# TEI Studio: When Realities Interweave - Developed Concepts

GEORG REGAL and JAKOB CARL UHL, AIT Austrian Institute of Technology, Austria
LINDA HIRSCH and YANNICK WEISS, LMU Munich, Germany
ALAN MATTHEWS, The Glasgow School of Arty, Scotland
ISAAC VALADEZ, Vrije Universiteit Brussel, Belgium
ROBERT LIKAMWA, Arizona State University, USA

Fig. 1. TEI Studio 2023

This white paper presents the concepts developed within the TEI 2023 studio - When Realities Interweave. The studio started with an initial demonstration of tangible interaction in XR. Subsequently, in a brainstorming session, we addressed how tangible objects can be used to transition between reality and virtuality. Within the TEI studio, seven ideas were conceptualized, and five concepts were further developed into low to medium-fidelity prototypes. In future work, we will further develop these concepts. We encourage the TEI and XR communities to build on these ideas, provide feedback, and share insights for future tangible interactions in XR.

CCS Concepts: • **Human-centered computing** → **Interface design prototyping**.

Additional Key Words and Phrases: XR, Tangible Interaction, TEI Studio, Transition between realities

## 1 INTRODUCTION

This white paper describes the concepts developed during the TEI 2023 studio - When Realities Interweave [6].

Within the TEI studio, we followed three overall goals: To discover potential use cases of tangible XR, provide a hands-on experience with tangible XR, and reflect upon evaluation methods for tangible XR. As an overarching goal, we aim to position the topic of tangible XR more prominently at future TEI conferences, as published papers in the field are scattered in many different venues.

## 2 PROCEDURE

The workshop started with an introduction of the workshop goals, the workshop organizers, and the workshop participants. Subsequently, participants experienced a demonstration of a mixed training application [5] that showcases the integration of a medical training manikin into mixed reality using fiducial markers, VIVE trackers, and chroma keying. The demo was shown using a Varjo XR3 headset. The goal of the demo session was to show possibilities for tangible interaction and how such options could be implemented using the Varjo XR3.

After each participant experienced the demonstration, a concept design brainstorming session was conducted to identify possible use cases for tangible XR. We defined the overall theme as “Transitioning between realities”. In particular, we asked participants as a design trigger:

> "How can we use tangible interaction to help transition between AR, AV, and VR? What interactions do you want to explore given the objects we provide?"

The discussed concepts were documented for further iterations in the second half of the workshop.

After a lunch break, we started a prototyping session to develop the discussed concepts into mock-ups and prototypes using technical equipment (e.g. Varjo XR3, Vive trackers), optical markers

*TEI Studio, Feb. 26, 2023, Warsaw, Poland*

(printed out), and a wide range of materials and making supplies (e.g., cardboard, pipe-cleaners, tape, etc.). Several concepts were developed into mock-ups and working prototypes described in the next Section.

The TEI studio ended with a reflection and discussion about the evaluation of tangible XR and ideas for future collaborations.

## 3 CONCEPTS

As an overarching theme for the workshop, we defined the "Transition between Virtual and Real using Tangible Interaction". We thus aimed to investigate how tangible objects and tangible interaction can support the shift between the virtual and real worlds. The workshop participants considered providing users with the possibility to control the transition between realities as an important aspect. Thus, special emphasis was put on defining (and developing) novel ways to support the agency of users.

Within the workshop, seven ideas were discussed and (partially) developed into mock-ups and experience prototypes. Within the concept design session, the following ideas were discussed and agreed on to work further on in the second half of the Studio: (1) Edibles, (2) Cone defined area, (3) Frame, (4) Milgram Accordeon, (5) Face Shield, (6) Game Objects, (7) Operator Presence Control.

The following subsection describes the developed concepts.

### 3.1 Edibles to enter VR

The initial idea is to support a transition between realities using edibles. The idea was inspired by the popular movie Matrix, where taking a red pill results in the main character Neo leaving the virtual world and entering the dystopian reality [1].

We developed a quick mock-up of the experience using a green grape (see Figure 2a) and a "wizard of oz" approach to controlling the VR environment. By using green chroma-keying the green grape could be used to "look inside" the virtual environment when brought close to the user's eye. Subsequently when the user stuck the grape in the mouth and took a bite the "wizard of oz" facilitator started the VR experience.

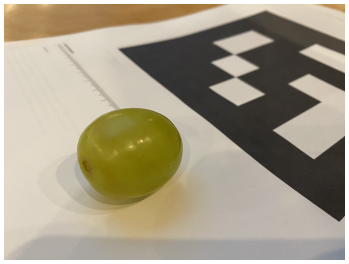
In future work, we plan to experiment with printing optical fiducial markers on edibles (e.g., by using sugarcoating on cookies) to aim for a fully automated transition into VR.

### 3.2 Cone defined area

Although current commercial solutions allow stepping in and out of a VR experience by leaving and stepping into the defined "play area", the definition of that area is often cumbersome. Also, it is not visible and easy to understand for bystanders how that area is defined. We, therefore, developed a concept in which four physical objects (e.g., cones) are used to define the VR area - see Figure 2b.

