# International Workshop on Multimodal Virtual and Augmented Reality (Workshop Summary)

Wolfgang Hürst
Information & Computing Sciences
Utrecht University
Utrecht, The Netherlands
huerst@uu.nl

Daisuke Iwai
Graduate School of Engineering Science, Osaka University
Osaka, Japan
daisuke.iwai@sys.es.osaka-u.ac.jp

Prabhakaran Balakrishnan
Department of Computer Science
University of Dallas at Texas
Dallas, Richardson, TX, USA
praba@utdallas.edu

## ABSTRACT
Virtual reality (VR) and augmented reality (AR) are expected by many to become the next wave of computing with significant impacts on our daily lives. Motivated by this, we organized a workshop on "Multimodal Virtual and Augmented Reality (MVAR)" at the 18th ACM International Conference on Multimodal Interaction (ICMI 2016). While current VR and AR installations mostly focus on the visual domain, we expect multimodality to play a crucial role in future, next generation VR/AR systems. The submissions for this workshop reflect the potential of multimodality for VR and AR, illustrate interesting new directions, and pinpoint important issues. This paper gives a short motivation for the workshop and its aim, and summarizes the aforementioned trends and challenges identified from the submissions.

## CCS Concepts
• **Human-centered computing~Mixed / augmented reality**

## Keywords
Multimodal virtual reality; multimodal mixed reality; multimodal augmented reality.

## 1. MOVTIVATION
Virtual reality (VR) and augmented reality (AR) are currently two of the "hottest" topics in the IT industries. Many consider them to be the next wave in computing with a similar impact as the shift from desktop systems to mobiles and wearables. The related hype is rooted in technological improvements (such as mass-produced high-resolution mobile displays), which resulted in cheaper, high-performant devices ready for the common consumer market. Examples include Facebook's Oculus Rift and Microsoft's HoloLens for VR and AR scenarios, respectively.

Despite this progress, we are still far from the ultimate goal of creating new virtual environments or augmentations of existing ones that feel and react similarly as their real counterparts. Many challenges and open research questions remain – mostly in the areas of multimodality and interaction. For example, current setups predominantly focus on visual and auditory senses, neglecting other modalities such as touch and smell that are an integral part of how we experience the real world around us. Likewise, it is still an open question how to best interact and communicate with a virtual world or virtual objects in AR. Multimodal interaction offers great potential to not only make this experience more realistic, but also to provide more powerful and efficient means of interacting with virtual and augmented worlds.

In order to address related questions and to identify current trends and future challenges, we organized a workshop on "Multimodal Virtual and Augmented Reality (MVAR)" at the 18th ACM International Conference on Multimodal Interaction (ICMI 2016). The aim of this workshop was to investigate any aspects about multimodality and multimodal interaction in relation to VR and AR. What are the most pressing research questions? What are the challenges? What opportunities do other modalities than vision offer for VR and AR? What are new and better ways for interaction with virtual objects and for an improved experience of VR and AR worlds? We invited researchers, practitioners, and visionaries to contribute their latest results, prototypes, and ideas. Naturally, a broad call like this will result in a variety of contributions addressing different issues and pinpointing in various directions for future systems and research. Yet, we can indeed identify certain trends and major topics from the accepted papers as they fit nicely in the following categories: position papers reflecting on the *definition of augmented and mixed realities*, work addressing *modalities other than visual* (e.g., haptics, taste, and smell), new experiences based on *cross-modal perception*, and finally *new systems and application domains*. In the following section, we shortly summarize the related contributions that got accepted for publication.

## 2. RESEARCH DOMAINS, CATEGORIES, AND FUTURE CHALLENGES
A little more than 20 years ago Milgram et al. [5] introduced their specification of a reality-virtuality continuum. Ever since then, researchers have been using it to introduce and illustrate related terms, including virtual, augmented, and mixed reality. As the title suggests, this publication in large parts focusses on (visual) displays. Azuma [2] published a new definition of AR one year later that purposely abstracts from technology, thus not explicitly addressing vision but potentially opening room for other modalities and multimodal mixed reality systems.

