Integrating VR/AR and AI-Chatbots in the Public Sector: Barriers and Synergies

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Abstract. Public administrations are increasingly confronted with demands for greater citizen engagement and a shortage of qualified professionals. The adoption of emerging information and communication technologies (ICTs) is often shaped by organizational factors such as resource availability, leadership, and interorganizational dynamics. As digital transformation accelerates, virtual technologies, particularly virtual reality (VR) and augmented reality (AR), offer promising opportunities to enhance administrative processes through immersive and augmented environments. However, the integration of these technologies remains complex and presents numerous applicational challenges.

This study investigates the barriers to VR/AR adoption in the public sector, with a particular focus on organizational and adaptation-related issues. Additionally, it explores the potential of AI-powered chatbots to mitigate these barriers. To that end, a deductive thematic analysis was conducted on a sample of 104 VR/AR projects. The study further examines the synergies between VR/AR systems and AI chatbots.

The findings provide a foundational understanding of the applicational barriers associated with VR/AR integration in public administrations, highlighting challenges related to infrastructure, human–computer interaction, system stability, financial constraints, and complexity. While AI-powered chatbots show potential in addressing several of these issues, the study emphasizes the importance of designing both technologies as complementary systems to enhance effectiveness, efficiency, and user experience.

Keywords. VR/AR, Conversational AI, Chatbot, Public Sector, Smart City
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1. Introduction

Public administrations have come into a new era of captivating changes and technological advancements (Lnenicka et al., 2024). Innovative digital technologies offer new potential to address upcoming challenges, such as the high need for qualified specialists and the growing demand for citizen communication and involvement (Cortés-Cediel et al., 2023). Virtual technologies, including VR and AR, are promising rising technologies which could allow to introduce a new type of virtual citizenship. Discussed as a foundational layer for an omnipresent virtual internet, the metaverse increasingly appears to be an imminent rather than distant application (Ricoy-Casas, 2023). Virtual reality (VR) refers to technologies, which shutdown the reality and create a virtual environment to the eyes of a human participant. On the other hand, augmented reality (AR) refers to technologies, which enhance the field of view of a user (Suh & Prophet, 2018). Currently, both technologies show potential in a variety of fields where information needs to be vividly visualized (Renu, 2021). From virtual city tours, digital twins, to participation. Several cases exist, which use the technology to vividly display projects and public processes to the people (Suh & Prophet, 2018). In science-fiction movies, these virtual worlds are often populated with artificial inhabitants, such as virtual intelligent avatars or intelligent AI-companions (Ricoy-Casas, 2023). Already today, we encounter almost daily interaction with virtual avatars or conversational agents, such as Microsoft Cortana, Google Gemini, or ChatGPT (Casheekar et al., 2024). Known under the umbrella term chatbots, these are engaging tools which can

help to close the communication gap between citizens and administration through engaging and almost human like natural conversations (Androniceanu, 2023; Yeh et al., 2019).

In contrast to virtual and visualizing communication tools, such as VR and AR, chatbots can independently have a verbal or textual conversation with a human (Dwivedi et al., 2021). Recent chatbot systems implement AI algorithms. These systems have the ability to learn from real-time input and learn to adapt to it (Abbas et al., 2023). Chatbots have demonstrated applicability in scenarios that demand extensive and diverse verbal interactions. (Cortés-Cediel et al., 2023). For public administration, this shows to be effective in settings where a large number of citizen requests need to be processed. To this point, chatbots in public administrations have primarily been used for simple requests. However, the accessibility of more complex systems, including Large Language Models (LLMs), shows potential for more advanced settings. With these new opportunities, a chatbot could guide citizens through VR/AR-environments and assist citizens in a new and engaging way (Dwivedi et al., 2022).

