

ARCADE: An Augmented Reality Display Environment for Multimodal Interaction with Conversational Agents

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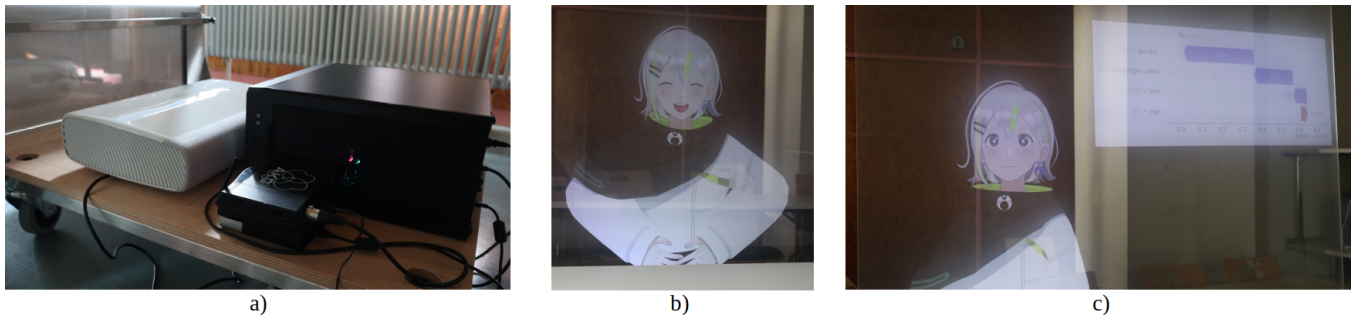


Figure 1: Impressions of ARCADE – a) Technical realisation, b) Chit-chat dialogue, c) XAI dialogue with additional visualisation

ABSTRACT

Making the interaction with embodied conversational agents accessible in a ubiquitous and natural manner is not only a question of the underlying software but also brings challenges in terms of the technical system that is used to display them. To this end, we present our spatial augmented reality system ARCADE, which can be utilized like a conventional monitor for displaying virtual agents as well as additional content. With its optical-see-through display, ARCADE creates the illusion of the agent being in the room similarly to a human. The applicability of our system is demonstrated in two different dialogue scenarios, which are included in the video accompanying this paper at <https://youtu.be/9nH4c4Q-ooE>.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**;
Interaction devices; Ubiquitous and mobile devices.

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KEYWORDS

Human-Computer Interaction; Human-Agent Interaction; Embodiment; Dialogue Systems

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1 INTRODUCTION

Conversational systems are becoming increasingly ubiquitous in our everyday lives. Embodying these systems by an agent [2], allows for a rich multimodal interaction leading to a more human-like and hence intuitive interaction. However, recent systems (e. g., [1, 10, 12]) do not integrate these virtual agents into the real environment in a truly natural manner. Making use of augmented reality (AR) [3], the illusion of a virtual agent being present in the room similarly to a real person can be created. Hence, it is worth investigating in the field of spatial AR, which integrates the AR experience directly into the environment and thus making it accessible to everyone passing by.

In this work, we present our in-room AR system, ARCADE (Augmented Reality Conversational Agent Display Environment). By

allowing to project any 2D or 3D content onto a specially prepared transparent surface, ARCADE serves as an AR display for interacting more seamlessly and hence naturally with agents and respective underlying dialogue systems in the real world. Our system can be used in the same way as a conventional monitor and thus is applicable to any conversational agent.

The remainder is organized as follows: In Section 2, we detail the design of ARCADE and demonstrate its applicability to embodied conversational agents, including showing additional information alongside the agent. Section 3 concludes the work with a brief summary and outlook.

2 ARCADE

ARCADE is an augmented reality (AR) system with a spatial optical-see-through display, allowing to interact with virtual agents of conversational systems in a natural and ubiquitous manner. Figure 2 shows ARCADE in full size from a user’s perspective. In the following, we first summarize the requirements and features that we identified as being relevant for constructing ARCADE. Afterwards, we detail our technical realisation and exemplarily demonstrate the applicability to two different conversational agent systems. A video of ARCADE including these exemplary demonstrations can be found at <https://youtu.be/9nH4c4Q-ooE>.

