Interaction Paradigms for Intuitive Augmented Reality

Proposed by: Dr Maite Frutos-Pascual

October 31, 2019

Abstract

Augmented Reality (AR) is getting close to real use cases,which is driving the creation of innovative applications and the unprecedented growth of Head-Mounted Display (HMD) devices in consumer availability. However, at present there is a lack of guidelines, common form factors and standard interaction paradigms between devices, which has resulted in each HMD manufacturer and AR developer creating their own specifications.

1 Background

Augmented Reality (AR) is defined as an interactive technology that incorporates virtual objects into the real world (Kim et al. [2018]). AR is now maturing and getting close to real use cases (Lee et al. [2017]), this leading to the creation of innovative applications (Moser and Swan [2016]) and the unprecedented growth of Head-Mounted Display (HMD) devices in consumer availability. Similarly, User Interfaces are rapidly evolving beyond traditional desktop and mobile environments. Technologies such as AR, tangible interfaces and immersive displays currently offer more natural ways of interaction, leveraging user interaction capabilities with the real world (Bach et al. [2018]).

AR interaction uses a wide variety of interfaces and wearable options, making the technology highly configurable. However, these emerging technologies currently have no established design guidelines or interaction metaphors (Gabbard and Swan II [2008]), with researchers and developers creating their own interaction paradigms. These interactions have predominantly been designed for optional recognition rather than for naturalness, being often arbitrary and not intuitive enough (Piumsomboon et al. [2013]); leading to a lack of consistency in AR interaction, thus introducing barriers into the wider application of AR.

2 Motivation

Immersive technologies are maturing to a level where reliable consumer-devices are becoming widely available. Many of the traditional barriers to AR/Virtual Rearlity (VR) adoption, such as hardware costs, rendering realism and tracking robustness, are now negated. However, usability and interaction barriers are still stymieing applications from expanding outside research laboratories into wider industry adoption.

The potential of immersive technologies in industry is huge. For example, virtual simulations have proven to be an efficient and safe method for industry apprenticeships and training. However, majority of companies using them currently rely on ad-hoc developments which incur long production times, limited transferability and limited interaction capabilities, seriously reducing the shelf life of their products.

Additionally, most current industry developments in AR solely rely on the overlay of context information and text-based instructions, without fully exploiting the interaction potential of the technology, impacting on user engagement and long-term usability.

Understanding interaction in AR from the user perspective and creating user centred interaction paradigms capable of being used across devices and augmented systems will solve shelf life, long term usability and transferability problems, greatly improving accessibility and engagement of AR experiences. The proposed research will focus on creating a brand new and innovative knowledge base leading to a plug and play interaction paradigm for enabling natural interaction in immersive experiences. Thus, making it easier for users to manipulate and interact with virtual objects in immersive environments and helping developers to enable this intuitive form of interaction.

3 Proposed Research

The proposed PhD research will cover the understanding and definition of the most suitable interaction methods for HMD and mobile AR. The research will be divided in two key areas:

1. Understanding of interaction constraints and User Experience (UX) fundamentals in AR. This will be done by defining and conducting fundamental UX studies in both HMD AR and mobile AR. Understanding the limitations of current technology and defining the working parameters needed to standardise interaction across devices.

2. Development of new Interaction paradigm. This will entail the definition of a new *"plug and play"* interaction paradigm(s) based in the research conducted during the previous stage. This paradigm will be developed in the form of an API enabling the automatic recognition of iconic interaction gestures identified during the user evaluation stage.

4 Potential Impact

The impact of this PhD is on the advancement of interaction design and interaction capabilities for commercially available AR devices. This is closely linked to previous research in the Digital Media Technology Lab, continuing to contribute to their research portfolio.

This line of research has been validated by the research community and it has already received a number of REF returnable outputs. It is foreseen that the research impact will be sustained during the development of the PhD, targeting key publications in A* and A venues such as CHI, IEEE ISMAR and IFIP Interact, among others. Current research in natural interaction for immersive technologies has produced the selected listed outputs below:

- Blaga, A., Frutos-Pascual, M., Creed, C. and Williams, I., 2020, April. Too Hot to Handle: An Evaluation of the Effect of Thermal Visual Representation on User Grasping Interaction in Virtual Reality. International Conference on Human Factors in Computing Systems. ACM. ***(Under review)***.