A combination of both VR and AR technologies could be a powerful new way of citizen engagement (Dwivedi et al., 2022). However, currently only a few projects implement both technologies in an operationalizable way (Suh & Prophet, 2018). These projects are often experimental or require a noticeable effort (Hwang et al., 2024; Lnenicka et al., 2024). Therefore, it is still questionable if a combination of both technologies is applicable in the public sector in the present and future. Therefore, we want to investigate current VR/AR projects, identify challenges, and highlight the potential of a combination in the given fields. The findings of our paper are both valuable for science and public administrations, analysing the potential of a technological combination. The research questions of this paper are consequently:

RQ1: What are the current barriers of VR/AR adoption in the public sector?
RQ2: How can AI-powered chatbots help to reduce barriers in VR/AR adoption in the public sector?

To answer the research questions, we first outline the theoretical background on VR/AR and highlight the potential of AI-Chatbot applications in the public sector. We also present a first given state on the combination of both technologies for public services. When the theoretical context is given, we present our methodology of a deductive thematic analysis on the basis of 104 VR/AR projects in the public sector. We outline the codebook for the analysis of potential barriers to VR/AR adoption in the public sector. Based on this, the findings of our analysis are presented. We discuss the potential to address current barriers in VR/AR adoption with an AI-Chatbot combination and present our conclusions as well as limitations and possible future research.

2. Theoretical Background

Immersive technologies blur lines between physical and virtual worlds, creating a sense of presence and engagement for users (Suh & Prophet, 2018). Widely available in the consumer market, head-mounted displays (HMDs) are one prominent example of these technologies. These devices, worn on the head, immerse users in a virtual environment (VE) by stimulating their senses, allowing them to interact with virtual objects and representations (Cassani et al., 2020). In contrast, augmented reality covers a broader range of devices and applications. A major breakthrough in the commercial adoption of AR came with the release of the mobile app Pokémon Go in 2016, which popularized location-based AR experiences (Suh & Prophet, 2018). Since then, AR applications for smartphones and tablets have become increasingly common.

The second focus technology are chatbots. Chatbots are conversational agents, which allow adaptive conversations on certain topics. In public administration, chatbots have high potential to achieve more transparent processes while providing 24/7 access to governmental data sources. Chatbots may be found in a variety of public processes (Abbas et al., 2023). However, chatbots integrated today in public administrations are mainly for simple and experimental interaction cases (Cortés-Cediel et al., 2023).

A combination of VR/AR and chatbots is currently scarce in public projects (Lnenicka et al., 2024). In regard to science-fiction and virtual digital utopias, the combination is foreseen to be powerful as intelligent technology becomes integrated into our daily lives (Dwivedi et al., 2022). Possible fields of application are virtual medical assistants or virtual AI systems, which may be positioned in the real or virtual world (Chadha et al., 2023). Promising fields are also educational or cultural settings where both technologies can enhance the common effect and provide vivid input to the learner (Hwang et al., 2024).

3. Methodology

3.1. Thematic Analysis

In order to highlight the potential of a VR/AR and chatbot combination in the public sector, we analyze a dataset of 104 VR/AR projects on possible application fields. As shown in Figure 1, 59% of the highlighted projects in the datasets originate from Germany and the broader DACH region. Germany is a country with a highly complex

bureaucracy that encounters many challenges in the introduction of innovative digital technologies (Sept, 2020). Further projects were located in the USA (18%), additional European countries (Sweden, Finland, Ireland, Netherlands and the UK) and Australasian countries (Indonesia and Australia). To understand the potential of VR/AR and chatbot combination, we initially started with an analysis of current barriers that were experienced in the projects.

