ZooniVRse: An Ethical & Social VR Zoo

Group 7: Animal Alliance

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Abstract
Although virtual zoos have the potential to be more ethical, educational and entertaining than physical zoos, current virtual zoo experiences are not sufficient in meeting user needs. Hence, we aimed to design a novel and improved virtual zoo by following a human-centred approach and iterative design process. After establishing user requirements, sketching and prototyping multiple ideas, and conducting user interviews and user tests, we came up with the ZooniVRse – a physical location in the city that people can visit with their loved ones to experience a fully immersive, multisensory and interactive virtual reality (VR) zoo. The realistic VR world is created using computer-generated imagery (CGI), where users can engage in various interactions with animals in their natural habitats. Our concept pushes the boundaries of virtual zoos by providing an experience that is more immersive and social, while also improving upon physical zoos by addressing the ethical concerns and physical discomfort associated with visiting real zoos.

Author Keywords
Virtual Reality; Virtual Zoo; Computer Generated Imagery; ZooniVRse

Introduction

Zoos have been around for centuries and first existed as private collections of animals procured by the wealthy as a symbol of power some 4000 years ago. The modern public zoo as we know it now emerged in the Age of Enlightenment when there was scientific interest in zoology. Thus, the function of zoos became motivated by research and education and this persists today with the added purpose of public entertainment (Rutledge et al., 2011).

However, over time, zoos have been faced with scrutiny from the media over their ethical problems, as concern for animal welfare has grown in society (BBC, 2014). There is belief that the modern function of zoos being motivated by conservation, education and scientific research is only a guise for what is a highly profitable industry thriving off animal exploitation (Henn, 2018).

With growing social concern for the welfare of animals in captivity, technological solutions are now something of great importance to consider. Virtual zoos are a recently emerging concept that simulate a visit to a zoo by allowing users to access exhibits and view animals through electronic devices and new technologies. In the face of growing ethical and moral concern, virtual zoos can mitigate, if not eventually eliminate, the cruelty associated with animals living in captivity and in unnatural, distressing habitats. Additionally, virtual zoos may one day surpass the entertainment potential of conventional zoos as they can simulate animals' natural behaviours, such as hunting or playing, which are more engaging, desirable to view and scientifically objective (Friends of Animals, 2015).

Considering the above, we aimed to design a novel and improved virtual zoo that was more ethical, entertaining and educational than conventional zoos. In this paper, we present the iterative user research and human-centred design process that we went through to create the final concept of our virtual zoo.

Related Work

To begin understanding the design space, we investigated previous work that explored and deployed virtual zoos in various ways. Allison et al. (1997) prototyped a virtual reality (VR) gorilla exhibit in which middle schoolers could learn about gorillas in their natural habitat, their behaviours, and social interactions with other gorillas. This educational prototype was intended to encourage students to learn experientially about social interactions with gorillas and to learn about the design of outdoor gorilla habitats for zoo exhibits. The results of the study showed that students enjoyed the experience and felt like they were part of the gorilla community. Interestingly, some of the behaviours observed during this study included students exploring the gorillas' habitats as well as social interactions with the animals. This provided us with early insight into what users desire from a virtual zoo, such as interactivity and habitat exploration.

In addition, Ahmed and Hossain (2020) created a virtual tour experience in a zoo where participants could watch animals walking around their natural habitats. Participants were immersed in the virtual zoo through a head mounted display created using Google Cardboard and by wearing headphones. The findings indicated a positive reaction to the technology and motivated our decision to explore the VR design space.

Though some of the literature has established that participants in the studies responded well to virtual zoos, commercial virtual zoo experiences that exist today have limited popularity compared to the appeal of physical zoos. To understand why this is the case, we conducted a competitive analysis of current virtual zoo experiences (Figure 1).

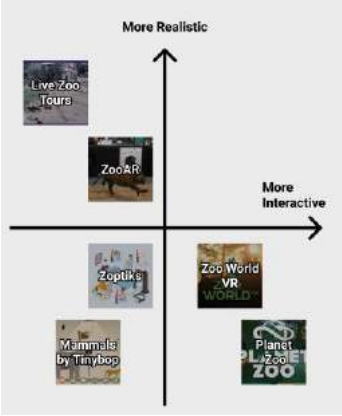

Figure 1. 2x2 matrix mapping the levels of realism and interactivity of competitor virtual zoos.