- Frutos-Pascual, M., Harrison, J.M., Creed, C. and Williams, I., 2019, October. Evaluation of Ultrasound Haptics as a Supplementary Feedback Cue for Grasping in Virtual Environments. In 2019 International Conference on Multimodal Interaction (pp. 310-318). ACM.

- Frutos-Pascual, M., Creed, C. and Williams, I., 2019, September. Head Mounted Display Interaction Evaluation: Manipulating Virtual Objects in Augmented Reality. In IFIP Conference on Human-Computer Interaction (pp. 287-308). Springer. ***(Reviewers' choice award)***.

- Al-Kalbani, M., Frutos-Pascual, M. and Williams, I., 2017, November. Freehand grasping in mixed reality: analysing variation during transition phase of interaction. In Proceedings of the 19th ACM International Conference on Multimodal Interaction (pp. 110-114). ACM.

- Al-Kalbani, M., Frutos-Pascual, M. and Williams, I., 2017, November. Freehand grasping in mixed reality: analysing variation during transition phase of interaction. In Proceedings of the 19th ACM International Conference on Multimodal Interaction (pp. 110-114). ACM.

- Al-Kalbani, M., Williams, I. and Frutos-Pascual, M., 2016, September. Analysis of medium wrap freehand virtual object grasping in exocentric mixed reality. In 2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR) (pp. 84-93). IEEE.

This research will link with ongoing industry projects, collaborations and the REF impact case for AR; with the aim to sustain this impact track with new funded projects and partnerships. Relevant and ongoing projects linked to the proposed research field are listed below:

- Projects:
  - Innovate UK - Knowledge Transfer Partnership with Murray Uniforms
  - Innovate UK - Knowledge Transfer Partnership with GlaxoSmithKline (GSK)
  - Advanced Powertrain construction project with Jaguar Land Rover (JLR)
  - Innovate UK ICURe Innovation to Commercialisation of University Research Programme (2018)
- Partnerships:
  - Academic Partnership with UltraLeap (since 2018)
  - Academic Partnership with Pearson Education (in progress)

The proposed field of research will also link with current teaching portfolio, specially with the *Advanced and Immersive Technologies* module, which is part of the MSc in User Experience Design. This research will also link with future new revisions of the Digital Media Technology programme.

References

Benjamin Bach, Ronell Sicat, Johanna Beyer, Maxime Cordeil, and Hanspeter Pfister. The hologram in my hand: How effective is interactive exploration of 3d visualizations in immersive tangible augmented reality? *IEEE Transactions on Visualization & Computer Graphics*, (1):1–1, 2018.

Joe L Gabbard and J Edward Swan II. Usability engineering for augmented reality: Employing user-based studies to inform design. *IEEE Transactions on visualization and computer graphics*, 14(3):513–525, 2008.

Kangsoo Kim, Mark Billinghurst, Gerd Bruder, Henry Been-Lirn Duh, and Gregory F Welch. Revisiting trends in augmented reality research: A review of the 2nd decade of ismar (2008–2017). *IEEE transactions on visualization and computer graphics*, 24(11):2947–2962, 2018.

Seungjae Lee, Byounghyo Lee, Jaebum Cho, Changwon Jang, Jonghyun Kim, and Byoungho Lee. Analysis and implementation of hologram lenses for see-through head-mounted display. *IEEE Photonics Technology Letters*, 29(1): 82–85, 2017.

Kenneth R Moser and J Edward Swan. Evaluation of hand and stylus based calibration for optical see-through head-mounted displays using leap motion. In *Virtual Reality (VR), 2016 IEEE*, pages 233–234. IEEE, 2016.

Thammathip Piumsomboon, Adrian Clark, Mark Billinghurst, and Andy Cockburn. User-defined gestures for augmented reality. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems*, pages 955–960. ACM, 2013.