

# Integrated Virtuality: Inspiration by the Built Environment

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## Abstract

With growing adoption of mixed reality technologies, they are increasingly integrated into everyday life. Yet, such experiences are often not seamless and easily noticeable as artificial looking and separate from the reality they extend. Ideally, we would like mixed reality to more integrally coexist with reality. To achieve this goal, we argue that it is helpful to examine other technologies that are already pervading our environments today. Specifically, we investigate the tension between natural and artificial in the built environment. While the spaces we live in and move through are commonly heavily altered and full of infrastructure, not all those technologies stand out to us as artificial. Understanding why this is the case can inform the design of mixed reality systems that integrate more smoothly with reality.

## Keywords

Mixed reality, integration, built environment

## 1. Introduction

Mixed reality (MR) technologies are increasingly tailored to everyday tasks and experiences. Devices like Meta's *Ray Ban Display* are not much bigger than regular glasses, yet can process the environment around the user and display visual feedback right in their field of view. Where such MR devices were previously commonly situated in assembly lines and maintenance shops, they now also provide support while shopping, traveling, or when in conversations [1].

Supporting everyday tasks through MR generally results in various visual elements added to the user's view, often together with haptic, audio, and speech cues. Yet this could result in visual overload and a view of the world dominated by virtual elements, such as illustrated by Keiichi Matsuda's vision of *Hyper-Reality*. For virtual and real to co-exist, the former needs to be subdued to an extent that it does not take away substantially from the latter.

While this integration for MR is a pressing issue, there have been numerous technologies through human history that have impacted the reality around us. In many ways, the physical environment we inhabit today is shaped by these technologies and our use of them. For example, we pave roads and paths in order to make it easier to move between places, but that support also diminishes the natural environment, sealing away the ground below. Yet, while much of our environment is technology, we do not necessarily perceive it as such. For example, seeing other people in clothing, another kind of technology, does generally not strike us as deviation from the natural state of the world. In fact, clothing and many other technologies *are* often seen as the natural state of the world.

Distinctions between natural and man-made sit a basic level of how we perceive the world [2], and can be made without closer inspection of individual features. Vining et al. [3] have noted how perceptions of the world around us as natural can relate to the degree of human interference. Many of their participants descriptions of what is unnatural came down to materiality (e.g., concrete, wires, ...), but also in the displacement of nature and the jarring contrast between natural and unnatural parts of the world. Focusing on the urban environment, Cameli [4] also investigated the distinction between natural and artificial, and presents several lenses through which to view this distinction. Given the unclear boundaries and shifting perception of the two, however, he also points out the futility of making this distinction for more complex cases.

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*Co-Living between Reality and Virtuality as a Daily Routine, CHI 2026 Workshop, April 14, 2026, Barcelona, Spain*

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## More Natural



## More Artificial



**Figure 1:** Examples from the built environment, differing in their degree of apparent naturalness and artificiality. Images by Mnalis (natural trailmarker), Eplack (artificial trail marker), Donald Trung (natural electrical box), Killarne (artificial electrical box), Arbitrarily0 (natural fountain), Emijrp (artificial fountain), GeographBot (natural hedge), GeographBot (artificial hedge), GeographBot (natural bench), and GeographBot (artificial bench).

Man-made real spaces and man-made virtual spaces both clash with the natural world in some way. Yet, they both also provide comforts and capabilities lacking from the natural state of things. Furthermore, both require a balancing of their benefits and disturbances, so as not to impose undue negative effects on their users and others. Fortunately, as our built environments often demonstrate, harmony can be achieved and integration of the natural and artificial is possible.

## 2. Natural and Artificial in the Built Environment

If we look at the built environment we can find plenty of examples where technology is more or less visible, even when serving the same purpose. Figure 1 shows some of these cases, contrasting more natural and more artificial variants. For example, trail markers can be more subtly integrated with the natural environment, by affixing them to it. In contrast, free-standing markers, such as the metal pole shown, are inherently more distinct from nature. Another example are electrical boxes in the urban fabric. They serve an important role, but only need to be interacted with in rare occasions. While they are often painted brightly or left plain, they can also be camouflaged to blend in with the greenery around them, allowing them to seasonally disappear from our view. As the examples of hedges demonstrate, greenery itself can become more artificial, even though it is inherently natural. Through planting and shaping, we can appropriate nature and turn it into a man-made feature. Finally, the fountain and bench examples illustrate how man-made designs can emulate natural features and forms, but can also play up the unnaturalness.