The competitive analysis revealed that existing virtual zoo experiences are typically split into two main categories. The first category is live tours of existing zoos. These experiences involve a tour guide giving a group of visitors a virtual tour of an existing physical zoo (e.g. Chester Zoo in the UK) which might include animal live-cams and 360-degree views of the exhibits. Although these experiences are social, educational and incorporate real animals, visitors are unable to interact with the animals or immerse themselves in the environment, and there may still be ethical concerns about how the animals are treated in the physical zoo.

The second category of virtual zoo experiences are made using computer-generated animals. For instance, there are existing games where you can manage and build your own zoo (*Planet Zoo*, 2019), explore animals in their own habitats in virtual reality (*Zoo World VR*, 2019) or project an animal hologram into your room through augmented reality (*ZooAR*, 2020). There are also educational applications where you can learn about different animals (*Mammals by Tinybop*, 2020) or go on virtual adventures in different habitats (*Zoptiks,* 2020). While these games and applications can be highly interactive, engaging and even educational, the experiences often lack a sense of immersion as the animals do not look realistic. These experiences also lack a social component as they are designed mainly for individuals.

By conducting secondary research on some of the virtual zoo products that are currently available today, we were able to identify where there was room for improvement for virtual zoo experiences, and develop an early understanding of what constituted a well-designed virtual zoo. Next, we moved on to user research to learn about people's perceptions of physical zoos and their motivations for visiting, in order to identify the key requirements for our design.

User Research & Establishing Requirements

We conducted initial user research to identify the user needs for our virtual zoo and distributed a survey of 19 questions to 127 adults (recruited through convenience sampling). We sought to better understand their demographics and technological competency, why they visit or do not visit zoos, and what they like and dislike about zoos (see Figure 2). In addition, we conducted observational studies at both the ZSL London Zoo and the San Diego Zoo to understand the behaviour and pain points of zoo visitors.

We found that the main reason people visited the zoo was to see real animals. When asked why they visited the zoo and what they liked about zoos, the majority of our survey respondents indicated that they wanted to see different species of animals, especially exotic animals which they would not be able to see otherwise. This was supported by our observational studies, where we noticed that zoo visitors were most attracted to real animals in the exhibits rather than other aspects of the zoo (e.g. signs). Visitors also showed interest in interacting with the animals, and often waved at and talked to the animals. Nevertheless, our survey respondents still indicated that the most important aspects of a zoo were to allow visitors to learn about animals and conservation efforts.

Another important finding that emerged from our user research was the social nature of zoo visits. Over 95% of our survey respondents visited the zoo with family, friends or their significant others, with many of them indicating that the reason they visit zoos was because it was an organised social event. This was supported by our observational studies at the zoos, where we noticed most zoo visitors were accompanied by their loved ones.

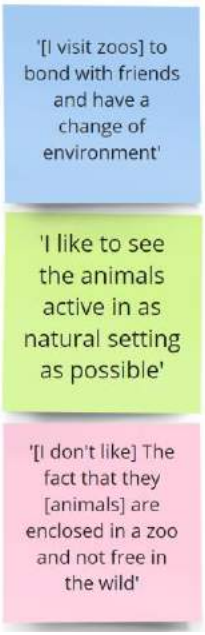

Figure 2. Selected quotes from our survey respondents.

Figure 4. Low-fidelity sketches and storyboards used during our initial ideation phase.

Conversely, our survey revealed that many people disliked zoos because of ethical concerns. Many of our survey respondents did not like how animals were not in their natural habitat and had insufficient space. Many respondents also believed that animals should not be kept in captivity, placed in unnatural habitats, or be used for entertainment. Two members of our research team who visited the San Diego Zoo observed a polar bear that seemed to be struggling with the heat, which on that day was approximately 30 degrees Celsius. Additionally, our survey indicated that people disliked the physical discomfort of going to the zoo, and were especially deterred by the unpleasant smells, bad weather and fatigue from walking around. The researchers also found these physical discomforts to be detrimental to their experience as well, finding the day to be so hot and the zoo so crowded that they decided to leave early from fatigue.

Based on these findings, we created our persona (Figure 3), an animal-loving socialite who enjoys visiting the zoo with her loved ones, but who has ethical concerns about the wellbeing of the animals. We decided that our virtual zoo needs to have the following requirements:

- Be realistic and interactive while incorporating elements of education and conservation.
- Emphasise zoo visits as a social activity.
- Address the ethical issues and physical discomfort associated with real zoos.

