Perceived Realism of Virtual Environments Depends on Authenticity

While the perception of a virtual environment (VE) is usually described in terms of its level of immersion and users' sense of presence, the construct of authenticity might be more useful. The authenticity of a VE depends on whether the affordances and simulations chosen in its implementation support (1) users' expectations based on their Bayesian priors for regularities in the real world and (2) the users' intentions in the VE.

With the growing number of consumer-grade virtual reality (VR) headsets, there is increasing interest in what makes a good virtual environment (VE). While there are several useful constructs for discussing users' perception of a virtual environment, that is, fidelity, immersion, and presence, the term "authenticity" refers to whether the virtual environment provides the experience expected by the user, both consciously and unconsciously.

The concept of fidelity is frequently tied to the goodness of a VE; how realistic is it? However, depending on the context, different types of fidelity become relevant. Visual fidelity (Does it look realistic?) might be important for the windshield portion of a driver training simulator (McMahan, Bowman, Zielinski, & Brady, 2012; Riener, 2010), but auditory fidelity (Does it sound realistic?) is critical for simulators of heavy equipment operation (Lu & Davis, 2016), where operators make decisions based on engine sounds. In a surgical simulator (Triantafyllou, Lazaridis, & Dimitriadis, 2014), surgeons need to feel the tension of tissue through a high-fidelity haptic interface (Does it feel realistic?). This list of fidelities is by no means exhaustive, but enumerating a few argues that measuring fidelity depends on the context and tasks at hand. Also, the concept of fidelity offers no real guidelines for establishing target thresholds. How much fidelity is good enough?

Bowman and McMahan (2007) use the terms "immersion" and "presence" to discuss the realism of a virtual environment, framing immersion as an objective measure of the simulation equipment provided. What field of view is provided by the VR headset or surround screen? What is the reaction latency? A VE with higher immersion, so the argument goes, should lead to higher fidelity, and generate a greater sense of presence, the subjective experience felt by the user. But if I put you in a highly immersive environment and give you badly designed content to experience, will you perceive the VE as realistic and experience presence? Probably not.

What's missing from this dichotomy of immersion (objective, system-focused) and presence (subjective, user-focused) is a computational theory about the extent to which the VE reflects the expected regularities of world that it is attempting to represent—its authenticity. Authenticity draws on two streams of thought: expectations and motivations. The expectations stream arises from natural computation (Richards, 1988) and Bayesian inference (Tenenbaum & Griffiths, 2001). These researchers focus on the fact that perception is an underconstrained computational problem. Without observers' probabilistic assumptions about the external world (Bayesian priors), the mathematics of perception are not possible to resolve based solely on the limited inputs to our senses. Thus, as observers, we build mental probabilistic models of the regularities of the world around us. Yang and Purves (2003), for example, described how the visual space we perceive is based on Bayesian inferences.

A virtual environment, in its attempt to offer a useful proxy of one portion of the world, offers an even further reduced set of sensory information than the real world. However, a clever VE designer who understood observ-

Presence, *Vol. 25, No. 4, Fall 2016,* 322–324
doi:10.1162/PRES_a_00276

Stephen B. Gilbert
Iowa State University
1620 Howe Hall
537 Bissel Rd
Ames, IA 50011, USA
gilbert@iastate.edu

ers' assumptions and priors for the real world could emphasize only features that leverage those expectations and leave out irrelevant features. The resulting VE could have lower fidelity but higher authenticity than even a real environment, since the signal-to-noise ratio for relevant world features would be much higher in this cleverly designed VE than in the real world, which is full of distractions. A VE populated with human-controlled avatars, for example, could offer highly authentic human interaction while displaying low-fidelity cartoon avatars.

