Augmented Urban Space: Everyday AR in Outdoor Environments

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1 Background: Conceptualising and Prototyping Everyday AR

I am a second year PhD student at Glasgow University in the Augmented Society (AUGSOC) project. My research investigates the impact that the mass adoption of everyday Augmented Reality (AR) could have on how we experience public space and the built environment. In my first year, I conducted a systematic review of 159 XR/AR/MR applications that involved augmentations situated in space. From this, I developed a taxonomy of the five high-level dimensions of space that AR systems leverage. This framework extends beyond physical geometry to include dimensions such as the socio-relational and experiential, which are often overlooked in the design of AR experiences.

Building on this foundation, I have recently developed an in-the-wild AR application in which participants walk through a high density urban environment while wearing a Meta Quest 3 headset (Figure 1). The system overlays digital advertisements onto real building façades using geospatial mapping and 3D spatial rendering in Unity, with Cesium for Unity used to position billboards in alignment with real-world coordinates. It is anticipating a near future where AR advertising is not limited to the strict regulations of billboards and out-of-home advertising [1].

Companies such as Meta, Google and Samsung have already released, or are expected to release smartglasses to consumers over the next year. Given the commercial interest in this technology, we expect that they will become widely adopted in the coming years. Augmentations may become continuous and spatially embedded. This shift has direct implications for public space. We anticipate that these devices could exploit thousands of augmentable surfaces in the built environment; buildings, vehicles, trees, pavements, and even open sky.

My motivation for this research stems from the rapid development of 6DoF AR hardware, including projects such as Orion and emerging XR glasses initiatives from major platform providers. As visual positioning and environmental mapping improve, all-day augmentation may become commonly available to wearers. At that point, AR will not simply add digital content to space—it has the potential to reshape public environments through competing commercial and civic interests, and deepen social stratification by enabling radically different spatial experiences for different users.

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2 Developing On-the-Move AR: Advertising in the Built Environment

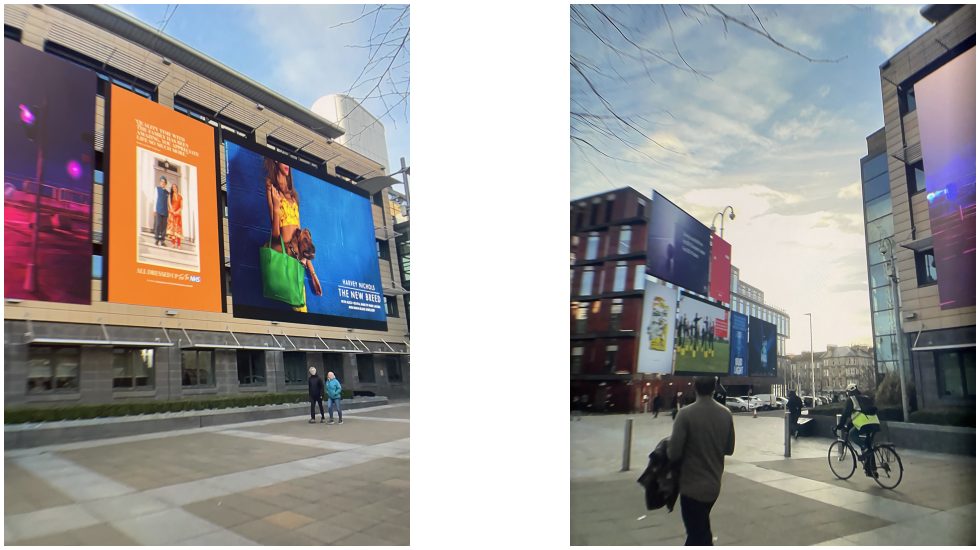

Fig. 1. In-the-wild deployment of the AR advertising system in urban environment. The AR advertisements vary in size and density. The images depict the large-format condition with the highest density coverage, where augmented billboards occupy the full surface area of surrounding building façades.