Yet, to this day, vision has remained the dominating and often defining modality for AR and VR and related systems are often described by their visual features. Therefore, and not surprisingly for a workshop focusing on multimodal aspects, two position papers from the program reflect on these *definitions of AR and VR* and such vision-based views. Schraffenberger and van der Heide [9] review this focus on vision and discuss a more perception-focused and user-centered understanding of AR. Likewise, Rosa et al. [8] introduce a different view on the terms "real" and



*ICMI'16*, November 12–16, 2016, Tokyo, Japan
ACM. 978-1-4503-4556-9/16/11...$15.00
http://dx.doi.org/10.1145/2993148.3007631

"virtual" based on stimuli rather than objects, and address, among other issues, also so-called mediated stimuli. This results in a classification system for different forms of mixed reality that better reflects multimodal aspects.

Three papers from the workshop program address *modalities other than vision*, such as haptics, smell, and taste. In particular, Zhang and Cheok [11] propose a networked device to sense the lip pressure of users and produce accurate force feedback to simulate kissing sensations. Such a system can be seen as a special form of augmented reality in itself, where the augmented part is purely tactile instead of visual. In addition, it also provides interesting opportunities for multimodal AR when integrated with other modalities. Hariri et al. [3] explicitly address the latter by introducing a prototype using electric pulses to stimulate the olfactory receptors of the nose. The produced stimulated smell sensations can be integrated into multimodal AR and VR systems. Rhaman et al. [7] present the design of a magnetic dining table interface that allows new interactions for food and utensils.

Another work addressing food falls into the category of *cross-modal perception* in AR and VR systems. Nishizawa et al. [6] use projections, i.e., the visual modality, to alter not only the appearance but also the perception of taste. Aoyama et al. [1] also use visuals to alter the perception of another modality, in this case touch. In particular, a dot pattern projected on one's hand is used to manipulate the perception of resistive force when touching something. Lugtenberg et al. [4] present a position paper aiming at changes of physical property perception, such as object density, using the modality of sound.

Finally, the work by Voinea et al. [10] is a good example for *new systems and application domains* for multimodal AR and VR. The authors present a prototype AR system designed to improve biomechanic studies of human movement. We are just starting to explore the different opportunities VR and AR offer for various application domains and related goals, and this system nicely illustrates one of them. As a general conclusion, despite the various different aspects and directions addressed by all the submissions summarized above, they have one thing in common for sure: they highlight the importance and potential that multimodality has for the future of virtual and augmented reality.

# 3. REFERENCES


[1] Aoyama, S., Iwai, D., & Sato, K. (2016) Altering Resistive Force Perception by Modulating Velocity of Dot Pattern Projected onto Hand, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 7.

[2] Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and virtual environments*, *6*(4), 355-385.

[3] Hariri, S., Mustaffa, N.A., Karunanayaka, K., and A.D. Cheok (2016) Electrical Stimulation of Olfactory Receptors for Digitizing Smell, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 4.

[4] Lugtenberg, G., Sandor, C., Hürst, W., Plopski, A., Taketomi, T., Kato, H., & Rosa, N. (2016) Changing Perception of Physical Properties using Multimodal Augmented Reality: Position Paper, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 8.

[5] Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995, December). Augmented reality: A class of displays on the reality-virtuality continuum. In *Photonics for industrial applications* (pp. 282-292). International Society for Optics and Photonics.

[6] Nishizawa, M., Jiang, W., Okajima, K. (2016) Projective-AR System for Customizing the Appearance and Taste of Food, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 6.

[7] Rhaman, N.E.A., Azhar, A., Karunanayaka, K., Cheok, A.D., Johar, M.A.M., Gross, J., & Aduriz, A.L. (2016) Implementing new Food Interactions using Magnetic Dining Table Platform and Magnetic Foods, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 5.

[8] Rosa, N., Werkhoven, P., & Hürst, W. (2016) (Re-)Examination of Multimodal Augmented Reality, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 2.

[9] Schraffenberger, H., & van der Heide, E. (2016). Multimodal Augmented Reality – The Norm Rather Than the Exception, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 1.

[10] Voinea, A., Moldoveanu, A., & Moldoveanu, F. (2016) Bringing the Augmented Reality Benefits to Biomechanics Study, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 9.

[11] Zhang, E.Y., & Cheok, A.D. (2016) A Networked Device for Reproducing Multisensory Kissing, *Proceedings of the Multimodal and Augmented Reality Workshop* (MVAR 2016), Article 3.