Designing Interactive Experiences in the Interplay between Ambient Intelligence and Mixed Reality

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ABSTRACT

Our physical environments integrate more and more sensing, processing, and communications technology toward the realization of the vision of Ambient Intelligence (AmI). At the same time, virtual worlds are increasingly more linked to physical spaces by means of applications delivering the vision of Augmented and Mixed Reality (AR/MR). In this context, several opportunities emerge at the intersection of these two visions of computing. The goal of this course is to achieve the realization that AmI and MR are two sides of the same coin in order to deliver a fresh perspective to HCI researchers and practitioners interested in designing interactive experiences beyond the desktop and mobile computing paradigms by employing the concepts, principles, and methods of AmI and MR.

CCS CONCEPTS

• **Human-centered computing** → **Ambient intelligence**; **Mixed / augmented reality**; **Ubiquitous and mobile computing systems and tools**; **HCI theory, concepts and models**.

KEYWORDS

Ambient intelligence, mixed reality, augmented reality, extended reality, interaction design, methods, examples, software tools

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1 INTRODUCTION AND CONTEXT

The vision of smart environments [1,6] that are responsive to the presence and actions of users, but also anticipatory and adaptive in their responses, has already entered mainstream with various products and services, such as smart lighting, personal voice assistants, personalized on-demand streaming services, and IoT protocols and standards implemented by smart objects designed for the home. At the same time, the original visions of Augmented and Mixed Reality (AR/MR) [2,14] are now at the fingertips of end users in the form of applications for mobile devices, smartglasses, and head-mounted displays (HMDs) with a steadily growing consumer market.[1] In this context, designing interactive experiences for smart environments that integrate sensing, processing, and communications technology in the physical surroundings and everyday objects, but also for environments that are hybrid versions of the physical and the virtual has never been more actual and needed. *The unique perspective of this course comes from the interplay between AmI and MR environments, which enables opportunities for the design of new interactive experiences at the intersection of these two areas of scientific investigation and practical development.* The realization that AmI and MR are two sides of the same coin will be helpful for HCI researchers and practitioners that are looking for a new perspective to employ in their work. This course offers this realization by taking the attendees in a journey represented by a critical analysis of the theoretical foundations of AmI and MR accompanied by practical examples of systems, applications, and tools from AmI and MR.

2 DESCRIPTION

The course will introduce attendees to the theoretical foundations and practical aspects of designing interactions for AmI and MR.[2] Relevant references from the scientific literature will be discussed and software tools demonstrated; see the next subsection for examples. The course will be offered in the form of two sessions of 75 minutes each, pointing attendees to the most relevant aspects of designing interactions in the interplay of AmI and MR by combining expositions and practical activities. The first session addresses theoretical foundations—principles and concepts for AmI and MR—accompanied by examples from the scientific literature. The second session focuses on methods for designing interactions in the interplay between AmI and MR environments, featuring more examples as well as a practical activity. A dedicated web page is available for this course with notes and references for the attendees. Key literature and tools from the course are linked to this page.

2.1 Content

Part 1: Theoretical foundations of AmI and MR

❶ *Introduction.* Setting the context and overview of the course.

❷ *The user experience of Ambient Intelligence environments.* An exposition of the design principles and quality characteristics of

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[1] Forecast augmented (AR) and virtual reality (VR) market size worldwide from 2020 to 2024. Available from https://www.statista.com/statistics/591181/global-augmented-virtual-reality-market-size, last accessed December, 2021.
[2] According to Milgram and Kishino's [14] Reality-Virtuality Continuum, we interpret AR as a subset of MR. As we discuss in this course the interplay between AmI and MR, MR also includes AR.

AmI environments [1,6,7,26], such as integration, personalization, and anticipation, among others, with a focus on the user experience design [11], such as metaphors for AmI. Examples of tools, including SAPIENS [23] for implementing interactions in smart environments involving a diversity of I/O mobile, wearable, and ambient devices, the flower model for ambient media [16], and databases to inform interactions with specific devices [37], will be discussed. *Benefits:* attendees will discover opportunities offered by interactive AmI environments in the context of the original vision of AmI, with many practical references to use in their own work.