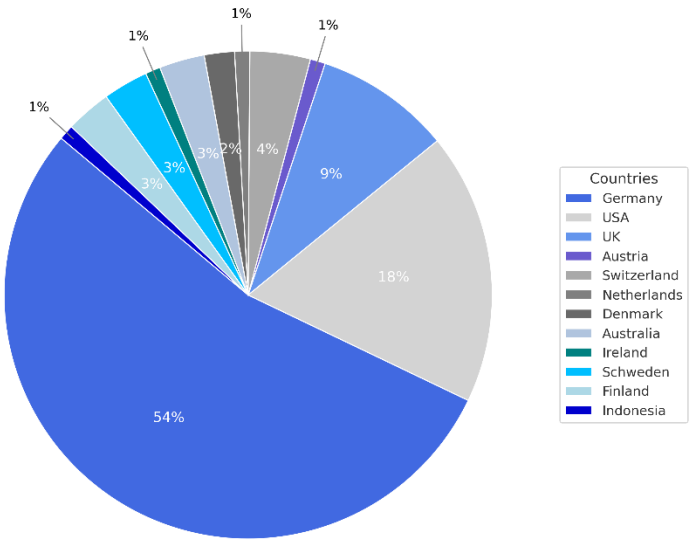

Fig 1. - VR/AR Project Sample

Barriers were observed based on project descriptions, reports, videos, and additional content about the projects. These were coded in a deductive thematic analysis (Boyatzis, 1998; Braun & Clarke, 2019), following the Steps presented in Figure 2. For the coding process, a category system of potential barriers was developed based on secondary literature on VR/AR integration in the public sector. Each category was defined and described with anchor examples and coding rules. The findings were consolidated and organized through the pre-defined category system. If findings were reoccurring, new subcodes on relevant topics were created on the basis of the defined categories. After conducting the deductive thematic analysis (Boyatzis, 1998; Naeem et al., 2023), we continued to explore potential application areas for chatbots within the projects and noted the potential of their integration in the given domain. We analyzed the potential of chatbots for public integration based on the proposed principles and fields of application presented by Cortes Cediél et al. (2023). We incorporated the proposed chatbot evaluation metric to highlight potential attributes that could be integrated into the list of projects.

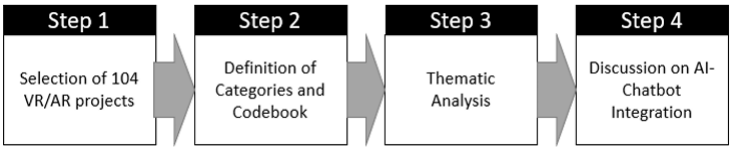

Fig 2. - Steps of the Thematic Analysis

To understand the current status of acceptance of VR/AR systems in public administrations, we rooted the analysis in theories of acceptance. The UTAUT model, as a modern and well-researched approach, involves the key aspects of performance expectancy, effort expectancy, social influence, and facilitating conditions, which lead to behavioral intention and use behavior. In regard to VR/AR adoption, users need to experience satisfaction based on their initial expectations of the system. Especially with immersive technologies like VR/AR, expectations may widely range. A totally immersive world may be expected, where the other one has no expectations (Xiong et al., 2024). Further, it needs to be mentioned that the UTAUT does not include an explanation of potential barriers that limit the acceptance of technology (Le Tan et al., 2024). Moreover, an individual's perspective is taken into account, while an organizational view is not prioritized (Ajibade, 2018). Barriers to the adoption of digital technologies stand in contrast to the adoption of a technology. In regard to VR/AR adoption in the public sector, well defined barriers are still missing to our knowledge (Vimal et al., 2023). Previous literature mentions the challenge to adopt VR/AR in the public sector (Lnenicka et al., 2024). The barriers in the public sector are versatile, which makes an evaluation of VR/AR technologies challenging. Nevertheless, to identify barriers regarding technology, the purpose and goal need to be taken into account. VR and AR are technologies that are well suited to educate vividly on different topics (Dwivedi et al., 2022). Le Tan et al. (2024) identified relevant barriers to VR/AR adoption in educational settings . They propose five central barriers from scientific literature: VR/AR adoption is affected by

infrastructure, technical issues, cost factors, complication, and human interaction. In this regard, VR/AR barriers in the public sector display similarities that warrant attention. VR/AR projects in the public sector demonstrate a strong focus on educational settings, with over 65% of the identified projects falling into this category. This includes public learning, but also education on public projects and cultural and historic settings, as for instance city tours and virtual art installations.