Shared aspects across these examples are material choices, messiness, and integration. Materials that are found in nature also make the artificial seem more natural. This is even more the case when also extending to structure, such as wall made of larger rocks compared to a more manufactured rock aggregate. Messiness on the other hand is a consequence of letting nature run its course, where straight lines or right angles will rarely appear. As we shape things or strictly confine them, we are taking away from this naturalness and creating contrast, even though the materials might be natural. Integration then describes how much artificial parts of the environment appear separate overall. Spatial separation is one way to lessen integration, while extending the natural or mashing it together with artificial extensions can help increase integration.

### **3. Lessons for Co-Located Mixed Reality**

Just like physical additions to the built environment, virtual additions can also feel more or less artificial. Seeming artificial is not inherently a bad design, given such elements stand out and are likely comparably functional. But in scenarios where use of MR is ubiquitous and many tasks are supported with such technology, a more subtle [5] and integrated experience is desirable.

Just as with physical technology, the material of virtual technology matters. Currently, while MR content appears in our view of the world, it also generally looks noticeably different than what we see in that world. This is partly due to rendering limitations, but also is a design issue, where it is much easier to create MR content that does not look natural than content that does. As demonstrated by technologies like photogrammetry or Gaussian splats, captured content can be replicated at high fidelity. However, this contrasts with all other virtual elements, such as user interface components, for which this is rarely the case.

Where nature is often messy, we rarely find organic and messy designs in MR experiences. This likely also is due to the added complexity of designing and rendering such elements, while cubes and planes are easy to work with. But while such simple geometries are convenient, they also clash with the spaces we might want to use MR in. For example, a cozy living room will often feature plenty of smooth and soft objects and surfaces, while the MR interfaces we might use therein do not.

Finally, integration of MR with the real world is another important aspect and overarching goal. Visual elements floating in free space, 3d models detached from the world around them, and interactions with no heft to them, all work counter to MR being perceived as a natural part of the world. More grounded visual representations, relating to the space and people around them could help integration. If we affix MR elements to surfaces and objects, they ideally should also be able to act as if they actually integrated with these. For example, just as with physical parts of the world, there could be signs of wear and tear, fingerprints on oft-pressed buttons, and visual blending instead of just overlaying. Just as a layer of paint that still lets the surface structure underneath show through, a layer of MR elements might also want to reflect what it has been applied to.

### **4. An Example of Integrated Mixed Reality**

To concretize what designing for more natural and integrated MR could look like, we can examine an example scenario: baking. An MR system would show recipes, track ingredient amounts, provide timers, and help with decorating. All this information could be shown on panels floating on the air, but much of it could also be directly integrated with the work area and the items used during the process. For example, the timer could be added to the oven, the ingredient amounts could be shown as shading on the packaging or height levels to hit on a mixing bowl, and what tool to use next could be indicated by slightly desaturating all other ones to make the one to use stand out. As demonstrated in previous work [6], cutting the baked cake could also be an augmented interaction, reacting to the knife and showing resulting slice sizes right on the cake.

## 5. Conclusion

The built environment is full of technology, yet much of it appears as a natural part of the world to us. If MR technology is to be as ubiquitously used, it similarly should strive to blend in with reality and integrate. This can mean to adopt fitting materials and rendering styles, but also to deviate from simple geometries to built more organic and messy interfaces. MR systems should feel like a part of the environment, not something artificial and detached from it. Of course, this does not hold for all experiences and fully immersive ones, for example, can more readily break with such integration patterns. Furthermore, leaning into less-realistic styles, such as comics [7], can also enrich experiences. However, these should be used only momentarily and short-term, while longer uses likely are better when integrated with the world.

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