

PreView: Rehearsing Real Routes in VR to Support Independent Navigation with Low-Vision

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Abstract

Low-vision individuals (LVI) must focus on their immediate surroundings while walking, a rational response to the risk of unseen curbs and obstacles. This protective attention leaves the landmarks that anchor cognitive maps unattended, and most navigation support concentrates on the walk itself, when attention is scarcest. We present PreView, a system that turns real 360-degree route imagery into a VR rehearsal of a route that a LVI plans to walk: realistic enough to learn from, safe enough to look up in. PreView highlights salient, permanent landmarks, layers an imagery-derived soundscape with surface-matched footsteps, and answers questions through an AI agent grounded in the user's current view. Rehearsing a route in PreView lets LVI form a cognitive map in advance and navigate it more independently. In this demo, attendees freely explore real captured routes and experience how multimodal AI augmentation turns commodity imagery into route knowledge that LVI could acquire safely before ever walking the street.

CCS Concepts

• **Human-centered computing** → **Accessibility systems and tools**; **Virtual reality**; **Accessibility technologies**.

Keywords

Low vision, Navigation, Route rehearsal, Landmarks, Soundscapes

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1 Introduction and Related Work

Independent navigation depends on familiarity with the environment: a cognitive map and the landmarks that anchor it [22, 23, 34, 37]. Sighted pedestrians often acquire this familiarity incidentally; a quick glance at a distinctive corner building can establish a useful landmark. For low-vision individuals (LVI), however, looking away

from the path carries a real cost. Curbs, uneven pavement, and small obstacles can be difficult to detect with reduced acuity or field of view, requiring LVI to focus on their immediate surroundings to reduce the risk of harm [17, 25]. As a result, LVI may be unable to attend to the landmarks that would help them build route knowledge and navigate independently [25, 36].

Most navigation support tools for blind and low-vision (BLV) people concentrate on the walk itself. Turn-by-turn guidance [2, 3, 18], obstacle, intersection, and street-crossing support [6, 19, 20], sonification techniques [24, 27], and scene description [26] provide in-the-moment assistance toward a destination. However, these tools can leave travelers dependent on connectivity, which is not always reliable [8, 9, 17, 29], and real-time guidance may add distraction during an already demanding walk.

Pre-trip route rehearsal offers an opportunity to build familiarity before these demands arise. Practicing a route in virtual reality (VR) can ease the cognitive load of the real walk [14] and enable travelers to learn landmarks without physical risk. Yet, the pre-trip stage remains comparatively underexplored [9, 10, 16], despite familiar routes being associated with greater confidence and lower cognitive effort [7, 10]. Travelers already improvise this kind of rehearsal, for example by using Soundscape to build cognitive maps of street grids [7, 27].

Current approaches provide non-visual access to street-level imagery [12, 16], although LVI often prefer to interact through their residual vision [32]. Likewise, VR navigation training systems for BLV people [21, 28, 33] typically rely on routes and scenes curated by specialized instructors. Consequently, LVI planning an unfamiliar trip must choose between assisted non-visual exploration and unassisted visual exploration; no system supports them in using residual vision to rehearse a real intended route.

We present PreView, a system that transforms real 360° route imagery into a multimodal VR rehearsal of an intended route. With PreView, LVI can navigate a route, listen to realistic environmental sounds derived from route imagery, receive visual guidance toward salient landmarks, and query an AI agent using in-the-moment visuals as context. In this demo, attendees rehearse an unfamiliar real route in VR and experience how PreView can help LVI build route knowledge safely before walking it.

2 The PreView Prototype

PreView takes as input a sequence of 360° images capturing the scenes along a route, and renders them as a walkable VR route. Before rehearsal, a processing step turns the route images into the data behind PreView's two modules: vision language models analyze each frame to compose a soundscape, with sounds sourced from a

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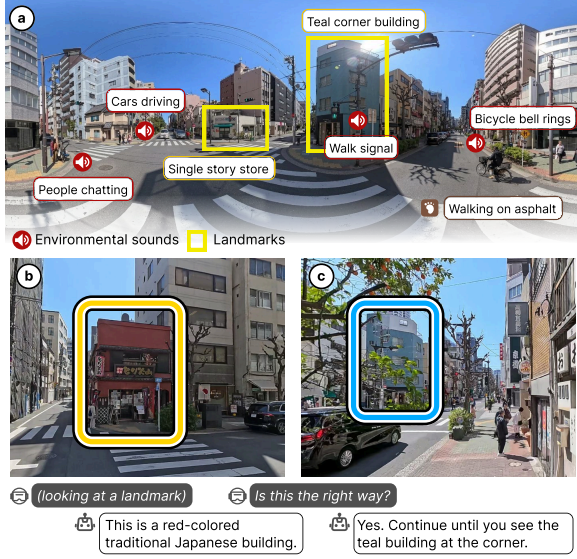