Infrastructure is highly relevant for the integration of innovative technologies (Dionisio et al., 2013; Lnenicka et al., 2024). Especially with the vision of an interconnected metaverse, infrastructure becomes a relevant indicator for VR/AR integration potential (Dwivedi et al., 2022). Public projects are already today integrated in internal services, support of urban planning, and e-participation (Ricoy-Casas, 2023). If a project manages to integrate existing data and information, the impact of this service increases in the eyes of the citizens (Frank et al., 2010). Existing public platforms, such as smartphones-apps and social networks, profit in the same way from an integration of VR/AR services. With regard to AI integration and the era of generative AI and technological advancements, infrastructure is a fundamental barrier to VR/AR systems and future adoption (Zuiderwijk et al., 2021).

Technical issues as barriers are a central problem for VR/AR adoption. These may result from technical limitations or immature implementations. Technical issues are the result of multiple factor problems and often strongly relate to the planning process and predicted goals for the system (Kumari & Polke, 2019). Regarding technical issues with VR/AR, it needs to be taken into account that already small flaws in the systems can highly affect the perception (Hsiao et al., 2024). In case of immature systems, users can experience technostress or cybersickness that affect the continuous use of a system (Souchet et al., 2023).

Avoiding unnecessary complexity is essential when quick results are valued (Lnenicka et al., 2024). As VR/AR projects often cope with unrealistic requirements, complication can arise without leading to observable value. Unnecessary complication may be the implementation of a VR system without a clear benefit in comparison to a 2D PC system (Stejskal et al., 2003). Also, complication can arise through nontechnical aspects in the project facilitation. Hence, inadequate communication of the service may lead to an awareness problem and ongoing complications with citizens.

Cost factors are relevant in the adoption process of a system. Innovative technologies can involve costs, which are not directly predictable (Naugolnova, 2024). Furthermore, the maintenance of these systems can create a quick overhead in comparison to the perceived reward. Some participants in public projects raised concerns about the impact of the technology and its complication (Teutenberg, 2025). Especially in learning settings, the results are not necessarily satisfactory. Further, the time cost factor should be considered while implementing these systems (Fegert et al., 2020).

The public sector needs to manage requirements from a variety of different users and stakeholders. Ease of use is not always guaranteed with public services (Chen & Aklikokou, 2020). Especially with technologies such as VR and AR, citizens need to be introduced on how to use and interact with a system. Usability can become a central barrier if not satisfactorily addressed (Kim et al., 2020). How effectively systems in public administrations address this topic is decisive for their further usage. Alongside usability, human interaction also becomes a relevant factor (Kim et al., 2020). As a technology that embodies users, VR is creating new normative rules and interaction patterns that influence how individuals perceive themselves and others within virtual environments.

3.2. AI-Chatbot Integration

The identified chatbot characteristics in the public sector by Cortés-Cediel et al. (2023) are used as a fundamental source for potential application fields. Cortés-Cediel et al. (2023) observed five principal purposes for chatbot integration: 1) searching for government information; 2) supporting access to government data; 3) providing public services; 4) improving citizen participation; and 5) facilitating communication between stakeholders. In regard to the identified barriers of VR/AR in the public sector, we outline how chatbots can be integrated with regard to these five principal purposes in public VR/AR applications. We propose solutions that could be implementable in the upcoming 3-10 years from the time of the given analysis due to technical advancements and innovation cycles in the public sector (Lnenicka et al., 2024; Stewart-Weeks & Kastelle, 2015). Data policies and individual country perspectives were not included, as the primary goal of the analysis is to highlight the potential of VR/AR and AI-chatbot integration in a divergent idea generation process without prematurely focusing on country-specific limitations.. We root the discussion on existing functionalities of chatbots and conversational agents and create an extensive perspective for the given problems in the public sector. Except for commercial services like ChatGPT, we analyzed multiple chatbot platforms for the public sector from private and governmental providers, including Botfriends, DialogBits, and the General Service Administration Chatbot. We analyzed these systems to extract a comprehensive picture of potential integration in VR/AR services.

