Combining Virtual and Augmented Reality to improve daily autonomy for people with Autism Spectrum Disorder

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ABSTRACT

Cognitive rigidity and behavioral and communication problems are the most common symptoms that characterize Autism Spectrum Disorder (ASD). In fact, people with ASD face complications in everyday life, from interacting with other persons to being autonomous in the most ordinary daily tasks. To overcome these limitations and improve their quality of life, we developed 5A. 5A exploits cutting-edge technologies such as Virtual Reality (VR), Augmented Reality (AR), and Conversational Agents (CA), combining smartphones and wearable headsets to offer new forms of intervention to persons with ASD. Virtual reality experiences enable learning common tasks, such as using public transport, through simulation in a safe environment. When people are in similar real-life situations, AR can help them generalize the skills they have learned in VR by overlaying interactive media assets on top of the view of the physical world around them. A customizable conversational assistant provides individualized prompts and feedback in both VR and AR to provide maximum user support.

CCS CONCEPTS

• **Human-centered computing** → *Virtual reality*; *Mixed / augmented reality*.

KEYWORDS

Augmented Reality, Virtual Reality, Public Transportation, Autism Spectrum Disorder

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1 INTRODUCTION

Autism Spectrum Disorder (ASD) is a developmental disability characterized by social communication deficits, cognitive rigidity, and deficits in adaptive behavior [1]. Behavioral training activities to consolidate functioning habits are the key rehabilitation approaches from a therapeutic standpoint. This method efficiently produces adaptable attitudes, but it can only be used in limited situations. These are the reasons why, to improve ASD people's autonomy and promote their social inclusion, we developed 5A. 5A provides a set of innovative and interactive applications integrating Virtual Reality (VR), Augmented Reality (AR), and Conversational Agents (CA). These technologies can help people with ASD understand the environmental and socio-organizational aspects of everyday life scenarios (such as taking the subway) and complete the actions that go along with them. VR experiences simulate tasks in such circumstances (e.g., identifying the subway entrance, acquiring a ticket, getting on the train). After that, when people are in comparable situations in real life, AR can help them generalize the abilities they learned in VR by superimposing multimedia assets on the view of the physical world around them (e.g., which button to press on the ticket machine, where to insert the ticket for validation). This paper will present an initial use case for the 5A's framework, which focuses on teaching users with ASD how to take the underground. Both applications have been designed in collaboration with therapists and psychologists who know this target group's needs and problems. In order to offer the best support to users, both applications have been enriched with a virtual conversational agent (VCA). Its main function is to guide users through the experiences, offering help if they get lost or do not know how to proceed.

2 RELATED WORK

5A is a framework that offers new and advanced forms of support to people with autism in everyday contexts such as urban mobility. In the literature we can find some examples where Virtual and Augmented Reality are used for this purpose. The works of [5] and [6] for instance focus on the plane scenario. The authors recreate 360 video simulations where users are explained how to take a flight. The experiences consist of narrative scripts in which users cannot interact with the elements in the scene and can only pause the video. In addition, there is no VCA that the user could refer to in case of need. The work of [7] instead, add interactions to the experience allowing ASD people to learn what to do in an airport by freely

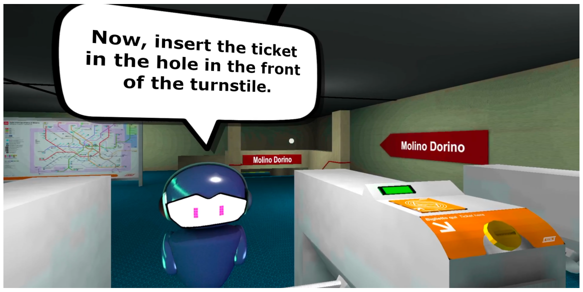

Figure 1: Screenshot of the VR subway experience. The VCA asks the user to insert the ticket in the turnstile.

