel appears in front of the user asking: "*Merge these two objects?*" If they choose *Yes*, all strokes from one object are transferred to the other object using coordinate space conversion to keep them in the correct position. The other object copy is then removed from the scene.

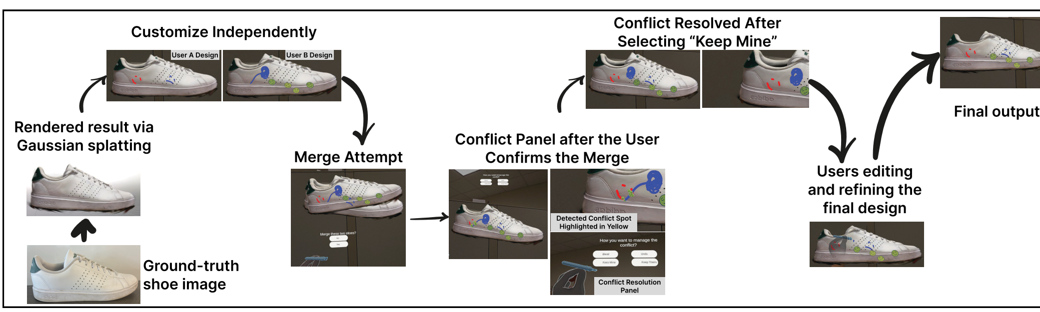

Fig. 2. **CoBranchMR**'s walkthrough: a real shoe is reconstructed via Gaussian Splatting, two users customize independent branches, a merge attempt triggers conflict detection, and users resolve conflicts before collaboratively refining the final design.

Conflict Detection. After the merge, a Conflict Manager script scans the combined object. It separates strokes into two lists by their user ID labels. It then compares every point in User A's strokes against every point in User B's strokes using 3D distance $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$.

If the distance between any two points from different users is less than 5 cm, a conflict is flagged. For each conflict found, a small yellow glowing sphere is placed at that location on the object's surface so both users can immediately see where their designs overlap. The system uses short-circuiting: once a conflict is found between a pair of strokes, it stops checking the remaining points in that pair to keep the frame rate smooth in VR.

Conflict Resolution. When conflicts are found, a resolution panel appears in the user's view. The panel rotates to always face the user (billboard behavior), offering four choices: (a) *"Keep Mine,"* which keeps the local user's painting and removes the other user's work; (b) *"Keep Theirs,"* which removes the local user's strokes and keeps the other user's painting; (c) *"Blend,"* which keeps all strokes and leaves both sets of paint visible together; and (d) *"Undo,"* which reverses the merge and both users get their separate copies back.

Technical Stack. The system is built on Unity 6 [14] and runs on Meta Quest 3 headsets. Key components include Unity-VR-Gaussian-Splatting [8], a Unity package that enables Gaussian splats to be rendered in VR/MR environments; AI-generated proxy mesh (MeshyAI [6]) for painting collision and physics; Normcore (Normal.Realtime) [9] for real-time multiplayer sync and networked object spawning; Meta XR Building Blocks [7] for hand tracking, grabbing, and UI interaction; and Unity LineRenderer [13] for smooth stroke painting on 3D surfaces.

3 Future Work

Future work will expand **CoBranchMR** in four directions. First, we plan a controlled dyad study to examine how collaborators negotiate conflicts in 3D creative work, including their coordination strategies, negotiation patterns, and satisfaction with merged outcomes. Second, we will study how decisions made on digital representations transfer to physical objects, including whether users feel confident implementing merged designs on the real artifact and whether the digital representation is sufficiently faithful to support that transition. Third, we will improve the manipulation of Gaussian splats. The current system paints an AI-generated proxy mesh over the splat, which can cause slight stroke offsets when the two are misaligned. Direct runtime editing of splat colors would reduce this issue and improve capture, editing, and export workflows. Finally, future versions could support more users and objects, including pairwise or group merges from a shared base object and generative AI features for recommending related virtual objects during ideation.

4 Conclusion

We presented **CoBranchMR**, an MR system that adapts branch-and-merge workflows to collaborative 3D object customization. **CoBranchMR** enables distributed users to edit parallel versions of a digital object and resolve surface-level conflicts through selection, blending, or undoing. This interaction model extends CSCW research on coordination, awareness, shared artifacts, and conflict negotiation into embodied MR settings. The prototype opens future directions for studying remote creative work around digital representations of physical artifacts.

AI Disclosure

Figure 1 was composed by the first author and includes AI-generated illustrative elements created with Google Gemini to depict the CoBranchMR workflow. Figure 2 was created by the authors from the CoBranchMR prototype. No AI-generated images were used as experimental data or evaluation results. AI-based writing tools were used to support grammar, clarity, and language revision. All technical content, claims, and final text were reviewed and approved by the authors.

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