4. Findings

The findings regarding barriers of current VR/ AR adoptions can be grouped into the five categories, namely infrastructure, technical issues, complication, cost factors, and human-interaction, as proposed by Le Tan et al. (2024). See Table 1 for a comprehensive overview.

Within the barrier of *infrastructure* three main problems could be identified from the sample set of VR/AR projects. Projects for firefighters or for police training, for instance, show promising applications to simulate critical situations in the job (e.g., project firefightervr). The project systems are mature and vividly present contents to the user. However, public administrations often set up cooperations with private IT-companies, which sell services to the public institutions. This can be problematic, as new content for the VR/AR systems is often not affordable or exceeds initial budget plans (Bonomi Savignon et al., 2024). A majority of the retrieved VR/AR projects did not actively proceed one year after release. Further, the education of administrative workers is a barrier, which limits the potential of VR/AR systems. IT experts are hard to recruit for the public sector (Haug et al., 2024). However, continuous maintenance of the VR/AR systems would be necessary to further develop and improve the contents. An additional challenge regarding infrastructure is the isolated setup of VR/AR services. Interfaces to existing infrastructure are rarely considered. So, projects that implement urban data, like the Ashbury Park Bike Lane Demonstration Project, are relying on a limited dataset. A continuous data-flow is nonexistent between external services and VR/AR systems. However, specifically projects aiming to boost efficiency require an accurate, precise, and current dataflow. The lack of real-time data decreases the quality of simulations and analyses. Thus, the continuous data updates are a highly relevant aspect for Digital Twin integration. For instance, the Hamburg port authority set up a promising project that integrates a continuous data stream from the port to the Digital Twin in the virtual environment, enabling real-time simulations (Hamburg Port Authority [Hg], 2025). This example indicates that an integration of urban data in VR and AR is already possible and that the incorporation into existing systems can be beneficial to allow data exchange. However, the majority of projects do not implement an API or interface to existing urban data sources. VR/AR infrastructure problems often root in design issues rather than implementation (Creed et al., 2024). Critical are limited standardizations, such as complicated devices or a limited scope of application. A variety of AR city tour apps were integrated in many different towns in Germany. The towns (e.g., Bergen-Belsen, Chemnitz, or Munich) developed their own system with individual functionalities. Furthermore, low-code tools, which allow the development of applications for the public, are not frequently applied (e.g., ARget). A common infrastructure of applications in general could condense the potential of the technologies and allow the exchange of knowledge and resources. For instance, 3D-models that are used in one project may also be applicable in an AR communication app in a different project. A shared technological infrastructure, including databases and APIs, sets the foundation (Creed et al., 2024). Barriers in project infrastructure sometimes were already rooted in the project design. For instance, the Ashbury Park Bike lane project, initially created to gather data on the usefulness of a new bike lane, lacked a control condition or site; thus, the infrastructural design flaw led to inconclusive results.

Tab. 1- VR/AR Integration Barriers in the Public Sector

Infrastructure	**Technical Issues**	**Complication**	**Cost Factors**	**Human Interaction**
1a) Difficulties finding schooled personnel	1b) Issues with system stability	1c) Unclear outlines of project necessities and value propositions	1d) Projects dependent on external funding	1e) Barriers of usability
2a) Introduction of isolated systems rather than incorporation into existing systems	2b) Necessities for additional equipment and sensors	2c) Insufficient communications to target audience	2d) High time-effort for setup and maintenance	2e) Demographic differences in interaction
3a) Infrastructural issues often rooted in the project design prior to implementation	3b) Difficulties with intuitive interaction and model quality	3c) Permanent relevance not ensured		3e) The dangers of over-gamification
	4b) Incomparability of data due to variations in quality			4e) Limiting negative effects
				5e) Difficulties with task alignment