I have developed a passthrough AR system that anchors digital advertisements to building facades in the real-world (Figure 1). The system has been fully developed and pilot testing will begin in the coming weeks. The aim of the study is to explore how AR advertising – varying in density and size – can impact user's engagement with and experience in space during everyday locomotion. While previous research has explored the various permutations of AR advertising in controlled settings, such as the effectiveness of AR ads and the potential manipulations, there have been no in-the-wild studies exploring AR advertising in the outdoor urban environment.

Participants walk approximately 500 metres around a busy section of a busy urban high street while wearing a Meta Quest 3 headset. The selected route includes a mixture of narrow pavements, shopfronts, and varying pedestrian densities, providing an urban environment in which attention and environmental context are constantly shifting.

Conceptually, the app is inspired by Keiichi Matsuda's Hyper-Reality system, an extreme example of an augmented future saturated with pervasive digital overlays [2]. In that vision, every available surface – bus walls, city streets, supermarket shelves, floors, and even pedestrians – is augmented with virtual information. My system is a more realistic version of this scenario in a real-world urban environment. The advertisements vary in size and density. Some appear as large-format billboards, stretching 7 metres tall and 4 metres wide; others resemble smaller posters clustered together in groups of 3, 6 or 9. All advertisements are spatially anchored so that they remain fixed to building surfaces as the participant moves. The streets have been modelled in Unity using Cesium, a 3D mapping platform, which allows geospatially accurate placement of digital billboards onto real building façades.

The system uses manual two-point calibration to align the virtual corridor with the physical street. Once aligned, advertisements are attached to a world-root transform and placement remain stable across sessions. OVR spatial anchors were initially implemented for persistence across sessions; however, these proved unreliable in

outdoor environments due to changes in cloud-cover, light, pedestrians and cars. In addition, prolonged outdoor use exposed limitations in headset tracking: after several minutes, accumulated drift can cause anchored content to shift from its registered position, suggesting that the system is operating at the limits of current consumer-grade SLAM stability in large-scale outdoor settings.

3 Reflection on the Opportunities and Challenges of AR in On-The-Move Contexts

When we are developing applications in-the-wild that are interacting with the urban environment, and negotiating how people will incorporate this technology into their everyday lives, there are a number of considerations to bring into account. The two implementation obstacles reported in section 2 (unreliable persistence of spatial anchors and tracking drift) will need to be addressed. Even small environmental changes—lighting variation, moving pedestrians, vehicles, or subtle façade shifts in shadow—can destabilise relocalisation. These limitations reflect broader constraints in current SLAM-based AR systems. It has been speculated that this may be contributing to the delayed rollout of persistent augmentation features such as Meta's "Augments." For everyday augmentation to function on an urban scale, platforms must achieve greater stability under changing environmental conditions. Until then, large-scale persistent overlays in public space remain technically fragile, challenging assumptions about Hyper-Reality style augmented futures.

This raises a practical and methodological question: how can we empirically test large-scale augmented displays in the wild using the technology currently available? If persistent augmentation remains technically unstable, researchers must work within these constraints while still attempting to understand how such systems could shape future public space and urban environments.

Beyond technical stability, there are broader structural questions about how an everyday AR future might operate. AR introduces a profound shift in how space can be used. Today, physical advertising in the UK is tightly regulated: billboard placement, shop signage, and fly-posting are subject to planning law and size constraints. In an augmented future, however, there are effectively thousands of potential surfaces available for digital overlay—façades, pavements, windows, trees, even open sky. Content would no longer be restricted to discrete panels or predetermined sizes. Instead, almost any visible surface could become a site of augmentation. This transformation raises deeper questions about how we understand and govern the urban environment. How will public and private boundaries operate in augmented environments? How might individuals navigate spaces where digital layers compete for attention? What safeguards should exist to prevent visual overload or inappropriate placement? In practical terms, this includes identifying which parts of the outdoor urban environment developers consider "augmentable," and where limits might reasonably be drawn.

References

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[2] Keiichi Matsuda. HYPER-REALITY, May 2016.