Authenticity's second stream of thought comes from art historians and archaeologists who think carefully about the past, and who often seek to establish whether artifacts found in the present are authentic. While establishing an artifact's date and place of origin might be a matter of objective fact, Lovata (2007) argues that these facts are simply nominal authenticity, and that a richer, more complex sense of authenticity is context dependent, and depends on the motivations of the observer. As an example, he notes that the Anasazi cliff dwellings of Manitou Springs, Colorado, USA, are fake, created in the early 20th century as an educational tourist attraction. Traditional archaeologists might deem these dwellings inauthentic archaeology. Lovata suggests, however, that this site can be considered authentic for tourists, because it was not built for archaeologists; it was designed with the intention of engaging tourists with a past culture. Because Manitou Springs is labeled accurately and allows complete touching and exploring by visitors, it fulfills its purpose for this audience. It could be deemed more authentic for tourists than the historically genuine cliff dwellings in Mesa Verde National Park, where visitors cannot touch or explore on their own, lest they damage artifacts.

Like Manitou Springs, a virtual environment is often a replica of some portion of the real world designed with a specific purpose. I suggest that immersion is the system-based factor that influences presence, and that authenticity is the human-based factor that influences presence, as measured by whether it aligns with the expectations of users in terms of Bayesian priors given the designed purpose of the VE (see Figure 1). Slater and Wilbur's (1997) Framework for Immersive Virtual Environments (FIVE) and Slater's (2009) more recent description of

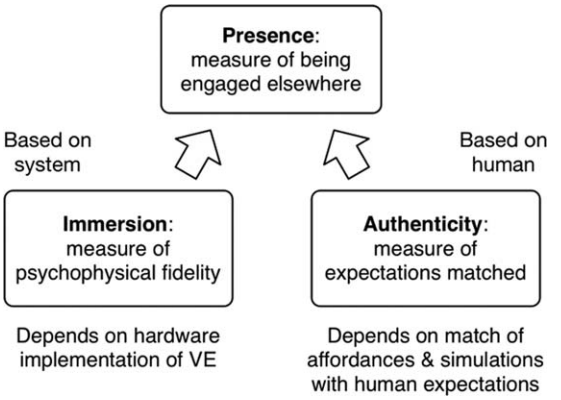

Figure 1. *Presence is affected not just by immersion, but also by authenticity, which arises from the choice of affordances and system models implemented in a virtual environment. If they match users' expectations and Bayesian priors, the perceived presence is high.*

the plausibility illusion offer related ideas, in that the VE's models of interaction affect presence, but these models are not easily measured or categorized. With the tools of Bayesian inference, I suggest that a VE's authenticity could be evaluated probabilistically, independently of the user, giving us another method of predicting presence more reliably.

Acknowledgments

Thanks to Jonathan Kelly and Michael Dorneich for formative feedback on these concepts.

References

Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: How much immersion is enough? *Computer, 40*, 36–43.

Lovata, T. (2007). *Inauthentic archaeologies: Public uses and abuses of the past*. Walnut Creek, CA: Left Coast Press.

Lu, X., & Davis, S. (2016). How sounds influence user safety decisions in a virtual construction simulator. *Safety Science, 86*, 184–194.

McMahan, R. P., Bowman, D. A., Zielinski, D. J., & Brady, R. B. (2012). Evaluating display fidelity and interaction fidelity in a virtual reality game. *IEEE Transactions on Visualization and Computer Graphics, 18*(4), 626–633.

Richards, W. E. (1988). *Natural computation*. Cambridge, MA: MIT Press.

Riener, A. (2010). Simulating on-the-road behavior using a driving simulator. *ACHI '10 Proceedings of the 2010 Third International Conference on Advances in Computer–Human Interactions,* (25–31).

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1535), 3549–3557.

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments, 6*(6), 603–616. doi: 10.1162/pres.1997.6.6.603

Tenenbaum, J. B., & Griffiths, T. L. (2001). Generalization, similarity, and Bayesian inference. *Behavioral and Brain Sciences, 24*(04), 629–640.

Triantafyllou, K., Lazaridis, L. D., & Dimitriadis, G. D. (2014). Virtual reality simulators for gastrointestinal endoscopy training. *World Journal of Gastrointestinal Endoscopy, 6*(1), 6.

Yang, Z., & Purves, D. (2003). A statistical explanation of visual space. *Nature Neuroscience, 6*(6), 632–640.