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Editorial: Use of immersive technologies in design

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Editorial on the Research Topic
Use of immersive technologies in design

In recent years, there has been a renewed interest in user-directed research in spatial sciences such as architecture, urban design, and GIScience (Çöltekin et al., 2020), often aiming to understand how people can perceive and experience built-environment designs in ever more realistic ways. Novel technologies such as virtual reality (VR) can now be confidently used for visualization of spatial designs to facilitate an understanding of the characteristics of the design, to conduct experiments to characterize near-real-world visual information processing, and to investigate how humans navigate in built environments.

Designing built environments, be it urban planning, buildings, interior designs, single objects or other, requires visualization during conceptual, urban and geospatial, architectural, and interior design phases of development. Historically this design process would tend to rely heavily on two-dimensional artistry. In recent years, industry has begun to utilize immersive 3D technologies such as stereoscopic displays and extended (virtual, augmented, and mixed) reality (XR) to aid in the visualization process of design work for built environments. While immersive technologies offer many benefits by simulating a near-direct experience of the intended designs (e.g., McIntire et al., 2014; Çöltekin et al., 2016) most likely amplified due to the feeling of *presence* (Jicol et al., 2023), their impact on the design process and the human users are yet to be reflected and validated through peer-reviewed academic research. A lack of nuanced evidence regarding immersive technologies has important ramifications. Immersive technologies may possess on the surface, a "wow-factor" (often touted in design work), but might fail to address underpinnings that are vital for the design process.

The goal of this Research Topic is to address and validate the novel uses of immersive technologies such as XR (i.e., virtual/augmented/mixed reality), for the direct or indirect purpose of designing built environments and better understanding how humans navigate in such environments. As importantly, a key goal is to assess how XR might serve "as a lab" for studying built environments and how useful they are for collecting user data that could enable studying both fundamental and applied science questions.

Immersive technologies allow for the collection of objective data from typically subjective experiences, by offering fully controllable environments that enable conducting controlled experiments, while still eliciting an arguably ecologically valid experience for the participant. Given the above, the scope of the present Research Topic is to highlight novel uses of immersive technologies for better understanding human factors in built environments. Contributors address themes from traditional architectural validation such as spatial and social density, and navigation-related experiments, as well as aspects from health and cognitive psychology, interior design, new forms of work, and workplace productivity. In addition, this Research Topic contains investigations into individual

differences, such as culture, personality, and social economics. Specifically, the Research Topic collection contains the following contributions:

Without taking individual and group differences into account, one can argue that we can never achieve universal design. In the perspective article "*How interior design responds to neurodiversity: implementing wearable technologies in neurodesign processes*," Kwon et al. discuss the benefits and challenges of using virtual environments and wearable technologies in interior design and related fields. They argue that neurodiversity plays a key role in the invisible human-environment interaction, and that measuring, analyzing, and understanding affective, perceptual, and cognitive experiences is a challenging process. After a review of the relevant work spanning from theories e.g., phenomenology, and practical implementations of e.g., eye tracking in VR to study cognitive differences in spatial perception including dementia, authors contextualize a novel process model in the context of their work, Participatory Neurodesign (PND) framework from wayfinding literature, along with other opportunities for neurodesign research.

A social science perspective in technology development can provide crucial insights. In "*The praxis of radical placemaking*," Gonsalves et al. propose a new digital placemaking design practice called Radical Placemaking, involving "marginalized bodies highlighting social issues through the ephemerality and spectacularity of digital technologies in public spaces" based on a 3-year design study. Authors demonstrate the effectiveness of this approach through three design interventions (participatory action research, slow design, and open pedagogies) and offer a conceptual framework with nine key strategies for co-designing within the triad of people-place-technology.

As XR technology advances in scope, wearables (XR wearables) are getting lighter, and more and more of them are coupled with artificial intelligence (AI), many questions about security and privacy are raised. Such concerns warrant questions around technology acceptance. Can we transition to these new technologies without creating an "ad nightmare" around us? In "*Evaluation of the extended TAM for digital signage augmented roadshow (DiSAR) using PLS-SEM*," Tan et al. propose an extended Technology Acceptance Model incorporating System Quality, Perceived Interactivity, and Perceived Enjoyment as antecedents. They empirically analyze the performance of this model in modeling the user acceptance of 203 participants, and identify key factors influencing the user acceptance, in a Digital Signage Augmented Roadshow. Their findings show a nuanced relationship between that System Quality and Perceived Interactivity have a significant relationship with the Perceived Ease of Use of DiSAR, Perceived Enjoyment has a significant relationship with the Perceived Usefulness of DiSAR; demonstrating that the rethinking classical TAM with new dimensions can reveal new correlations that are informative in designing immersive content.

Utilizing XR, especially VR as a laboratory, is an attractive concept due to its affordance of control. In "*The effects of social density, spatial density, noise, and office views on perceived personal space in the virtual workplace*," Jicol et al. investigate how different variables influence Indoor Environmental Quality (IEQ) and perceived personal space in shared office environments. They employ virtual reality to simulate shared and single occupancy offices and devise a novel measure of personal space estimation. Authors demonstrate that "participants experienced greater perceived personal space when (1) in a sparsely populated rather than a dense office, (2) in a private office rather than an open plan office, and (3) having any view outside of the office," and the fact that they can demonstrate this stands as a testimonial that the changes in virtual space creates a relative difference in people's reactions, and VR can be a viable tool to study Research Topics such as personal space.

Complementary to Jicol et al.'s study, finally, in "*Differences in office-based personal space perception between British and Korean populations*," Richardson et al. present a study that takes also a cultural view into account and compare the perception of personal space in South Korean and United Kingdom workplaces. They employ virtual reality to simulate shared and single occupancy offices and obtain personal space estimations using a retractable/extendable virtual disc around the participant, use the disk size as a measure, and compare it to the results of a questionnaire. While participants in either cultural group "perceived personal space (1) when in a sparse rather than dense office and (2) having a view of the city outside the office," British participants had significantly higher personal space estimations in single occupancy offices than in shared offices while Korean participants did not. This study further demonstrates that VR can be a medium to examine cultural differences and attitudes toward space. Richardson et al. state that "future research would benefit from comparing VR to actual workspaces," which is also a valid statement for Jicol et al. study, even though relative differences give interesting new information also within a VR study.

Taken together, these articles in our Research Topic demonstrate the potential of immersive technologies to transform the field of design and highlight the importance of considering human factors in built environments. We believe immersive technologies, specifically XR coupled with artificial intelligence (AI) will have a transformative effect in all fields related to design, including the studies of built environments. As we continue to develop and refine these technologies, it is essential that we prioritize research on their impact on human behavior, cognition, and emotion.

Author contributions

MP: Writing – original draft, Writing – review & editing. AC: Writing – review & editing, Writing – original draft.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Gen AI was used in the creation of this manuscript. Generative AI was used for proofreading assistance.

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