

Couch-AR: Soft Furniture as Interactive Augmented Reality Surfaces

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ABSTRACT

We present Couch-AR, a spatial augmented reality system that transforms soft furniture into interactive surfaces featuring touch and mid-air gesture input. While prior spatial AR systems have employed rigid surfaces such as tables, floors, and walls, soft furniture remains underexplored. A preliminary evaluation revealed a positive user experience across UMUX, UEQ+, and NASA-TLX, which creates the premises for future investigations on seated AR experiences.

Index Terms: Couch, AR, seated interaction, sofa, gestures, UX.

1 INTRODUCTION

Spatial AR has been applied to augment everyday surfaces, such as tabletops [6], coffee tables [8], and entire rooms [5], enabling new immersive experiences. In contrast to these rigid surfaces, large soft furniture, such as couches, sofas, and armchairs, offers a distinctive tactile experience and a comfortable seated posture for lean-back interaction. Despite these qualities, couch-based interaction remains underexplored in AR systems, where existing designs are primarily proof of concepts, such as Zebra’s sofa,¹ Draw Light’s bedroom,² or Mr.Beam’s Living Room,³ which use projections to turn couches and beds into immersive environments. However, these systems focus on visual augmentation only and do not support user input. The closest related work is ChairMX [9], which explored chair-based input for controlling digital devices, Andrei et al.’s [1] empirical results about user-preferred gestures on and around chairs, such as swiping across the seat, and Brauner et al.’s [2] evaluation of smart interactive textile interfaces, revealing limited research in this area.

In this work, we contribute Couch-AR, a prototype system for spatial AR on soft furniture of various configurations (Figures 1,2), and report preliminary user experience (UMUX, UEQ+, TLX) results.

2 DESIGN AND IMPLEMENTATION

We designed Couch-AR starting from a set of design requirements informed by prior work involving seated users [1, 9] and interactive soft furniture [2]: (DR₁) content should be within easy reach, accessible via effortless hand stretch; (DR₂) content placement should be flexible according to the couch structure and user’s preference for couch regions; (DR₃) interaction should span a wide spectrum of gesture types, including touch and mid-air input, already familiar to users from touchscreen and AR setups. Based on these requirements, we implemented Couch-AR using a ceiling-mounted video projector (Epson EH-TW6250, 4K PRO-UHD resolution, 2800 lumens) and a Vicon motion tracking system (six Vero 1.3 cameras, each providing 250 fps at 1.3 MP with 3.4 ms latency); see Figure 3. The projection



Figure 1: Couch-AR is a spatial AR system designed for soft furniture, which calibrates according to the specific couch configuration, e.g., a conventional couch (left) or a sectional sofa with chaise (right).

covers the entire couch area, which enables selection of regions of interest where to project content, according to requirements DR₁ and DR₂, while setting the background color to invisible black. To track hand movements, we designed 4-marker patterns worn via hand straps. The mapping between projection and surface was calibrated by placing reflective markers and applying geometric warping to the projected image to compensate for the irregular couch geometry.

This setup enables integration of a wide spectrum of gesture types, according to requirement DR₃, from touch to strokes and mid-air input; see Figure 2. For on-surface gestures, the system maps the 3D coordinates of the user’s hands to the 2D coordinate space of the projected interface to determine whether the tracked hands overlap with projected elements. Our current implementation enables navigation through common types of media content: images, videos, music, and documents, e.g., a hover gesture activates the home menu (Figure 2c), swipes across the surface select items (Figure 2b), and touches engage with projected soft buttons (Figure 2a); according to DR₂, content can be flexibly rendered by grabbing it, transferring it across different couch regions, and releasing it (Figure 2d); lastly, a bimanual hover gesture deactivates the projection (Figure 2e).