Figure 3. The persona profile that was created based on our survey findings.

Design Process

Initial Ideation

With our persona and user requirements in mind, we began ideation with a diverging process, in which each member of our team individually generated a wide range of ideas and portrayed them using sketches and storyboards (Figure 4), After our Crazy-8s (Knapp et al., 2016) and storyboarding exercises, each member presented their best ideas to the group. We then started the converging process by getting together to group and merge similar idea components.

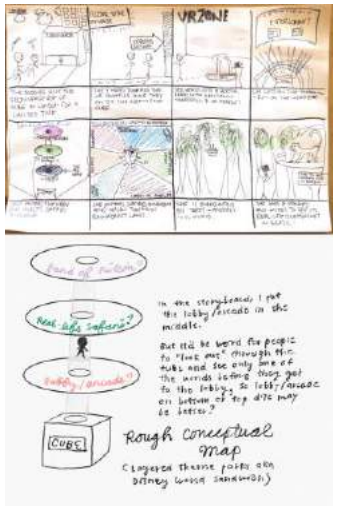

Figure 5. Sketches and storyboards used as design probes to help us explain our ideas to participants during our interviews.

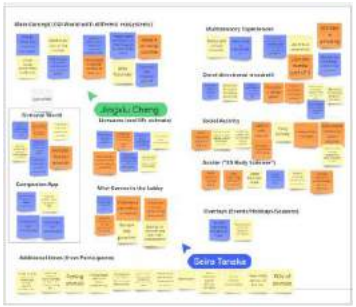

Figure 6. Affinity map of our interview insights.

At the end of this process, we came up with our initial concept – a physical room in the city which people could visit with their loved ones to experience an immersive and interactive virtual reality (VR) zoo created using computer-generated imagery (CGI). Our VR zoo initially had a multi-level structure, with a different theme for each level. We also came up with an idea to build a companion app that would supplement the VR zoo experience.

User Interviews

After defining our initial concept, we conducted user interviews with 8 participants who fit our persona to get their feedback on our ideas. We used sketches and storyboards as design probes during the interviews (Figure 5), and asked participants if they had any opinions, concerns or suggestions regarding the layout of the physical room, the design of the virtual world and the specific features and interactions. In general, our initial concept and specific ideas were well received by the participants.

Importantly, we grouped the interview responses into themes, and made use of these insights to improve our idea (Figure 6). Firstly, the interview insights helped us to narrow down the number of ideas to focus on. For instance, one of our initial ideas was to introduce a fictional world comprising of extinct species (e.g. dinosaurs) and mythical creatures (e.g. dragons) into our virtual zoo. However, we did not proceed with this idea because our participants thought it may be "distracting" or "random" and would prefer the world to be as realistic as possible. Similarly, while we considered developing a companion app to encourage repeat visits to our virtual zoo, we removed this idea because many participants thought it was "unnecessary" and that they would not bother to download the app.

Secondly, the interview insights helped to inform our design of the physical rooms. We initially introduced omnidirectional treadmills in the physical rooms as a method of allowing users to move freely in the virtual world while remaining in the same spot in the real world. However, participants highlighted that the experience might be tiring, and our virtual zoo might not be accessible to those with mobility impairments. Hence, we decided to also introduce chairs so users could take frequent breaks, and a game controller mode so tired or impaired users could experience the VR world while sitting down. In addition, some of our participants that had previous experience in using VR headsets highlighted that users are likely to remove their VR headsets during breaks. Hence, we decided to put screens in the physical room that shows every user's view in the virtual world, so resting users can continue to observe what their friends and family are doing in the virtual world and remain engaged and social.

The interview insights also gave us ideas of specific interactions to incorporate into our virtual world. For instance, some participants indicated that they would like to pet the animals and wanted to see events that they would not normally be able to see in the real world. Therefore, we added a "Touch Me" activity and a "See Me in Action" activity when users encounter an animal in the VR world.

Lastly, the interview insights helped us to identify concerns around specific ideas. For example, our virtual zoo contained multisensory experiences, such that users were able to engage in tactile experiences with the animals (i.e. "Touch Me" activity) and ambient experiences (automatic changes to temperature, smells and weather of the physical environment to match the virtual world). While many of our participants liked these ideas, a minority of them expressed worry

Figure 7. Our physical mockup of the futuristic-themed ZooniVRse lobby.