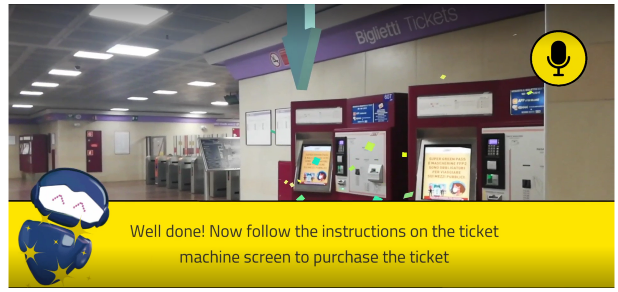

Figure 2: Screenshot of the AR subway experience. The VCA asks the user to reach the ticket machine.

moving into the scene, interacting with objects, and performing actions as they were in the real world. Another example is presented by [3] in which the authors made the users perform all the necessary tasks in order to reach a specific destination by bus. Although augmented reality is a technology that can considerably help people with autism [2] there are few examples in the literature where it is used in public transport scenarios. The most representative is the work of [4] who designed a navigation app using visually-oriented navigation. As far as we know, there are no examples of augmented reality applications to support people with autism, nor are there any use cases that show an integration of virtual and augmented reality experiences, as is done in our framework.

3 5A SUBWAY VR

The VR experience was designed to simulate all the necessary steps needed to take the underground, namely: locating the underground entrance and entering it, finding a ticket machine to buy a ticket, validating the ticket and passing the turnstiles, reaching the platform, boarding the train and getting off at the right stop. The experience has been divided into three main moments, each corresponding to a specific virtual environment. These are the outside of the subway, the inside of the subway, and the inside of the train. In each environment, the user must complete one or more of the tasks presented above. For example, inside the underground, the user has to buy a ticket, pass through the turnstiles, and find the correct direction to take. Each task is then divided into sub-tasks that correspond to the experience's building blocks and represent the simplest interactions that the user can make in VR, namely gazing, selection and movement. Each of these interactions is mapped to an action that the user will have to perform during the activity, and by combining them, it is possible to create the whole flow of the experience. The user is guided throughout the experience by a VCA who tells him, step by step, what action to take (Figure 1). The assistant never disappears from the virtual scene and can also intervene to support users if they do not know how to proceed. For example, the user does not know how to select a turnstile. Depending on the type of support the user needs, the assistant can offer different levels of help. Initially, the assistant may display indicators and/or pointers that can direct the user to the correct key item to interact with. If the user has great difficulty completing the task, the assistant may even decide to skip it and move on to the next one.

4 5A SUBWAY AR

Instead, the AR experience was designed to support the user in generalizing the tasks already learned in the VR application in a real setup (e.g., from the VR station to the actual station). What changes dramatically in the AR case is that the system does not have absolute control over the experience as it does in virtual reality. By performing the activity in the real world, the system cannot know all the actions that the user has performed or is performing. For this reason, the experience design in AR is composed of the same logical moments that we have seen in VR. The interaction, nevertheless, is completely changed. The primary interaction available to the user is the Object Recognition. In other use cases, GPS tracking is also used, but in the subway, it has been observed that the GPS signal is not reliable and therefore not usable, also considering the needs of the end-users. On the other hand, Object Recognition proved to be functional even from a few meters away from the object with which to interact. This allows the system to be proactive, trying to indicate to the user the following action to be taken. In this way, when the user frames an object, the system understands that s/he is near a key element of the experience. However, not being able to rely on what users are scanning thoroughly, the VCA asks what has been already done. Thus, in the application, users will always be able to contact the VCA by pressing the mic button present in the UI (Figure 2). To further help the user, the VCA can show some AR animations, map over the real objects, recall the VR training, and understand how to interact with the real-world items in the scenario. To face the difficulty of non-verbal users and the possible confusion in the recorded audio analysis, our UI allows the user to answer the VCA both through voice and modal buttons.

5 CONCLUSION AND FUTURE WORKS

This work represents a first attempt to bring together different advanced technologies to improve the daily life of persons with autism. VR, with its immersiveness, can facilitate the learning of very simple tasks. AR can superimpose the key elements of the tasks learned in VR in the real situation. This shift from the virtual world to the real-augmented world may be the key to overcoming the inability to abstract learned concepts that often characterize ASD. The 5A framework will be tested in a study involving more than 30 persons with ASD from the "Sacra Famiglia" and "Nostra Famiglia" therapeutic centers who cooperated in the design of the 5A experiences.

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