3 USER EXPERIENCE EVALUATION

To evaluate the user experience (UX) of Couch-AR, we conducted a preliminary study with six participants (three male and three female), aged 27 to 35 ($M=31.5$, $SD=2.8$). After providing informed consent, participants were presented the system and encouraged to explore it by navigating through a collection of 150 images, videos, songs, and PDFs. At the end, they filled in UMUX [3] for usability, UEQ+ [7] for various UX measures, such as stimulation and aesthetics, and NASA-TLX [4] for perceived workload, including physical and cognitive; see Table 1 for the results. Overall, we found very high perceived usability with a mean UMUX of 95.1, close to the maximum 100. All UEQ+ dimensions scored in the positive side of the scales, toward 3.0, corresponding to positively connoted adjectives, with *Attractiveness*, *Stimulation*, and *Visual Aesthetics* scoring highest (2.6 to 2.8). Lastly, perceived workload was relatively low (NASA-TLX 20.3). These preliminary findings indicate that soft-furniture AR can deliver effective, enjoyable, low physical and cognitive effort, and visually attractive interactive experiences.

Our results suggest further investigation into couch-based AR, including users’ preferences for on- and above-surface input, the

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¹Digital storytelling for retail - interactive projection mapping on sofa, <https://www.youtube.com/watch?v=bKy2CNgJWW0>

²Immersive slow shopping, <https://www.drawlight.net/en/portfolio/retail-futuro-immersive-slow-shopping>

³Living Room immersive projection, <https://www.mrbeam.com/project/living-room-immersive-projection>

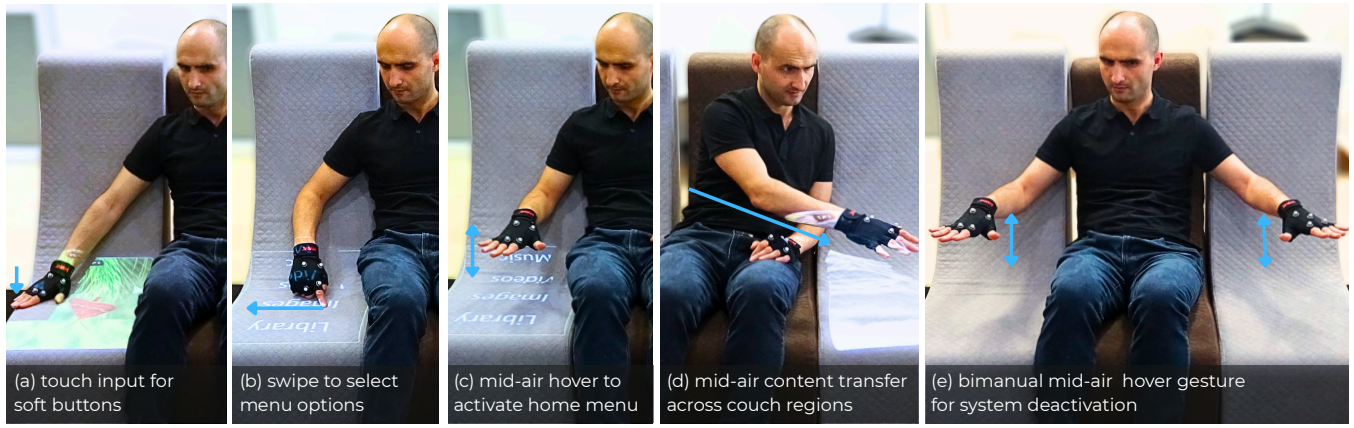


Figure 2: Gesture types supported by Couch-AR include touch input on specific couch regions (a), swipes and symbolic strokes across the couch surface (b), and unimanual (c,d) and bimanual (e) mid-air gestures above the couch, spanning both the on-surface and above-surface space.

Table 1: Preliminary user experience evaluation results of Couch-AR.