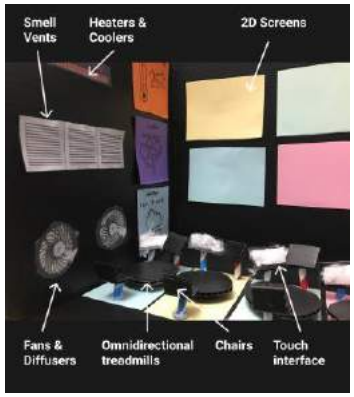

Figure 8. The first version of our physical mockup of the individual VR room.

because they were especially sensitive to temperature changes and/or certain smells, so we decided to make the ambient experiences optional (toggled by the user). Many participants were also afraid they would be shocked if they unknowingly brushed past a dangerous animal, so we decided that the tactile experiences would not occur until a user explicitly decides to engage with the "Touch Me" activity. In addition, we had an early idea to include a "3D Body Scanner" in the physical room, in which users could scan a realistic model of themselves into the virtual world. However, because some participants expressed privacy concerns, we decided to also give users the option to create their own custom avatars for the virtual world.

Physical and Digital Prototypes

Following the valuable contributions of our interview participants, we arrived at a concept that was ready to be prototyped. At this stage in the design process, the concept could be described as a virtual world comprising of different biomes in which users form parties, exploring together and engaging in a range of different interactions with CGI wildlife. The virtual world is hosted at a physical location in a city where users enter VR booths equipped with treadmills and multi-sensory simulators (air vents, haptic pads) that create ambient effects such as weather changes and produce tactile feedback for petting animals. Users are represented realistically within the VR world so they feel that they are actually in the world with their party.

We created low-fidelity prototypes to showcase our refined ideas. To display our idea of the real world, we made two miniature physical mock-ups – one to show the lobby of the building (Figure 7), and another to show the layout of an individual VR room (Figure 8).

To display our concept of the VR world, we created a digital prototype (Figure 9) using the sandbox video game Minecraft (2011). The world had a circular layout with a home base (which doubled as the spawn point) located in the centre, and three biomes extending out from the home base. The base structure of the world was created using WorldPainter (2011), an open-source interactive map generator for Minecraft, while other details (e.g. home base, biome boundaries, animals, vegetation) were added manually within the game.

Since we could only conduct remote user tests, we also put together a video prototype to show our participants during user testing sessions. The video prototype incorporated scenes from both our physical mock-ups and digital prototype and demonstrated the user journey of a hypothetical character ("Emma"), based off our persona, as she visits the virtual zoo with her friends. It visualised the overall process of Emma entering the building, exploring a part of the VR world, and engaging in the different activities and interactions.

Video Walkthrough

To evaluate our ideas, we used a video walkthrough to conduct user testing with 6 participants who fit our persona. At the start of the session, we played the video prototype for the user to give them a walkthrough of our concept and asked general questions about the layout of the physical room and VR world. Subsequently, we replayed small clips of the video prototype and asked more specific questions about the individual features and interactions in our design. Overall, feedback was extremely positive, and all of our participants indicated interest in visiting our virtual zoo.

Nevertheless, the video walkthrough provided us with important insights which we used to refine the physical virtual reality rooms. Firstly, because participants felt that the users in the physical rooms were too close together, we changed the layout of the physical room

Figure 9. Screenshots from our Minecraft prototype of the VR world.

Figure 10. A refined version of our physical mockup of the lobby.

to be more spacious. Secondly, participants emphasised that they would like to see the facial expressions and body movements of their friends while they were in the virtual world. Hence, we replaced our "3D Body Scanner" idea with cameras and motion sensors that track the real-time facial expressions and body movements of users in the physical world, so that these can be synchronised with the realistic projections of them in the VR world.

Moreover, we also improved the VR world based on feedback from the video walkthrough. Participants indicated that they would like to be guided on where to explore, so we included hiking paths into the virtual world. Participants also said they would want to continue to be immersed in the virtual world while they take breaks, so we included resting areas in the VR world where users can sit and view beautiful scenery.

Furthermore, we used the feedback from the video walkthrough to improve the specific activities that users could interact with in the VR world. Since our "Live-Cam" activity (where users could view live-cams of animals in the real world) was not popular amongst participants, we removed this activity from our virtual zoo. Additionally, participants wanted to access more information relating to conservation efforts, so we added a greater emphasis on animal conservation in our "Learn More" activity.