Figure 1: PreView turns route panoramas into a multimodal VR rehearsal. (a) Processing detects landmarks (yellow) and localizes environmental sounds (red), including the walking surface. (b) Gazing at landmarks, users can hear what it is. (c) The agent answers questions, with landmark highlighting.

sound effects dataset [11], and to detect landmarks, verified and localized within and across frames [22]. Each module realizes design choices derived from prior work on navigation and wayfinding and from the lived experience of the first author, shifting the cognitive effort of landmark learning from the street, where it competes with safety, to the rehearsal, where it does not.

2.1 Soundscape Module

In the headset, the user hears the route: an environmental soundscape spatialized to head orientation, so the scene sounds as it would from the street, and continuous footstep sounds matched to the walking surface, each heel strike pulsing the controller with the footstep waveform. Sound is a navigational beacon: BLV travelers track where they are by auditory texture, a busy street reads differently from a quiet alley [7, 36]. Terrain is a tactile beacon in its own right: gravel, tile, and grass each feel and sound different underfoot [7, 36]. The **environmental soundscape** therefore lets the route’s auditory identity be rehearsed alongside its visual one, and **surface awareness** keeps the underfoot cue present even while the user stands in place. During processing, each sound receives a source location, loudness, and layer, and the walking surface is segmented for footstep synthesis.

2.2 Visual Understanding Module

Looking around a scene, the user sees its two most salient landmarks highlighted with world-anchored rounded outlines (Figure 1) that breathe gently to draw the eye and settle as the user turns toward them. Holding the gaze on a landmark for 250 ms registers it: a chime sounds, the controller pulses, the outline fades, and that

landmark is never cued again, the user looks once, and PreView trusts that they know it. The user can also ask the AI agent about what they are looking at, and the agent, sensing the viewport, the landmarks, and the soundscape, highlights landmarks as it speaks about them. Distinctive objects act as navigational beacons that travelers monitor as they move, in real and virtual environments alike [4, 35], yet monitoring them is precisely the demanding visual task that outdoor walking denies LVI. LVI also prefer interacting through their residual vision [32], so PreView surfaces **landmark cues** visually and supports **visual AI interaction** in that same channel, rather than replacing vision with audio description. During processing, landmark candidates are scored on color prominence, shape prominence, and semantic prominence (e.g., distinctiveness within the environment), and ranked by combined salience [15, 31], prioritizing permanent urban features [4, 22, 35]. We filter out transient or temporary objects (e.g., cars, advertisements) [36].

3 Demo Experience

At the booth, attendees freely explore several prepared routes captured with a 360° camera around Tokyo, on standalone headsets (Meta Quest 2) running PreView as a WebXR application. They step through a route at their own pace, each controller press advancing to the next panorama while a ground marker indicates the route ahead. Attendees look around streets they have never visited, acknowledge landmarks as PreView cues them, hear the soundscape shift around their head, and question the agent about whatever catches their attention. Attendees leave having experienced how multimodal AI augmentation turns commodity imagery into route knowledge, the kind LVI could acquire safely before ever walking the street.

4 Conclusion and Future Work

PreView transforms real 360° route imagery into a multimodal VR rehearsal that enables LVI to attend to landmarks and build spatial knowledge before walking an unfamiliar route. The experience combines environmental soundscapes, footstep sounds that convey surface conditions, and an AI agent that communicates through visual aids. Together, these features position pre-trip rehearsal as a complement to the real-time navigation support that LVI may use while walking.

An important next step is to evaluate PreView with LVI participants, examining whether landmarks rehearsed in VR transfer to the real world as improved recall and confidence. Future work will also operationalize online street imagery [1, 13], allowing any searchable route to become a potential rehearsal experience. Repeated use could further support a training trajectory in which scaffolding gradually fades across sessions, while landmark salience adapts to each user’s visual profile [5, 30]. Because landmarks may be occluded, altered, or absent during the real walk, rehearsal should remain a supplement to—rather than a replacement for—real-time navigation skills.

We hope PreView moves pre-trip route rehearsal from an activity LVI must improvise toward a capability their navigation tools are designed to support.

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