Rapid Prototyping of Augmented Reality & Virtual Reality Interfaces

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ABSTRACT

This course introduces participants to rapid prototyping techniques for augmented reality and virtual reality interfaces. Participants will learn about both physical prototyping with paper and Play-Doh as well as digital prototyping via new visual authoring tools for AR/VR. The course is structured into four sessions. After an introduction to AR/VR prototyping principles and materials, the next two sessions are hands-on, allowing participants to practice new physical and digital prototyping techniques. These techniques use a combination of new paper-based AR/VR design templates and smartphone-based capture and replay tools, adapting Wizard of Oz for AR/VR design. The fourth and final session will allow participants to test and critique each other's prototypes while checking against emerging design principles and guidelines. The instructor has previously taught the techniques to broad student audiences with a wide variety of non-technical backgrounds, including design, architecture, business, medicine, education, and psychology, who shared a common interest in user experience and interaction design. The course is targeted at non-technical audiences including HCI practitioners, user experience researchers, and interaction design professionals and students. A useful byproduct of the course will be a small portfolio piece of a first AR/VR interface designed iteratively and collaboratively in teams.

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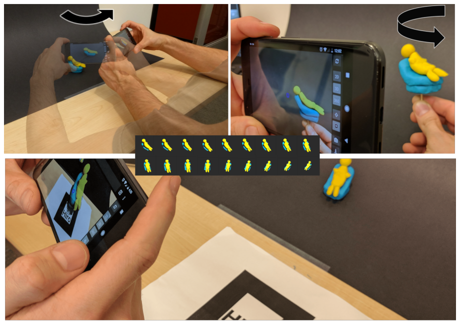

Figure 1: ProtoAR's 360-degree capture of Play-Doh model (top); captured quasi-3D object (middle); marker-based AR preview (bottom) (adapted from [4]). Course participants will use tools like ProtoAR to create interactive AR/VR prototypes.

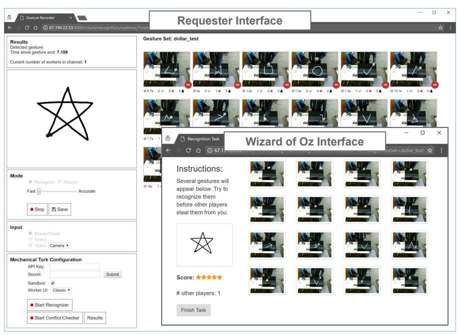

Figure 2: GestureWiz's rapid prototyping support for recording (top) and recognition (bottom) of custom gesture sets, including single-stroke, multi-stroke, and mid-air 3D gestures (adapted from [6]).

CCS CONCEPTS

• **Human-centered computing → Interface design prototyping**.

KEYWORDS

Augmented reality; virtual reality; physical prototyping; Play-Doh; Wizard of Oz.

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MOTIVATION AND BACKGROUND

The idea for this course grew out of the instructor's research and teaching efforts over the past two years at the University of Michigan. As part of his teaching, he recently created a U-M Teach-Out on AR/VR interfaces, a mini-MOOC launched on Coursera, which introduced thousands of online learners to terminology and the complex landscape of AR/VR technologies. He regularly teaches two interaction design courses and started a new AR/VR focused course with hands-on class activities dedicated to AR/VR prototyping. In his research, two recent projects include new rapid prototyping tools for AR/VR interfaces, *ProtoAR* [4] and *GestureWiz* [6].

ProtoAR: Quick & Easy Capture of AR Content. At CHI 2018, the instructor presented ProtoAR [4], a tool he created to support prototyping of mobile AR apps by crafting the main screens and AR overlays from paper sketches and quasi-3D objects from 360-degree captures of Play-Doh models (Fig. 1). The project used a series of student design jams around IKEA's furniture placement AR app called Place. Students started on paper sketching screens and user flow, then used Play-Doh to model miniature versions of furniture they wanted to place, and finally made use of ProtoAR's capture tools to digitize these physical materials and see AR views on smartphones. With ProtoAR, students with no training in 3D graphics and programming generated low-fidelity versions of the IKEA Place AR app in less than 90 minutes.

