



## INFORMATION, COMMUNICATION & COMPUTING

Fields of Expertise TU Graz

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**Kay Uwe Römer,**

Source: Lunghammer – TU Graz

**M**any research conferences feature a forum for PhD students, where they can present their research plans and get feedback from international experts.

However, the non-technical challenges many PhD students encounter such as how to handle stress induced by high expectations and deadlines, overcoming motivation crises when things don't go as planned, or how to master cooperation in a team with different cultural/disciplinary backgrounds are rarely

addressed by such PhD fora. Motivated by this observation, I co-organized with several colleagues a PhD School & Community Event at the International Conference on Embedded Wireless Systems and Networks (EWSN) in December 2024 that focused especially on such non-technical challenges encountered by young PhD researchers as well as early-stage postdocs and young faculty members. This format apparently resonated well with the needs of the international community of young researchers, as the number of applicants was roughly doubled compared to past versions which focused on the technical and research challenges during the PhD. Not only could the participants discuss their non-technical challenges individually with the participating experts, but different formats such as an expert panel, keynotes, and a "Mentimeter" session allowed advice to be shared with the whole conference audience. Simone Sil-

vestri, who also runs the YouTube channel CSMentor on related topics, gave a very inspiring keynote summarizing challenges and advice for PhD students, from how to choose the right thesis supervisor, how to align the PhD goals with long-term career aspirations, and how to avoid common pitfalls among which impostor syndrome stands out as a prevalent issue in academia, often undermining confidence and mental health. In summary, the aspect of non-technical challenges deserves more attention in PhD education, also the doctoral education at TU Graz could surely benefit.

In this edition of TU Graz Research, Alexander Plopski, gives us some insights on his research. Enjoy reading!



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Communication  
& Computing**

 **Alexander Plopski**

## The Future of Augmented Reality Interfaces

The benefits of Augmented Reality (AR), also known as Mixed or Extended Reality, have been confirmed in many studies in various fields. As such, it is no surprise that many industries expect a great benefit from this technology with the expected market to be over 300 billion USD by 2030.

Presenting computer generated content directly in the user's view on a head-mounted display (HMD), instead of on a monitor or a handheld device, offers the most compelling vision of the future of Augmented

Reality. However, despite global interest and ongoing research in academia and industry, many hurdles must be overcome before the vision of its everyday use becomes reality.

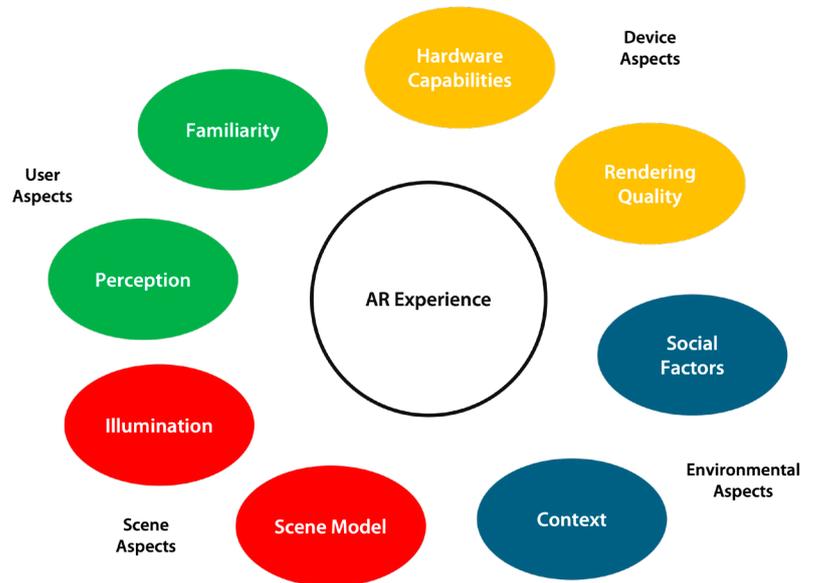
The Professorship on Mixed Reality at the Institute of Visual Computing is an endowed professorship supported by Snap Inc for five years. Our goal is to make the vision of everyday AR on HMDs succeed by understanding how the AR experience can be improved through hardware considerations as well as interface design aspects. In particular, we focus on applications of eye tracking and the effects AR has on the user's focus.

**Figure 1: AR experience is affected by various aspects highlighting its multidisciplinary nature.**

Source: Author's own illustration

## MULTIDISCIPLINARY ASPECTS OF AR EXPERIENCE

AR is inherently multidisciplinary (Figure 1). Any AR experience is affected by various aspects, such as hardware capabilities, environment understanding, social factors, user's state of mind and goals, as well as familiarity. It is thus necessary to consider not only an aspect on its own, but its interplay with and effects on other aspects as well. In our work we thus combine hardware design, perceptual studies, and human computer interaction.



