AuraMR: Bridging E-Commerce and Mixed Reality for Immersive Furniture Shopping

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Abstract

Online furniture retail has a fundamental limitation: customers cannot perceive how a product fits within their own space before purchasing. Static images and two-dimensional planners fail to convey spatial scale and material texture, contributing to high return rates. We present **AuraMR**, a Mixed Reality (MR) system that transforms a furniture e-commerce catalog into a gesture-driven shopping experience. Using Unity3D and the Mixed Reality Toolkit (MRTK), AuraMR lets users browse a paginated three-dimensional catalog, search via a hand-tracked virtual keyboard, and place true-to-scale prefabs in their physical environment without controllers. The system sustains 78 FPS on Meta Quest 3, achieves 24 ms average search response, and scored a 96.1% pass rate across 51 test cases. A preliminary evaluation with 12 participants found that 91% rated the interaction intuitive and 75% expressed intent to use AuraMR for real purchases.

CCS Concepts

• **Human-centered computing → Mixed / augmented reality**; *Interaction design.*

Keywords

Mixed Reality, e-commerce, furniture visualization, Unity3D, MRTK, hand tracking, spatial computing, HCI

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1 Introduction

E-commerce accounts for a growing share of furniture sales, yet the digital experience remains flat [6]. Customers rely on photographs and two-dimensional (2D) planners that do not convey how a piece of furniture fits a room. Spatial mismatch is the leading cause of returns, making furniture one of the highest-return categories in online retail [2].

Mixed Reality (MR) offers a direct solution by overlaying three-dimensional (3D) content onto the user's environment and enabling true-to-scale product trial before purchase [4, 9]. Augmented Reality (AR) reduces cognitive dissonance and increases purchase intention [1]. Most deployed solutions, however, are limited to single-object phone-camera placement with no catalog navigation or multi-item composition.

AuraMR addresses this by re-imagining furniture e-commerce as a controller-free MR experience. Users browse a paginated catalog, search by product name, and place spatially accurate prefabs via hand gestures on a Meta Quest 3, completing a full browse → search → place → compose loop with sub-100 ms latency.[1]

2 Related Work

MR in retail. AR product previews increase purchase confidence and reduce return intent [6]. Flavián et al. [4] show that MR shapes customer experience through presence and interactivity. Barta et al. [1] confirm that AR reduces cognitive dissonance through spatial pre-trial. Commercial apps such as IKEA Place and Wayfair AR demonstrate demand for in-situ product visualization, yet restrict users to single-object placement without catalog navigation [2].

Virtual Reality (VR) and hand interaction. Immersive environments improve spatial judgment over desktop tools [3]. Digital twin research demonstrates the value of coupling physical spaces with interactive virtual overlays [5]. Ye et al. [11] identify poke, pinch, and hand-ray as the dominant controller-free interaction primitives on headsets including the Meta Quest 3, which are the modalities AuraMR employs via MRTK [8] on Unity 6 [10].

[1] Demo video: https://youtu.be/R7N2A_GX4xI?si=6Zy3xQtS_Cyfmur8

Figure 1: AuraMR: paginated 3D catalog with poke interaction; true-to-scale prefab placed in a real room on Meta Quest 3.

3 System Overview

AuraMR is built in Unity 6 [10] with MRTK 2.8 [8], targeting the Meta Quest 3 [7] and Windows Personal Computer VR (PCVR) via SteamVR. The system follows a three-layer architecture.

The **Interaction Layer** uses MRTK's hand-tracking pipeline. Poke gestures activate User Interface (UI) elements, pinch-to-grab repositions placed objects, and hand-ray selects distant elements. No physical controllers are required.

The **Logic & Controller Layer** comprises three C# modules. `UIPageController` drives circular pagination via a modulo index, toggling `SetActive()` so only the active page renders and Graphics Processing Unit (GPU) load stays constant as the catalog grows. `ShowKeyboard` binds MRTK's `NonNativeKeyboard` to an `onValueChanged` listener with cached `Transform` references and an early-exit optimization, yielding 24 ms mean search response, a 60% reduction over a naïve scan, and propagating results across all pages simultaneously. `PrefabSpawner` instantiates furniture 0.5 m in front of the canvas at ±0.02 m accuracy, with radial jitter and object pooling to prevent overlap.

The **Presentation Layer** renders 20 furniture prefabs under 10 k polygons each, with world-space UI canvases and spatial audio. A client-only architecture stores all assets locally, keeping frame rate reliably above the 72 Frames Per Second (FPS) comfort threshold.

4 Application & Limitations

Shopping workflow. On launch, AuraMR presents a world-space catalog panel with four product cards per page, each showing a thumbnail, name, and price. Users navigate pages by poking the Prev and Next buttons, or type a query on the virtual keyboard to filter results across all pages in real time: matching cards reveal and non-matching cards hide immediately. Poking a product card triggers `PrefabSpawner`, which places a true-to-scale 3D model 0.5 m in front of the panel. The user can walk around the object and reposition it anywhere in the room via pinch-to-grab, or place additional items to compose a scene. All interactions are driven entirely by hand tracking without a controller. The complete browse-to-placement loop required no tutorial: 91% of first-time users completed it without assistance, with an average session duration of 8.5 minutes.

Performance. AuraMR sustained 78 FPS with 20 concurrent prefabs, 24 ms average search response, 1.8 GB memory, 3.2 s launch time, and 48 ms poke latency. Testing across 24 unit, 15 integration, and 12 User Acceptance Testing (UAT) cases reached a 96.1% pass rate at 49 of 51 cases. Two multi-page search failures were resolved with a coroutine-based `SetActive()` queue.

Rendering pipeline. AuraMR includes a custom ShaderLab and High-Level Shading Language (HLSL) rendering pipeline comprising 38% and 7% of the codebase. Shaders support real-time ambient occlusion approximation and surface normal blending so that placed furniture responds to the physical room's lighting. Shader variants are compiled per platform, with a lightweight fallback path providing consistent visual output on both Quest 3 standalone and Windows PCVR without requiring Unity High Definition Render Pipeline (HDRP).

Limitations. The catalog is fully offline. Supporting live inventory, real-time pricing, and checkout requires a distributed backend with on-demand asset streaming. Prefab geometry is capped at under 10 k polygons to meet Quest 3 performance budgets, limiting surface detail relative to Unity HDRP with hardware ray tracing on a tethered PC. Hand tracking degrades under rapidly changing ambient lighting or when hands leave the headset's tracking volume, causing occasional missed poke inputs. The interaction model lacks haptic feedback, reducing the sense of physical contact during poke and grab gestures. The system has been evaluated with 12 participants in a controlled lab setting; a longitudinal in-home study is needed to measure real-world impact on purchase decisions and return rates.

5 Conclusion

AuraMR demonstrates that a complete furniture e-commerce loop covering browse, search, place, and compose is achievable in MR with hand gestures, sub-100 ms UI latency, and comfort-level frame rates on commodity VR hardware. The system replaces static online product images with direct spatial experience, targeting the decision uncertainty that drives high furniture return rates [1]. A 96.1% test pass rate and positive reception from 12 participants validate the approach as a practical foundation for MR-native retail. Future work will connect to live inventory Application Programming Interfaces (APIs), enable multi-user shared sessions, integrate Artificial Intelligence (AI)-driven style recommendations, and add ARKit/ARCore room-scanning for automatic furniture scaling.

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