A major *technical issue* in VR/AR projects is the stability of the systems. Especially in complex experimental settings with collaborative VR or with real-time rendering (e.g. Vision 5.G or FX Reality), systems tend to be still immature. Further, in some cases additional equipment is necessary, which can affect the motivation of the citizens and public target groups. Specifically simulators for medical or police training often involve heavy and complex tools, which reduces the scalability of these projects and requires additional testing (e.g., virtual extinguishing trainer). Moreover, latencies are still a major issue, which needs to be addressed (see project Telemedicine in the emergency services). Another factor often not sufficiently explored prior to implementation are barriers with quality and fidelity of the presented 3D-models. Depending on the field of usage, reduced quality can significantly impact the overall usefulness of the application (e.g. Pixplorer). Within the projects, complex 3D models were often taken as self-explanatory (e.g. HoloPLANNING). However, given that 3D models are the primary means of visualization in these systems, a clear definition and standardization of model requirements would enhance usability. In conclusion, the technical complexity of VR/AR projects varies widely, from high-end 5G-based implementations (e.g., Vision 5.G) to low-cost AR tools (e.g., ARget), making their technological maturity difficult to compare directly.

Based on the projects investigated, no direct conclusions could be drawn regarding costs or *financial stability*. However, many services appear to be highly dependent on external third-party funding (e.g., from the German Ministry of Education and Research).
Beyond financial stability, the time and effort required to set up and maintain these systems is considerable. Furthermore, due to the lack of reliable user data, it is important to emphasize that, at the time of this research, most VR/AR projects remain in an experimental phase and do not yet offer financially sustainable services capable of driving rapid transformation in the public sector IT landscape.

In the VR/AR-projects an overhead of *complications* are observable. VR and AR are complex technologies, which require well defined use-cases and a clear value-proposition (Kim & Hall, 2019; Pedersen, 2024). These technologies are often implemented in cases where a need for immersive visualization does not necessarily exist, or is not outlined sufficiently (e.g., Conflict Handling Ambulance Syd). Many public VR/AR projects are not sufficiently communicated to its audience and therefore endangered to not permanently be relevant (e.g. ARget). Furthermore, permanent relevance can be a barrier in project fields that are regularly subject to scientific advances (e.g. medical tr.AI.ning or OP der Zukunft, eng. OR of the future).

In relation to *human-computer interaction*, a few aspects may limit the interaction between citizens and administration. Primarily some services are described to have low perceived usability. For instance, in the project AR/VR.NRW figments, an open-source content creator tool, was developed to set up virtual environments for learning and teaching. In the project it was noticed that VR is not necessarily a better tool for communication of learning contents than a standard PC version: “With regard to self-assessed learning success, no significant advantage of the VR group over Desktop could be identified” (Müser et al., 2023).

A second point that administrations need to be aware of is the interaction with critical target groups. Some projects (e.g., SenopiVR) work with elderly, disabled, or dementia-affected people. Except for demographic states, the individual levels could also be considered. An application in historic settings could be addressed for different educational levels and personal preferences (e.g., Chemnitz.Zeitweise, eng. ChemnitzTimewise). Each target group needs special communication and treatment (Bruno & Muzzupappa, 2010). VR/AR often inherits gamification aspects that need to be aligned. Gamification can be an engaging factor; nevertheless, gamification can also reduce attention when not securely applied and adjusted to the educational level (Dicheva et al., 2015). Additionally, it needs to be taken into consideration that gamification can induce stressful and uncomfortable situations. Simulations in critical situations, such as police treatments, or training for firefighters should be limited to their target audience to not traumatize inexperienced users (e.g., projects Ambulance Syd and firefightervr). VR/AR applications in the public sector often have just one communication goal, which is communicated. Information is provided mainly to one target group. However, public processes, such as participatory initiatives, involve multiple target groups that play a significant role. A setup of multiple VR and AR views would address this problem and align knowledge states. Also, the experience in VR and AR is important to fulfill the potential of the applications. Especially avatars and interaction partners need to be aligned to the task. Here it is extremely important to mention that the right degree of abstraction and presentation is essential to create a satisfying presentation and relation (Commonwealth of Pennsylvania, 2025).

