A empirical study on immersive prototyping dimensions*

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Extended Abstract

Ubiquitous computing technologies provide exciting new opportunities for enhancing physical spaces to support the needs and activities of people within them. However, many aspects of the human characteristics of ubiquitous computing systems in built environments can only be explored in the context of the target environment (the texture of the environment is crucial to the success of the potential system). In evaluating these systems it is not only necessary to explore conventional properties of usability but it is also necessary to explore properties of the environment that contribute to the experience of its users. The displays, devices and sensors form an integrated whole contributing to the texture of the target environment.

Fielding such systems for testing purposes is, in many cases, not feasible because of the potential disruption to the ongoing business of the environment. Consider, for example, an emergency evacuation scenario. Also, developing the system to a deployable state might imply commitment to design decisions that can be expensive to reverse. Nevertheless, the potential impact of a system in user practice, justifies that its design should be explored as early as possible [3]. It should be possible to use prototypes to explore the consequences that different design decisions might have, while promoting the identification of new solutions

Simulated 3D environments offer an interesting solution to immersive prototyping [1, 2, 5, 4]. 3D Application Servers and game engines provide a fast track to developing virtual worlds that replicate the type of environments that needs to be prototyped. The use of these 3D Application Servers as the basis for a immersive prototyping framework enables agile development of simulations of the ubiquitous environment. However, to be successful, immersive prototyping requires a thorough alignment with the key properties of the target environment, both at the technical and social level, and a strong focus on the specific evaluation goals and they can be met while considering the specific limitations immersive prototyping. Simulated environments may offer a very diverse set of properties,

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enabling for example different degrees of fidelity for the prototypes, from simple desktop simulations, to fully immersive experiences in a CAVE environment.

With this in mind, we decided to study the design space of immersive prototyping based on 3D simulation, and provide a framework to guide the alignment between specific evaluation goals and particular prototype properties. This should provide a relevant contribution towards understanding the potential added-value of 3D simulation as a tool in the development of ubiquitous computing environments. So the key issue that we want to see is "what are the relevant dimensions that prototypes should exhibit to better support evaluation of the envisaged design?".

In order to establish relevant analysis dimensions for ubiquitous computing immersive prototyping, we performed a review of the research literature on the topic. More specifically, our review covered papers on evaluating user-interaction in 3D environments and specific evaluation for specific systems. The papers were analyzed in search of codes for two groups of characteristics of ubiquitous computing that we initially defined as:

1. Properties of the simulation;
2. Requirements for evaluation and evaluation objectives.

Open Coding [6] was used to analyze the contents of the papers. Each paper was read in order to identify phrases or paragraphs containing references to the two groups of characteristics of ubiquitous computing aforementioned. A code was assigned to each piece of text identified. At this stage, the goal was to generate as many codes as possible without much consideration of how they related with each other. The MAXQDA10 tool was used to aid the open coding process.

A total of 33 different codes were identified. Of these, 20 corresponded to the first group, while the other 13 were relative to the second group. The total of codes identified were 220. Then an affinity diagram was created to synthesize the gathered data (in our case codes). The goal here was to find the key dimensions, based on the natural relationships between codes. In a brainstorming session we grouped similar properties into logical groups. As we analyzed more codes, we discussed whether to place each of them in one of the existing groups, the possibility of creating more groups or of creating subgroups.

The paper presents the two groups of characteristics identified as a result of the work. The first relates to sets of dimensions of immersive prototyping ubiquitous systems, and includes topics such as Fidelity of immersion, Embody interaction support or Hybrid prototyping. The second addresses to the different perspectives to evaluate ubiquitous systems (from evaluation centered on the system and its functional qualities, to evaluation centered on the user's experience of the system), and the methods to gather the feedback about the user experience. A discussion on how the framework was applied to the development of a prototype used to aid the design of a concrete ubiquitous environment ends the paper.

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References

1. Terrence Disz, Michael E. Papka, and Rick Stevens. Ubiworld: An environment integrating virtual reality, supercomputing, and design. In *Heterogeneous Computing Workshop*, pages 46–57, 1997.
2. Ali A. Nazari Shirehjini and Felix Klar. 3dsim: rapid prototyping ambient intelligence. In *Proceedings of the 2005 joint conference on Smart objects and ambient intelligence: innovative context-aware services: usages and technologies*, sOc-EUSAI '05, pages 303–307, New York, NY, USA, 2005. ACM.
3. Derek Reilly, Dave Dearman, Michael Welsman-Dinelle, and Kori Inkpen. Evaluating early prototypes in context: Trade-offs, challenges, and successes. *IEEE Pervasive Computing*, 4(4):42–50, October 2005.
4. José Luís Silva, Óscar R. Ribeiro, João M. Fernandes, José Creissac Campos, and Michael D. Harrison. The apex framework: prototyping of ubiquitous environments based on petri nets. In *Proceedings of the Third international conference on Human-centred software engineering*, HCSE'10, pages 6–21, Berlin, Heidelberg, 2010. Springer-Verlag.
5. Pushpendra Singh, Hai Nam Ha, Patrick Olivier, Christian Kray, Zhiwen Kuang, Amy Weihong Guo, Phil Blythe, and Phil James. Rapid prototyping and evaluation of intelligent environments using immersive video. In *Proceedings of MODIE workshop at Mobile HCI'06*, Espoo, Finland, 12-15 September 2006.
6. A.L. Strauss and J.M. Corbin. *Basics of Qualitative Research: Techniques and Procedures for developing Grounded Theory.* Sage Publications Inc, 1998.