ZooniVRse

After refining our idea based on the user feedback from the video walkthrough, we developed the final concept for our VR zoo – the ZooniVRse. The ZooniVRse is a physical location in the city which people can visit with their loved ones to experience a realistic, multisensory, and interactive virtual reality (VR) zoo. Below, we elaborate on the specific features and interactions of our concept by describing the typical user journey through the ZooniVRse.

To begin, users visit the ZooniVRse building located in the city. The lobby of the building has a comfortable waiting area where users can collect their tickets and VR headsets and meet up with their family and friends (Figure 10). Once the users are prepared, they are ushered into their own VR room which contains the equipment and technology necessary to support their experience in the VR world (Figure 11). The users can then move to their respective positions and put on their VR headsets to enter the VR world.

Figure 11. A refined version of our physical mockup of the VR room. The room consists of omnidirectional treadmills to support movement, Ultraleap haptic panels to support tactile experiences, and heaters, fans and vents to support ambient experiences. Screens on the wall project each user's view of the VR world throughout the experience, allowing users to remain socially engaged even if they remove their VR headsets during breaks.

The VR world consists of a "home base" surrounded by different zones that represent various real-world ecosystems (see Figure 9) and will look indistinguishable from reality. Users are free to explore the world and interact with realistic CGI animals in their natural habitats. Throughout the world, there are be hiking paths and signs to guide users on where to go,

Figure 12. Cameras and motion sensors located in the VR headsets and the physical room records users' real-time facial expressions and body movements throughout the experience.

Figure 13. Changes in temperature, weather and smells are supported by heaters and coolers, fans and moisture diffusers, and olfactory vents in the physical room.

and frequent resting spots with beautiful scenery where users can take a break.

To ensure that the experience is social, each user has a realistic projection of themselves in the VR world that shows their facial expressions and body movements (Figure 12). However, if users have concerns relating to data privacy, they can choose to opt out and create their own avatar for the VR world instead.

Users can move around the VR world by walking on an omni-directional treadmill in the physical room, allowing them to move in every direction at their own pace while remaining in the same spot in the real world. There is also a foldable chair installed which allows users to sit down if they need to rest during the experience. Alternatively, if users are tired or have mobility issues, they can choose to sit down and move around using a game controller instead. They can continue to experience the ZooniVRse world in VR or use the 2-dimensional screens located on the walls of the physical room instead if they are prone to motion sickness.

When users walk into a new biome, the ambient effects (e.g. temperature, weather and smells) change to match the respective ecosystem to facilitate an immersive and multisensory experience (Figure 13) Importantly, these experiences will be kept to comfortable levels (i.e. the room will not freeze even if users enter the snowy tundra). Nevertheless, users have the option to opt out from these experiences if they are particularly sensitive to temperature changes or certain smells.

When users encounter an animal in the virtual world, they are given the option to engage in one of four different activities (Figure 15).

The first type of activity they can engage with is "Touch Me", in which users feel like they are petting the animal (Figure 14). This is made possible by Ultraleap haptic technology, which uses ultrasonic technology to generate haptic sensations of an animal's texture. If the animal is dangerous, the "Touch Me" activity will be accompanied by a disclaimer to warn users (especially children) not to touch an actual wild animal in the real world.

A second activity that users can choose is "Play Mini-Game", where users can engage in single or multiplayer games that involve the encountered animal. For instance, users can play "Escape the Tiger" if they encounter a tiger in the jungle, in which the remaining user (who has not been caught by the tiger at the end of the game) wins.

A third activity is "See Me in Action", in which users can see a realistic simulation of the animal engaging in an activity that is rarely seen in the real world. This could be a parrot performing a mating ritual, a tiger chasing its prey or an elephant giving birth.

Finally, a fourth activity that users can engage with is "Learn More", where they can read more about the habitats, behaviour traits of the conversation status of the animal. They can also choose for the information to be narrated by celebrities such as famous nature documentary narrator David Attenborough.

At the end of the day, users can return to the lobby together to view a leaderboard of their stats, which includes the number of animals they encountered, their mini-game points and the number of steps they took. They can also view the latest updates to the ZooniVRse (e.g. new biomes and animals) and upcoming events (e.g. northern lights in the snowy tundra). These features aim to encourage the users to consider repeat

Figure 14. The "Touch Me" activity is supported by the UltraHaptics panel.

Figure 15. Users select the activity they want to engage with by moving their arm to the appropriate menu item. This is supported by a Ultrahaptics haptic panel placed around each user in the physical room.

visits to the ZooniVRse before they end their experience.