Scale	Mean	95% CI ¹	Interpretation
UMUX²	95.1	[88.2, 99.3]	A+ / excellent³
❖ Requirements	94.4	[88.9, 100]	system meets requirements
❖ Frustration	100.0	[100, 100]	no perceived frustration
❖ Ease of use	97.2	[91.7, 100]	very high ease of use
❖ Correction	88.9	[72.2, 100]	little correction necessary
UEQ+³	2.3	[1.9, 2.6]	positive experience
❖ Attractiveness	2.6	[2.2, 2.9]	very positive (enjoyable, good, pleasant, friendly)
❖ Efficiency	2.4	[2.0, 2.7]	positive (fast, efficient, practical, organized)
❖ Perspicuity	2.5	[2.2, 2.8]	very positive (understandable, easy, clear)
❖ Stimulation	2.8	[2.6, 2.9]	very positive (interesting, exciting, motivating)
❖ Novelty	2.5	[2.1, 2.8]	very positive (creative, inventing, innovative)
❖ Haptics	2.1	[1.6, 2.6]	positive (stable, pleasant, smooth, slip-resistant)
❖ Personalization	1.4	[0.2, 2.6]	moderate (adjustable, changeable, extendable)
❖ Usefulness	2.1	[1.5, 2.6]	positive (useful, helpful, beneficial, rewarding)
❖ Value	2.1	[1.7, 2.6]	positive (valuable, presentable, tasteful, elegant)
❖ Aesthetics	2.6	[2.3, 2.9]	very positive (beautiful, stylish, appealing)
NASA-TLX⁴	20.3	[10.2, 31.4]	low perceived workload
❖ Mental	20.8	[6.7, 43.3]	low perceived cognitive demand
❖ Physical	17.5	[10.8, 25.0]	low physical strain
❖ Temporal	13.3	[7.5, 20.8]	little time pressure
❖ Performance	25.8	[7.5, 56.7]	favorable perceived performance
❖ Effort	20.0	[5.0, 41.7]	low perceived exertion
❖ Frustration	8.3	[5.0, 13.3]	negligible frustration

¹CIs computed using bootstrap resampling (10,000 samples). ²UMUX ranges from 0 to 100, higher values indicate better usability. ³According to the Sauro-Lewis curved grading scale, the SUS-equivalent scores range 84.1-100 is A+; according to Bangor et al.'s adjective ratings, 85.0 or higher is excellent. ⁴UEQ+ ranges from -3 to +3, higher values show more positive evaluation; each UEQ+ dimension consists of 7-point bipolar items with opposite adjectives, e.g., annoying vs. enjoyable for *Attractiveness*. ⁵NASA-TLX dimensions range from 0 to 100, higher values show greater workload.

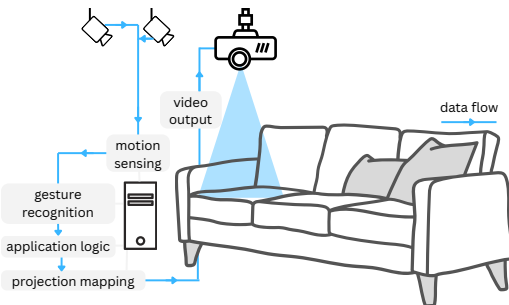


Figure 3: System diagram of the Couch-AR system, highlighting the system hardware, key software components, and data flows.

role of couch modularity and form factors, and integration with personal devices such as smartphones and smart wearables. For example, HMDs could provide an alternative to ambient projection,

enabling always-available augmentations for virtually any couch and environment, including outdoor settings; this may also offer a more affordable and sustainable technical solution where, instead of integrating augmentation technology into the environment, users wear it, as in ChairMX [9]. We suggest future examination of the effects of visual quality on UX, resulting from device type (projector vs. HMD) and soft furniture materials (rough vs. smooth textures and different colors), as well as the impact of prolonged use that may cause eye strain or neck discomfort from downward gaze. Future research should also explore other application opportunities, such as pairing the couch with display devices (e.g., smartphones or TVs) or using it as an interface for smart home control, as well as other input modalities, such as speech or multimodal input. We look forward to richer immersive seated experiences involving soft furniture.

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