GestureWiz: Prototyping Gesture Interactions for AR. A second tool the instructor also presented at CHI 2018 is GestureWiz [6]. Inspired by Wobbrock et al.'s $1 recognizer's simple and flexible design, it provides a rapid prototyping environment to designers with an integrated solution for gesture definition, conflict checking, and real-time recognition by employing human recognizers in a Wizard of Oz manner (Fig. 2). GestureWiz was designed based on a series of online experiments and user studies in the authors' lab. In one study, 12 participants worked in pairs to co-design and test a novel gesture set. Part of the study required them to split up and assume the roles of user and wizard to demonstrate and recognize gestures, respectively. GestureWiz implements techniques to manage complex gesture sets by coordinating multiple wizards via live streams, and achieves reasonable accuracy and latency for prototyping purposes. GestureWiz was also shown to support a variety of gesture-based interfaces from the literature that previously required complex system implementations. With GestureWiz, pairs of users and wizards co-designed and tested a gesture-controlled slideshow prototype in less than 45 minutes.

These efforts laid the foundation for this course. Participants will use tools like ProtoAR and GestureWiz in physical and digital prototyping activities as part of the practical work sessions.

BENEFITS & LEARNING OUTCOMES

The course has two major learning outcomes. First, participants will be introduced to a comprehensive set of methods for both physical and digital prototyping. Second, participants will learn about different types of tools, their requirements in terms of technical skills, and their supported level of fidelity. The methods and tools will be taught hands-on based on AR/VR mini-projects that course participants will co-design, test, critique, and reflect on throughout the course.

The primary reason for CHI attendees to take this course will be to obtain knowledge and experience with easy-to-learn and apply prototyping techniques and tools the instructor has developed over two years of research and teaching in interaction design courses. Those who teach similar courses and design workshops, and are interested in adding practical, hands-on AR/VR portions to their instruction, will especially benefit. The instructor will not only teach the methods and tools, but also share instructional materials and access to tools for attendees to give similar courses in the future.

Other benefits for CHI attendees include being able to create a small portfolio piece. Participants will work in teams through hands-on prototyping sessions and will be asked to critique each other's work and reflect on their own experience using the popular "I like, I wish, What if" method.

INTENDED AUDIENCES

The techniques are tried-and-tested with teams of 4–5 and audiences of up to 40 participants. Intended audiences include not only AR/VR researchers and designers, but also HCI practitioners, and user experience and interaction design professionals and students.

The instructor is experienced teaching the techniques to a broad student body with a wide variety of non-technical backgrounds, including design, architecture, medicine, education, and psychology, in addition to HCI and computer science. While initially developed over a series of student design jams in his research lab, the instructor regularly teaches the techniques in his interaction design courses at UMSI at both the undergraduate and graduate levels. The instructor developed the materials further into its own AR/VR focused application design studio course.

Table 1: Tentative course schedule with emphasis on practical activities

Course Schedule
1 Intro to AR/VR prototyping *(20mins)* Participants will be given a brief overview of AR/VR design principles as well as the prototyping methods, tools, and materials used in this course.
2.1 Physical prototyping *(40mins)* Participants will work in teams to create paper prototypes and Play-Doh models of AR/VR scenes. **2.2** Physical prototype demos *(20mins)*
3 Digital prototyping *(40mins)* Participants will work in teams to prototype 1–2 key interactions using 1–2 digital prototyping tools.
4.1 Peer critique & feedback *(30mins)* **4.2** Lessons learned, Q&A *(10mins)*

Figure 3: Examples of physical prototypes created in a student design jam. Course participants will create physical prototypes to explore design requirements and the main AR/VR interface components.

PREREQUISITES

The course is designed for non-technical audiences. Participants with basic knowledge in HCI, user experience, and interaction design will find the contents of this course accessible. There is no need for programming. However, for more advanced participants, the instructor will also be able to share tips and resources, including information on how the techniques could be incorporated with advanced AR/VR development workflows with tools like Unity.

COURSE CONTENT & PRACTICAL WORK

The course will involve two 80-minute blocks structured into four sessions (Tab. 1): *(1)* intro to AR/VR prototyping, *(2)* physical prototyping for AR/VR, *(3)* digital prototyping, *(4)* peer critique and feedback.