❹ *The user experience of Mixed Reality environments.* An exposition of the principles and foundations of AR and MR [2–5,13,14,24,25], such as AR as intelligence amplification, AR as a new form of media, AR as an interface and gateway to a 1:1 correspondence between the virtual and the physical world, and AR as a subset of MR. Practical examples will be provided to the attendees, such as AR for television [39], interacting with mid-air virtual content [20], and specific interaction techniques, such as Smart Pockets [33], designed to augment physical reality for various sensory channels. *Benefits:* attendees will discover opportunities offered by interactive AR/MR environments in the context of the original visions of AR/MR.

Part 2: The interplay between AmI and MR

The second part of the course builds on the foundations set in the first session to achieve the realization of the interconnection between AmI and MR and also to illustrate new design opportunities available in the interplay between AmI and MR.

❺ *Designing interactions for AmI and MR, two faces of the same coin.* An exposition of the similarities of the visions of AmI and MR by means of commonly shared characteristics of systems implementing these visions toward *adaptation*, *personalization*, and *context awareness*, while other characteristics, such as *integration*, are conceptually similar. Examples will be provided of AR/MR systems that can be described from an AmI perspective, such as IllumiRoom [10] *vs.* AroundTV [29] *vs.* Ambilight[3] as well as of AmI systems that can be described using AR/MR characteristics, such as Hover [17] or "I bet you look good on the wall" [9]. *Benefits:* the realization that AmI and MR intersect significantly and that their intersection can be creatively exploited for designing novel interactive experiences.

❻ *Group work: ideation session on a given topic.* Members of the audience will form teams (random composition of groups) and apply the realization ❺ to their own work, previous projects, and research interests about interactive systems. Each group will present briefly their result and highlight the interplay between AmI and MR. *Benefits:* this part of the course will create the opportunity for the attendees to get to know each other, interact, and collaborate by exchanging ideas and apply the findings from the course.

2.2 Audience and Prerequisites

The level of the course is introductory. No previous knowledge about AmI or AR/MR is required. The ideal audience is researchers and practitioners that wish to design new interactive experiences involving MR and AmI concepts. This audience includes experienced researchers, UX and interaction design professionals that use the course to get acquainted to AmI and MR terminology, concepts, principles, and methods, but also HCI practitioners with an interest in exploring interactions beyond desktop and mobile computing scenarios, and PhD students that wish to expand their range of knowledge and expertise to gain new perspectives to apply in their own research. The course is planned to be delivered online in order to foster broad participation. To this end, the Google Cloud Platform will be used to host resources, notes, and communication channels between the instructors and attendees.

3 INSTRUCTOR

Radu-Daniel Vatavu, Ph.D., works in the areas of HCI, AmI, AR/MR, Accessible Computing, and Entertainment Computing with focus on designing novel interactions informed by understanding users' needs, preferences, and behavior with interactive computer systems. He directs the Machine Intelligence and Information Visualization Lab (MintViz),[4] an interdisciplinary research laboratory within the MANSiD Research Center at the Ştefan cel Mare University of Suceava. The goal of the MintViz lab is design, development, and evaluation of new artificial intelligence and information visualization technology to support innovative, rich interaction between humans, computers, and environments to advance HCI knowledge. Examples of the instructor's prior research relevant for this course are interaction techniques and tools for AmI application scenarios [8,12,16,20,22,23,28,33,38] and AR/MR [15,18,19,21,39]. A full list of publications is available from his web page.

Teaching Experience. Radu-Daniel Vatavu is a Professor of Computer Science at the Ştefan cel Mare University of Suceava, where he has been teaching courses in Ambient Intelligence, Augmented Reality, Natural Human Computer Interaction, and Algorithms Design since 2008 for undergraduate and graduate students. He has also delivered courses at CHI'18 [27], CHI'17 [32], CHI'16 [31], TVX'15 [30], and other events. He has participated in the design and development of many software tools that were released publicly under an open license, such as the $P [34] and $Q [36] gesture recognizers, AGATe [40], GHoST [35], SAPIENS [20], Euphoria [22], GestuRING [37], and others, of which a selection will be featured in this course.

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