5. Discussion

From a long- and short-term perspective AI-chatbots can be relevant to improve current VR/AR-applications in multiple fields. Before possible integrations are presented, we would like to note that the proposed concepts are not filtered on cost-efficiency and maturity level. The proposed applications of chatbots address primary the identified barriers and highlight potential synergies.

Infrastructure Barriers: AI-chatbots may help in the upcoming years to reduce the dependency of private IT

providers with VR/AR services. AI-powered low-code environments could be useful to reduce the number of external providers through AI-services. Already today advanced conversational agents and chatbots are able to provide content based on a given prompt of a user. For instance, AI-driven 3D agents, which produce VR/AR models based on a given prompt like e.g. Shutterstock Generative-AI. In comparison with the public low-code platforms in the administrations (e.g. ARget or VRpigments), public integration could improve flexibility and generalizability. Dependency problems from external partners would not vanish, however the number of VR/AR IT-service providers could be reduced, as more functionalities could be implemented with the assistance of an AI chatbot. Also, the maintenance problems would fade away, as the chatbot could enable to generate new content without the need for external maintenance. AI-chatbots are often able to learn, which could help to improve VR/AR-services over time. The core functionalities would improve constantly without the need for updates after the end of potential funding. Apart from core functionalities, a chatbot could provide quick data analysis on top of the existing data-streams and visualizations (Alaaeldin et al., 2021). For instance, in digital twin projects, such as the Hamburg Port Digital Twin, a chatbot in the virtual environment could provide additional information on visualized data-streams and highlight critical points in the virtual environment. A chatbot would also allow new interaction techniques in the VR/AR-environments, as it may interact with the user by verbal communication. As typing is not a reliable option in VR/AR, voicebots could be an alternative (Hwang et al., 2024). A chatbot does not necessarily require integrated data operations. However, advanced chatbot systems provided by external vendors may include limited data analytics functionalities. For complex requests, an API driven chatbot could be an optimal solution. This type of solution only handles requests with a language NLU and forwards the contents to an external service provider (data-warehouse, BI-platform) (Adamopoulou & Moussiades, 2020).

Technical Stability: The quality of VR/AR projects is critical. AI-chatbots and agents could be used for optimization and quality control in VR/AR projects. A chatbot could serve as a guide during the implementation process, for instance within low-code applications (e.g., ARget). Public employees could then streamline development processes of future applications (Kumar et al., 2024). The chatbot could engage with the employee and give guidance either in a content management interface or integrated in the virtual environment as a virtual avatar. If problems occur in the development process, the chatbot could also work as an advanced developer console, which gives hints on development issues, or makes suggestions for given coding problems (Simão de Deus & Barbosa, 2024).

Cost-factors & Complications: As an additional functionality, chatbots do not resolve the financial challenges of current VR/AR projects. However, given the growing demand for chatbots in public websites and services, integrating VR/AR functionalities into chatbot systems could enhance the visibility, flexibility, and user guidance of existing applications

Human Computer Interaction: Chatbots can provide guidance in VR/AR-applications and allow to streamline interactions. Possible application fields are citizen participation, facilitation of communication between stakeholders, provision of public services and presentation of government data (Cortés-Cediel et al., 2023). Especially for different demographic groups, chatbots could provide assistance in VR/AR-applications. Based on this, flexible interaction techniques could be enabled through a chatbot that processes spoken information and transforms it into meaningful content. One possible application would be a chatbot acting as a virtual tour guide in interactive experiences, answering questions, providing guidance, or engaging in storytelling. Moreover, AI-chatbot collaboration represents a novel form of interaction that could enhance the liveliness and responsiveness of VR and AR environments. Particularly, AI-driven avatars used for onboarding processes (e.g. in firefighter training scenarios) could help personalize the experience (Luo et al., 2024). In this context, the perceived similarity of the chatbot may foster closer interaction between users and administrative systems.