First, participants will be introduced to AR/VR prototyping and the main differences to prototyping for web and mobile. The materials will cover key design principles central to AR/VR and the main differences between designing for AR and VR, raising awareness of the increased degrees of freedom of movement and interaction in AR/VR, the notions of autonomy/agency and presence/immersion, as well as how to deal with eye strain and motion sickness as important design challenges.

The remaining sessions are hands-on. Participants will be assigned groups (pre-defined based on participants' backgrounds and interests collected prior to the workshop) and start working on AR/VR mini-projects based on a common design prompt to promote discussion and enable comparison between artifacts created by participants. Based on participants' input collected prior to the workshop, a prompt that likely resonates with the majority will be chosen. One such prompt could be "reimagine instruction and teaching and address a real problem in co-located or remote educational scenarios by prototyping usable and useful AR/VR interfaces." The instructor recently used this prompt in his AR/VR course and it generated promising VR applications supporting learning of evacuation procedures during earthquakes, self defense, new languages and culture, and collaboration (Fig. 3).

In the practical work sessions, participants will first engage in physical prototyping with paper and Play-Doh in three steps. First, participants will start with traditional paper prototyping, which, while being 2D and "flat", is still useful to create mockups and user flows. Second, participants will be introduced to a new set of paper prototyping templates emerging in the practitioners community (e.g., 360-degree templates based on the principles of 360 photos & videos to conceptualize and sketch AR/VR scenes "around" the user [1, 2]) and Play-Doh (from the instructor's ProtoAR project [4]). Third, participants will transition to physical prototyping, making use of the physical environment (e.g., using the table as a stage) to create "dioramas", i.e., physical 3D models of the envisioned AR/VR scenes created using cardboard, transparency and Play-Doh (Fig. 4).

After sharing their progress and experience with the physical prototypes, participants will engage in digital prototyping with selected authoring tools. To scope the activity and make sure it can be

Figure 4: Physical 3D models of AR/VR scenes (i.e., dioramas) created in previous student design jams. The interactions were simulated using Wizard of Oz often involving multiple wizards. One of the students typically narrated the scene. Course participants will enact their prototypes in dioramas to share their ideas.

effective despite major time constraints, participants will be asked to focus on prototyping 1–2 key interactions from their AR/VR mini-projects using 1–2 digital prototyping tools with specific support for AR/VR, such as Proto.io, Vizor, Ottifox, or the instructor's own ProtoAR [4] and GestureWiz [6]. The instructor will share his competitive analysis of these tools to guide participants [5].

The final session will be dedicated to peer critique and feedback. Participants will be shown how to best capture, share, and demo their digital prototypes to put together a small portfolio piece from the course. They will then be asked to critique each other's work and formulate their own lessons learned using the "I like, I wish, What if" method. The instructor will wrap up with his main observations from the course and additional resources.

INSTRUCTOR BACKGROUND

Michael Nebeling is an Assistant Professor at the University of Michigan School of Information, where he directs the Information Interaction Lab (https://mi2lab.com). He studies the next generation of user interfaces, as well as the methods and tools to create them. His most recent work includes new techniques and tools for prototyping AR/VR interfaces, such as **360proto [3]** for making interactive AR/VR prototypes from paper, **ProtoAR [4]** for generating mobile AR interfaces with 2D overlays made from paper and 3D models from Play-Doh, and **GestureWiz [6]** for experimenting with gesture-based interface designs.

Michael has enjoyed teaching a variety of courses on interaction design principles and techniques at ETH Zurich, Carnegie Mellon, and University of Michigan since 2011. He currently teaches undergraduate and graduate interaction design studios as well as two new AR/VR focused courses, including an introductory course with emphasis on rapid prototyping techniques which formed the basis for this CHI 2019 course.

RESOURCES

The following resources will be available to course participants:

- Course attendees will get free access to **360proto [3]** and **ProtoAR [4]** during the course.
- Our new AR/VR prototyping blog at **https://arvrprototyping.wordpress.com** will be used as a platform for sharing resources before, during, and after the course.
- More AR/VR research by the Information Interaction Lab is available at **https://mi2lab.com**.

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