2.1 Requirements and Features

For our usage of ARCADE as an AR system for natural, human-like interaction with conversational agents, we define the following goals and corresponding requirements: To create the illusion that the conversational agent is actually present in the room, every part of the display that is not occupied by the agent needs to resemble the real environment. This also means that there should be no obvious border around the display. For resembling human-human interaction, the agent needs to be displayed in the size of a real human. Additionally, there should be the possibility to show external content, including texts, images, and videos, referenced during the conversation. To account for ubiquitous usage, neither special environmental conditions nor special equipment is required by the user(s) to experience the illusion. Furthermore, the effort of porting existing conversational agent systems to be displayed on ARCADE should be kept to a minimum.

2.2 Technical Realisation

The display is a transparent surface with a special foil for back-projection. Where no content is projected, i. e., the color black is used, one can see the real environment through the transparent display. To allow for real-sized virtual agents in sitting as well as standing scenarios, our surface is a 1.80m high and 1.30m wide acrylic glass. The width moreover allows to display additional content on the surface next to the agent. The acrylic glass is mounted on the bottom only, therewith preserving the border-less design of the system and hence the AR illusion.

We use a high luminosity, ultra-short distance projector to project onto the glass from behind. The ultra-short distance property allows for a compact design of the system as shown in Figure 1a, while the high luminosity (2800 ANSI Lumen) allows to use ARCADE by daylight as long as there is no source of light directly interacting



Figure 2: ARCADE from a user’s perspective.

with the beam of light of the projector. For practical reasons, including storing and transporting the system in the laboratory, the system is on wheels and the part of the construction holding the acrylic glass can be separated from the remainder.

Any existing embodied conversational agent can be displayed through ARCADE by connecting the respective computer with the projector. No specialized software or hardware link is required: Only the display output of the computer needs to be changed to the projector of the AR system. This way, ARCADE is usable just like a conventional monitor and therefore can be integrated into existing research easily.

Since the illusion of the agent being in the room involves that it seems as if its utterances are spoken by it, the device for audio output should be placed close to the display. In our case, we simply utilize the loudspeaker of the projector. Depending on the scenario, additional sensors for recording and inferring the state of the user(s) can be utilized. When the sensors need to be placed in the direction of the agent (e. g., an RGB-D camera providing the system with vision), their positioning should be well thought out in order not to disrupt the illusion and the border-less design.

2.3 Application to Exemplary Conversational Agents

To demonstrate the applicability of ARCADE and to showcase the fulfillment of our requirements and features, we employ two different conversational agent systems. Both systems are built upon the MMDAgent-EX [8] framework with “Gene”¹ as the embodiment of the agent. However, every agent within any framework can be displayed on ARCADE.

Chit-Chat Dialogue with ChatGPT. Following the implementation in REMDIS [4], we employ ChatGPT² as the dialogue system manager behind the agent. Based on the utterance by the user, ChatGPT is not only generating the agent’s utterances but also selecting respective expressions. The generated response texts are forwarded to the speech synthesis and the selected expressions are used to control the motion of the agent. Thereby, the users can seamlessly engage in an every-day conversation with the agent in either a standing or, as in Figure 1b, a sitting scenario.

Explainable AI through Dialogue with Athena. The field of explainable AI (XAI) [6], which aims at providing transparency for decisions made by AI systems, is becoming more important the more complex and wide-spread AI systems are getting. The dialogue system Athena [7] offers access to these explanations in the form of a conversational interaction. Its explanations are based on the XAI methods of counterfactuals [5] and Shapley values [9]. Additionally, the explanations provided through the dialogue are supported by visual aids like a waterfall plot of the Shapley values. Figure 1c shows an interaction with “Gene” embodying the Athena system and demonstrates having the plot as an additional source of context displayed next to the agent.

3 CONCLUSION AND OUTLOOK

We have presented ARCADE, an augmented reality system for natural and ubiquitous interaction with conversational agents. With two conversational agents, one tailored towards multimodal chit-chat dialogue and the other towards explainable AI through dialogue, we demonstrated the applicability of ARCADE to different interaction scenarios and the fulfillment of our above defined requirements towards the system. To improve the multimodal capabilities of the system towards symmetric multimodality [11], additional sensors for affective computing, among others an RGB-D camera, are going to be integrated into the system. Moreover, it is of interest to evaluate the effect of our proposed AR system compared to existing ways of displaying embodied conversational agents in a user study. Further work can be done in compressing the design of ARCADE to make it more portable; though, any transparent surface in an environment can be prepared as a display for ARCADE.

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²<https://openai.com/chatgpt/>