## DISPLAY DESIGN AND USER PERCEPTION

The most commonly used HMD design utilizes a single display panel focused through a lens. This results in virtual content appearing in focus at a fixed distance from the user. If the user focuses on a virtual object that should appear closer or further away, the eyes will verge accordingly while the accommodation of the eye will remain at the display. This effect is known as the vergence-accommodation conflict (VAC) and can result in

faster fatigue, headaches, eye strain, and reduce the perceived quality of the rendered content. While various approaches to mitigate this problem exist, they usually suffer from reduced contrast and rely on accurate measurements of the user's focus distance through eye tracking. Due to eye tracking inaccuracies however, this

will rarely perfectly match the actual focus distance thus the VAC effect will not be fully mitigated. We developed a novel display design (Figure 2) that significantly improves the observed contrast even in the presence of eye tracking errors [1] and while mitigating the VAC. We have shown the improved results of our design in simulations and camera captures. As we do not experience AR through a camera, our next steps are to evaluate the system with users to better understand and to quantify how different HMD designs affect the user's ability to interact with virtual content, content legibility, and depth perception, to name a few aspects.



**Figure 2: Our novel display architecture significantly improves the contrast even in the presence of eye tracking errors.**

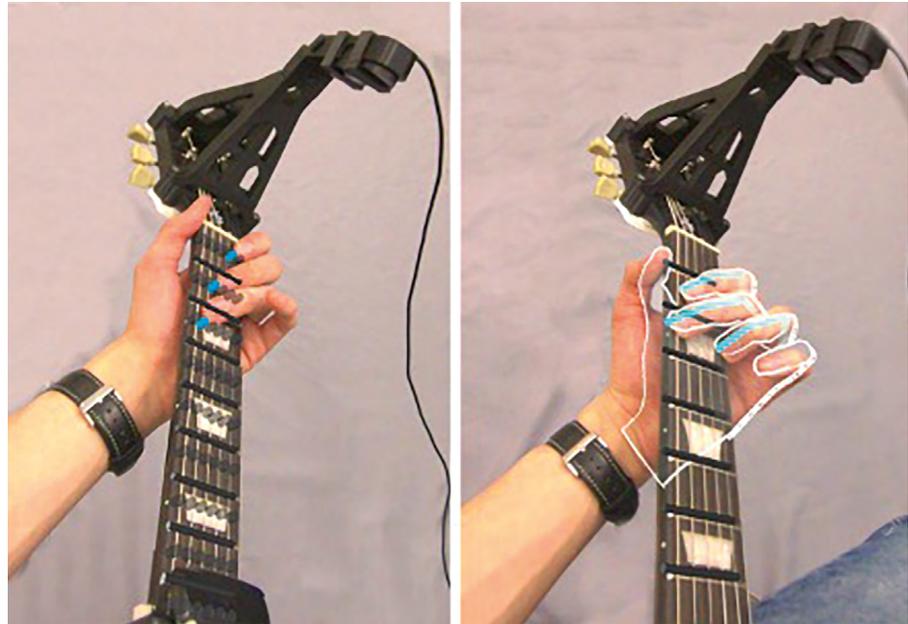
Source: Christoph Ebner

### INTUITIVE USER INTERFACES

When designing user interfaces for AR, it is also important to consider what information should be presented to the user, and how. A big advantage of AR is the in-situ placement of the content allowing it to be overlaid onto the object it is supposed to enhance. While this can incite sharing of as much information as possible, it can overwhelm users. In several studies, we have shown that participants may prefer less input to balance visibility and information. For example, while learning to play guitar we considered whether visualizing the hand pose would help students to play the chord more intuitively (Figure 2). However, contrary to our expectations, participants preferred to see only the frets they should press rather than the full hand pose due to its simplicity [2]. At the same time, once users have grown used to the interface, other information could become more important. It is thus necessary to adjust the interface to the user’s needs and demands in real-time. We will achieve this by incorporating eye gaze to estimate the user’s focus, goals, mental workload, fatigue and stress.

### EVERYDAY EXPERIENCES

Finally, it is also important to understand how AR will be utilized not only in a lab setting, but in everyday life. In 2013, Google released Google Glass, the first



↑ **Figure 3: Different visualizations for finger placements during guitar lessons in AR**

Source: Lucchas Ribeiro Skreinig

HMD to receive wide publicity. However, it also faced headwinds and ultimately disappeared from the public in part due to privacy concerns, public backlash, and not living up to expectations. We are exploring how our interfaces will affect our interactions with others, and how user experience changes over time. By better understanding these aspects our goal is to gain insights into how AR applications can be designed to ensure long-term benefits and usability. ●



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is assistant professor at the Institute of Visual Computing. He holds the Professorship of Mixed Reality established in 2023. His research focus is on the applications of eye tracking in Mixed Reality with a focus on user interface design and perception.

Source: Lunghammer – TU Graz

### REFERENCES

- [1] Ebner, Christoph, Alexander Plopski, Dieter Schmalstieg, and Denis Kalkofen. "Gaze-Contingent Layered Optical See-Through Displays with a Confidence-Driven View Volume." IEEE Transactions on Visualization and Computer Graphics (2024).
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