

# Using Mixed Research Methodologies in the Development of Olfactory Displays for Video Games

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**Abstract**

Olfactory displays (digital interfaces that generate and diffuse smells to a user with a purpose) have been proposed and researched to support the user experience (UX) of video game players. These emerging human-computer interfaces have great potential for stimulating players' mood, helping immerse them in video game scenarios, and supporting other human senses used for playing games, among other useful applications. However, little is known about effective mixed research and reporting methodologies for developing and testing olfactory displays in video games. These interfaces pose a number of multidisciplinary research challenges, such as how to measure the smell perception in video game players. This workshop paper will discuss mixed research methodologies on the development of olfactory displays in video games, such as the use of usability questionnaires and field testing, and reporting aspects regarding quantitative and qualitative aspects on the odors and players' UX.

**Author Keywords**

Olfactory interfaces; smell; video games; UX; usability; qualitative data; quantitative data; multidisciplinary research

## **ACM Classification Keywords**

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## **Introduction**

Olfactory displays (digital interfaces that generate and diffuse one or more odors to a human user with a purpose) have been proposed and used in computer interfaces for a supporting users in information recall, helping immerse users in 3D environments, and supporting other human senses, among other applications [1]. In addition, smell can convey meaningful information at the computer/digital product interface. Other applications of olfactory display include the use of smells as warning signals, and as a “mood enhancer” employing aromatherapy techniques, since smell stimulates emotional responses. In addition, olfaction is a powerful recall stimulant that may support learning of complex information. Odors have a number of technical properties that can be successfully exploited in human-computer interaction (HCI), such as directional properties, intensity, the chemical nature of the odor, and hierarchical properties, among others [2]. An olfactory interface provide users with smells that convey meaningful information.

The use of smell at the computer interface was initially proposed and researched during the eighties and nineties as an important component in virtual reality/virtual environment applications, since olfaction can be a powerful sensory channel to enhance presence in virtual reality and improve the perception of spatial cues [4]. Recent research describe the use of olfactory displays in video games, where smells can be a powerful medium for supporting the user experience (UX) of video game players, enhancing their mood, and supporting players' immersion, among other applications [5,6].

This workshop paper focuses on discussing mixed research methodologies and reporting issues regarding the development and application of olfactory displays in video games. Despite significant advantages of olfactory interfaces, the sense of smell is one of the least used and researched senses in HCI, including its applications in video games. One possible reason is because olfactory displays pose challenges regarding smell generation, diffusion, and removal. Another reason is that effective mixed research methodologies are needed. Why we need a mixed approach? Because, based on our previous experience with olfactory interfaces, an olfactory display project should analyze both quantitative and qualitative data obtained from prototyping and playtesting sessions. In particular, we should analyze qualitative aspects on the UX of the olfactory interface used in the game and how the interface affects its playability, and quantitative aspects based on the usability of the olfactory display, such as the efficiency and the efficacy of the odors used in the game, among other research aspects. In addition, we also need to find effective reporting techniques for conveying the results from the mixed research.

## **Proposed Methodologies**

We believe that combining sound interface design and testing methodologies such as the user-centered design paradigm (integrating users in all the interface development steps) [3], usability studies and field testing will greatly support research on smell in video games. Usability questionnaires such as the System Usability Scale (SUS) [10] are suitable for playtesting video games and obtaining quantitative data. With the SUS questionnaire, for example, players can assign a usability value from 0 to 100. Field studies will allow us to observe and get qualitative data from players using the olfactory interface in a natural setting. The triangulation of both quantitative and qualitative data from

the studies, as well as analyzing past research data, will improve our understanding on the effects of olfactory interfaces in video games, and researchers and practitioners will get more valuable user feedback for improving their design.