Chatbots can serve as a powerful tool to address barriers encountered by current applications and to reshape the landscape of VR/AR service systems. In particular, chatbots help streamline existing applications and communicate their functionality in a more flexible and personalized manner. However, it remains debatable whether AI-driven chatbot integration and the incorporation of chatbot personality are essential, or whether the provision of information could be sufficiently handled by standard text interfaces or simple rule-based logic. With technological advancements such as the emergence of Generative AI, the introduction of intelligent, AI-driven chatbots in the public sector appears to be a matter of time. Nonetheless, considering current technological limitations, it may take several more years before the public sector reaches a level of maturity where both technologies, VR/AR and chatbots, can develop meaningful synergies. It is worth emphasizing that VR/AR and chatbot projects should ideally be designed in close alignment. These technologies complement each other through combining visual, auditory, and textual elements. For the VR/AR projects analyzed in this study, chatbot integration may pose a challenge, as the systems are often deeply embedded within their own ecosystems and databases. Establishing a reliable and unified network infrastructure is a crucial prerequisite for unlocking the full potential of a combined VR/AR and chatbot solution.

6. Conclusions

This study examined the current state of VR/AR applications in the public sector, with a particular focus on barriers, potential use cases, and technological synergies. Special attention was given to AI-powered chatbots as a complementary technology that may enhance usability, accessibility, and human–computer interaction. Against this backdrop, two central research questions were addressed: (1) What are the current barriers to VR/AR adoption in the public sector? and (2) How can AI-powered chatbots contribute to overcoming these barriers? A thematic analysis of 104 public sector VR/AR projects was conducted, highlighting four key challenge areas: infrastructure, technical limitations, system complexity, and human-centered design.

The analysis revealed several recurring challenges. Many systems are dependent on private IT providers, which reduces autonomy and increases long-term vulnerability. High maintenance requirements and a lack of standardization have led to a fragmented ecosystem of incompatible platforms and services. System stability, positioning accuracy, and hardware requirements remain problematic. Core components such as 3D models often fall short of application-specific demands in terms of quality and clarity. In addition, the absence of established design patterns hinders the scalability and usability of these systems. Financial sustainability poses another critical issue, as most projects rely on temporary external funding. In many cases, the complexity of the solutions outweighs their practical value, making their unique selling points difficult to identify or justify in comparison to conventional approaches.

In regard to chatbot applications, the study explored several promising use cases aligned with the barriers identified. Chatbots show potential in enhancing interaction with VR/AR systems by simplifying navigation, providing guidance, and personalizing experiences. However, their integration is more feasible in high-quality systems with substantial data communication. It remains questionable whether low-budget implementations would benefit equally. The analysis also suggests that AI chatbots could assume administrative roles in immersive environments, acting as tutors, assistants, or digital workforce elements. In particular, AI-driven avatars functioning as public companions present a compelling area for future exploration.

This study has certain limitations that should be acknowledged. Primarily, the analysis is based on a dataset of 104 VR/AR projects, which, while supported by secondary literature, cannot be considered representative. Thus, while the findings provide meaningful insights, they are to be understood as an initial foundation for further empirical and design-oriented research.

Looking ahead, the convergence of chatbot and VR/AR technologies opens up promising interdisciplinary fields. As chatbot functionalities become increasingly compatible with immersive systems, the boundaries between modalities—visual, auditory, and textual—begin to dissolve. This intersection calls for the development of new design patterns tailored to hybrid applications in the public sector. Exploring these frontiers may significantly shape the future of digital public services and user engagement.

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