We developed a fully working prototype using the Varjo XR3 and cones as tangible objects. We attached fiducial markers to the cones and developed a script to position four quads to fit the edges of the cones. Thus the cones define a space that allows transitioning between worlds. In the prototype, the quads contain a texture that allows looking into reality provided by the Varjo XR3 Toolkit. Thus the defined area allows stepping from VR into "self-defined" reality.

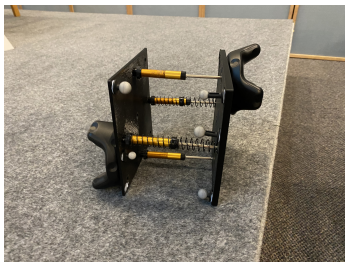
[1] https://en.wikipedia.org/wiki/Red_pill_and_blue_pill



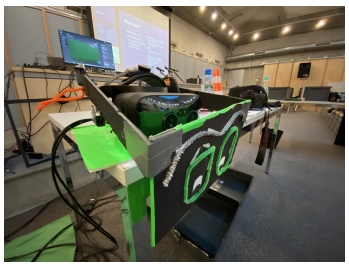
(a) Edible - "magic" grape

(b) Cone defined Area

(c) Frame with Vive tracker



(d) Milgram Accordeon - Switch



(e) VARJO Headset with Color Shield

Fig. 2. Concepts developed in the Studio

In future work, we will also implement a way to step into virtual reality by using colliders.

### 3.3 Frame

We considered that a Frame (or Hula Hoop Ring or equivalent) could be an alternative to defining a play area with cones. Thus, the concept is that if the frame is put over a person's head, they will "dive" into VR.

We developed a mock-up using cardboard and a Vive tracker - see Figure 2c. We did not develop the required software, but we conceptualize that a collider attached to the frame can be used to trigger the removal of a quad with see-through textures in front of the users' eyes (a virtual version of the concept described in section 3.5).

### 3.4 Milgram Accordeon

During the brainstorming, the idea was developed to build an object that can be used to seamlessly transition between real and virtual by blending virtual and real environments. We thus conceptualized the "Milgram Accordeon". The name is a pun on the Milgram Continuum [3] and was coined by co-author and studio participant Robert LiKamWa.

Within the studio, we developed a tangible mock-up - two panes with springs and Vive trackers (see Figure 2d). However, due to time constraints, we could only develop the tangible object and not work on the software part. This remains to be done in future work.

### 3.5 Face Shield

Within the concept design session, we identified the need to leave VR quickly. Based on this consideration, we developed a fully functioning prototype using green tape, the Varjo XR3, and chroma-keying. A shield with green tape that is placed in front of the headset allows the user to move from real to virtual by moving the shield up above the headset - see Figure 2e.

An interesting aspect of the concept is that the user can control the position of the shield, which also allows for a half-virtual, half-real experience. Moreover, others (e.g., bystanders) can also control it from the outside by moving the shield.

In future work, we want to investigate the usefulness of this approach in evaluation with end-users. Especially as this aspect could also be done without tangible interaction, e.g., with a button, thus the benefit of having a tangible approach must be investigated.

### 3.6 Game Objects

In tangible XR tangible tools and tangible props might be an important aspect of the experience. We developed a concept that taking and using tangible objects (that also can play a role as a prop, controller, or tool in the VR) allows people to enter the VR. Similarly, dropping the object or passing an object to another person can result in leaving the VR. For example, picking up a tangible tool could transition users into an XR assembly simulation - similarly picking up a tangible prop gun could transition users into a VR shooter game.

As we did not develop a prototype but only a theoretical concept, in future work a first proof of concept shall be developed.

### 3.7 Operator Presence Control

Especially in extreme use cases (e.g., fear-inducing environments, roller-coasters, stressful virtual situations) users can be overwhelmed. Thus the concept of a tangible object as "Operator Presence Control" (also known as Dead Man or Dead Person Switch [2]) was discussed. The tangible object must be manipulated, e.g., pressed, squeezed, etc., so the user stays in XR. For example, a ball could act as a Dead Person Switch that must be squeezed if the person wants to stay in XR. By releasing or dropping the ball, the person exits the virtual environment and transitions into the real world.

Since we have not developed a prototype, but only a theoretical concept, future work shall develop an initial proof of concept.

## 4 REFLECTION OF THE EVALUATION OF TANGIBLE XR

For the final discussion and reflection current challenges regarding the evaluation of Tangible XR were presented to the participants and subsequently discussed. For one, at the moment, in related work, a multitude of questionnaires are used, making it hard to compare different approaches regarding the various associated effects. Secondly, many evaluations do not involve a comparison group but rather only evaluate one tangible XR solution in isolation, which does not provide good evidence for the effectiveness of a given tangible approach in XR. Therefore, the third discussion point centered around the need for a specialized, or at least standardized, measurement instrument for assessing the quality of tangible XR interactions. The challenges for such a measurement instrument were discussed, and possible solutions were proposed.