Discussion

In summary, the ZooniVRse is a physical location in the city that people can visit to experience a fully immersive and multisensory VR zoo. In the VR world, which is realistic to the point of being almost indistinguishable from reality, users can explore various biomes and engage in activities with the CGI animals. Throughout the experience, users are able to explore the VR world with their party and engage in activities together, regardless of whether they are located in the same physical room or met up in the virtual world from different physical rooms. Overall, the ZooniVRse improves upon existing virtual zoos by providing a more immersive, integrated and social experience.

Moreover, the ZooniVRse improves upon real-life zoos by eliminating the tension between users' ethical concerns about animal welfare and their desire to have a fun social outing. By creating a virtual experience using only CGI animals, the ethical concerns regarding animal cruelty associated with physical zoos are eliminated. Hence, the ZooniVRse has the potential to reinvent the concept of physical zoos, bringing much-needed innovation to a market that has faced increasing public pressure for reforms. This would allow conventional zoos to return to their primary purpose of being dedicated to species conservation and ecological research.

In addition, the combination of technologies involved in our concept could be extended to a truly broad range of applications beyond virtual zoos. The creation of large-scale VR worlds with free movement, simulated ambient features, and haptic feedback could be used across a range of sectors for a multitude of different purposes. In healthcare, virtual worlds could be created to support patients undertaking physical therapy and rehabilitation by placing them in stimulating virtual environments with motivational prompts and interactions. Further related to health, virtual experiences could be constructed to promote physical movement and tackle obesity. In entertainment, there are seemingly endless applications of this technology and most interestingly, there is opportunity to combine entertainment with education. The worlds of ancient civilisations could be constructed to be explored by users ranging from school children to museum goers. Also related to education, virtual worlds could be used for modelling the impacts of climate change and environmental degradation, allowing users to experience a realistic representation of an uncertain future.

Limitations

However, we came across several limitations when attempting to represent the concept of our virtual zoo. Firstly, the scale and complexity of the VR world meant we were only able to prototype the world in Minecraft, which may have influenced participant responses to the video walkthrough; for example, participants may have felt differently about petting a tiger, or walking up to one, if the tiger in question looked and felt like a real tiger instead of a Minecraft representation.

Secondly, social restrictions due to the COVID-19 pandemic meant that we were unable to prototype any aspect of the users' physical experiences with the technology. Thus, at this point, we are unable to speak to whether users will encounter issues with the experience leading up to the VR world and to the technologies in question (e.g. the VR headsets, facial scanners, motion tracking technology, omnidirectional treadmills, and mid-air haptics), and how much explanation will have to be provided with regards to their use.

In addition, an important limitation in relation to the concept itself is cost. The technologies required for the concept are all highly sophisticated and will be costly to implement. There will also be considerable logistics involved in combining them all into a fully immersive, integrated experience.

Future Steps

The next steps toward the realization of our concept would involve creating a high-fidelity prototype of the VR world to explore how users would react to exploring, interacting with animals, and engaging in activities within a VR wilderness. We would also need to create additional prototypes to explore users' physical experiences with the technology (e.g. the physical layout of the room and their experience with the multisensory technologies), as this was something we were unable to explore due to the limitations outlined above.

Due to the large-scale, highly conceptual nature of this project, we were also unable to zero in on some of the specific interactions that users would encounter through their experience of the ZooniVRse (e.g. making a reservation, forming a party with their friends, selecting certain settings, and entering and leaving the VR world). The details of these interactions would certainly have to be established as well.

Finally, it remains an open question whether the current design could be realised given the current technological limitations. Can a hyper-realistic ZooniVRse be programmed? Can haptic feedback create realistic tactile stimuli similar to that of a physical animal? These are questions that should be addressed in future research.

Conclusion

In conclusion, the aim of our project was to develop a concept for an immersive, social and ethical virtual zoo. We followed a human-centred approach and iterative design process which involved establishing user requirements, generating a wide range of ideas, creating sketches and prototypes of our ideas, and refining our concept through user interviews and user tests. Through this process, we came up with ZooniVRse - a physical location in the city that people can visit with their loved ones to experience a realistic, multisensory and interactive virtual reality (VR) zoo. We believe the ZooniVRse pushes the boundaries of existing virtual zoo experiences, and our next step is to evaluate the feasibility of our concept with high-fidelity VR prototypes, and prototypes exploring users' physical experiences with the technology.

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