### **Challenges Regarding Research on Olfactory Displays in Video Games**

The selection and application of research methodologies and reporting techniques for developing olfactory displays in video games is not a trivial task, since smells in video games pose a number of cognitive, cultural, psychological, and technical challenges, including the following:

- As [7] pointed out, it can be difficult to effectively measure the user experience (UX) on the quality of olfactory data presented through olfactory interfaces. This is important because UX will, in turn, affect players' motivation and engagement when interacting with video games that use olfactory displays.
- There is very little research on how to efficiently and promptly remove artificially-generated odors from the video game setting (e.g. a living room) [1].
- [8] warn that it can be challenging to generate a specific smell that suits the context of an olfactory display application. Similarly, it can be difficult to find a suitable smell that can be used effectively as a smell that conveys abstract information.
- Some researchers argue that Western culture is

### **References**

predominantly visual [9], which may have slowed down the widespread use of olfactory interfaces. However, although Western learning styles are generally visual, this does not exclude using other learning styles or incorporating other senses in learning and training.

- There is no consensus within the science of smell on how to classify odors effectively [1]. This may affect the design and development of olfactory interfaces with multiple odors.
- Some users may have medical conditions that affect smell perception in computer interfaces, such as anosmia (the inability to perceive any odor) or hyposmia (a decreased ability to smell). In addition, the common cold is the usual cause for temporary or partial loss of smell [1].

### **Conclusions**

Olfactory displays (digital interfaces that generate and diffuse smells to a user with a purpose) have been proposed and researched to support the user experience (UX) of video game players. This paper discusses multidisciplinary research methodologies regarding the development and testing of olfactory displays in video games. Smells in video games pose a number of cognitive, cultural, psychological, and technical research challenges that will need to be addressed in the workshop.

[1] Kaye, J. N.V. Making scents: Aromatic output for HCI. *Interactions*, 11(1) (2004), 48-61.

[2] Wook Kim, D. & Ando, H. Development of directional olfactory display. *In Proceedings of the 9th ACM SIGGRAPH Conference on Virtual-Reality Continuum and its Applications in Industry (VRCAI '10)*. ACM (2010), 143-144.

[3] Rogers, Y., Sharp, H., Preece, J. *Interaction design – beyond human-computer interaction*. 3rd edition. John Wiley & Son, London, UK, 2011.

[4] Barfield, W., & Danas, E. Comments on the use of olfactory displays for virtual environments. *Presence*, 5(1) (1996), 109–121.

[5] Garcia-Ruiz, M.A. & Santana, P. Design, evaluation and impact of educational olfactory interfaces. *In Proceedings of AMCIS*, Chicago, IL, (2013).

[6] Tortell, R., Luigi, D.P., Dozois, Bouchard, A.S., Ford Morie, J., and Ilan, D. The effects of scent and game play experience on memory of a virtual environment. *Virtual Reality*, 11, no. 1 (2007), 61-68.

[7] Ghinea, G., and Ademoye, O. The sweet smell of success: Enhancing multimedia applications with olfaction. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMCCAP)*, 8(1), (2012).

[8] Basdogan, C. & Loftin, B.R. Multimodal display systems: haptic, olfactory, gustatory, and vestibular. In Nicholson, D., Schmorow, D., Cohn, J. (eds.). *The PSI Handbook of Virtual Environments for Training and Education: Vol 2 (VE Components and Training Technologies)*, pp. 116-135, Westport, CT: Praeger Security International, 2012.

[9] Mirzoeff, N. *An introduction to visual culture*. Routledge, London, UK, 2009.

[10] Bangor, A., Kortum, P.T. and Miller, J.A. An empirical evaluation of the System Usability Scale (SUS). *International Journal of Human-Computer Interaction* 24(6) (2008), 574–594.

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Miguel A. Garcia-Ruiz graduated in Computer Systems engineering and obtained his MSc in Computer Science from the University of Colima, Mexico. He received his PhD in Computer Science and Artificial Intelligence at the University of Sussex, UK. Miguel took a virtual reality course at Salford University, UK, and a graphics techniques internship at the Madrid Polytechnic University, Spain. Miguel is an Assistant Professor with the Department of Computer Science and Mathematics, Algoma University, Canada. He has published scientific papers in major journals, book chapters and three books, and directed a video documentary on virtual reality. His research interests include olfactory displays and usability of multimodal human-computer interfaces.