### 4.1 Challenges

*4.1.1 Multitude of Contexts.* Tangible interfaces for XR are often highly specific to the respective use-case, be it medical tools as in the workshop's demonstrator, more abstract shaped interaction devices like cubes or spheres for collaborative design [4] or specific tangible objects in realms like cultural heritage installations [2]. This makes a comparison challenging, as the interactions are fundamentally different due to the different goals for the respective devices.

*4.1.2 Appropriate Baseline.* How should we assess the effectiveness of tangible XR? This question was discussed, as previous related work either does not compare tangible XR solutions to a control group or compares to different baselines. These can be traditional VR without tangible interaction, real-life interaction in the respective context, or different fidelities of tangible XR. To improve the value of evaluations, we agreed that - at least - some form of comparison should be present, though it may be challenging to define a universal baseline condition.

*4.1.3 Specific Tangible XR Artifacts.* Furthermore, previous related work often reports the creation of specific tangible XR artifacts developed in specific projects for narrow purposes. This may be a reason why often no comparisons are made. Often in such projects, the initial goal is to create the respective interaction and few resources are available to create a fitting comparison condition for evaluation.

[2] https://en.wikipedia.org/wiki/Dead_man's_switch#Alternative_names

## 4.2 Solutions

*4.2.1 Specialized Usability Questionnaire.* One proposed solution was the creation/adaption of a specialized usability questionnaire aimed at capturing specifically the tangible experience in an XR environment. This questionnaire could incorporate existing conceptualizations of tangible interaction [1] with existing constructs from usability research. The participants expressed interest in pursuing this questionnaire further in future collaborations.

*4.2.2 Helping Neighbors.* Another solution - identified in the TEI studio - was to look for inspiration from neighboring fields, like psychology, ergonomics, and medicine. HCI has a long history of adapting existing theories from other fields, and regarding tangible interaction in XR, this could be a fruitful endeavor in the future.

*4.2.3 Questioning the Need for Generalized Evaluation.* As many tangible XR solutions are situated in a specific context, the question arose whether there was even a need for a generalized evaluation method. A more pragmatic solution to ensure a valid evaluation could be guidelines for evaluating tangible XR rather than a fixed measurement method. One guideline could be to evaluate the respective tangible XR interaction concerning the intended context to answer the question: does this solution facilitate the experience or performance in the specific context?

## 5 CONCLUSION

Within this TEI studio, we conceptualized and (partly) developed mock-ups and working prototypes of tangible interaction to transition between the virtual and real world. Subsequently, the topic of how to evaluate tangible XR solutions was discussed, with identified challenges and possible future solutions as outputs for further research. In future work, we will further develop the concepts and solutions. We strongly encourage the TEI and XR community to provide feedback and expand on these concepts for future tangible interaction in XR.

## ACKNOWLEDGMENTS

This work and the TEI studio were partly supported by the project MED1stMR funded by the European Union's Horizon 2020 Research and Innovation Program under grant agreement No 101021775 and the project 'Illusionary Surface Interfaces', which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 425869442 and is part of Priority Program SPP2199 Scalable Interaction Paradigms for Pervasive Computing Environments. Lastly, this studio is partly supported by the funded industrial PhD program by the Austrian research promotion agency (FFG, grant agreement No FO999887876).

We would like to thank the studio chairs, general chairs, and student volunteers of TEI 2023. Special thanks to Robert for the relaxing piano playing during the studio.

## REFERENCES

[1] Eva Hornecker and Jacob Buur. 2006. Getting a grip on tangible interaction: a framework on physical space and social interaction. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*. 437–446.

[2] Vedad Hulusic, Linda Gusia, Nita Luci, and Michael Smith. 2021. Tangible Interfaces for VR Cultural Heritage Application-School House Virtual Museum. (2021).

[3] Paul Milgram, Haruo Takemura, Akira Utsumi, and Fumio Kishino. 1995. Augmented reality: A class of displays on the reality-virtuality continuum. In *Telemanipulator and telepresence technologies*, Vol. 2351. Spie, 282–292.

[4] Kadek Ananta Satriadi, Jim Smiley, Barrett Ens, Maxime Cordeil, Tobias Czauderna, Benjamin Lee, Ying Yang, Tim Dwyer, and Bernhard Jenny. 2022. Tangible globes for data visualisation in augmented reality. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–16.

[5] Jakob C Uhl, Helmut Schrom-Feiertag, Georg Regal, Katja Gallhuber, and Tscheligi Manfred. 2023. Tangible Immersive Trauma Simulation: Is Mixed Reality the next level of medical skills training? *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (2023). (in press).

[6] Jakob Carl Uhl, Helmut Schrom-Feiertag, Georg Regal, Linda Hirsch, Yannick Weiss, and Manfred Tscheligi. 2023. When Realities Interweave: Exploring the Design Space of Immersive Tangible XR. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*. 1–4.